European
Commission

Possible extension of the EU Emissions Trading System (ETS) to cover emissions from the use of fossil fuels in particular in the road transport and the buildings sector

Final report

September – 2020

EUROPEAN COMMISSION

Directorate-General for Climate Action
Directorate B — European & International Carbon Markets
Unit B.1— ETS Policy Development and Auctioning
Contact: Polona GREGORIN

E-mail: polona.gregorin@ec.europa.eu

European Commission
B-1049 Brussels

LEGAL NOTICE

This document has been prepared for the European Commission however it reflects the views only of the authors, and the European Commission is not liable for any consequence stemming from the reuse of this publication. More information on the European Union is available on the Internet (http://www.europa.eu).

PDF	ISBN 978-92-76-42442-0	doi: 10.2834/779201	ML-06-21-074-EN-N

Luxembourg: Publications Office of the European Union, 2021

© European Union, 2021

The reuse policy of European Commission documents is implemented by the Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Except otherwise noted, the reuse of this document is authorised under a Creative Commons Attribution 4.0 International (CC-BY 4.0) licence (https://creativecommons.org/licenses/by/4.0/). This means that reuse is allowed provided appropriate credit is given and any changes are indicated.

For any use or reproduction of elements that are not owned by the European Union, permission may need to be sought directly from the respective rightholders.

Possible extension of the EU Emissions Trading System (ETS) to cover emissions from the use of fossil fuels in particular in the road transport and the buildings sector

Table of Contents

Executive Summary

The objective of this study was to:

- Explore options for possible inclusion of CO2 emissions into an emissions trading system of the road transport and/or buildings sectors.
- Assess with qualitative and for selected questions also quantitative tools the relevance and the impacts of the identified options, in particular in terms of effectiveness (emissions reduction achieved in both sectors), of regulatory robustness (monitoring, reporting and verification), as well as distributional effects on households and small and medium enterprises (SMEs) and potential quantitative impacts on the existing EU Emissions Trading System (ETS) and the Effort Sharing Regulation (ESR).
- Explore the option for possible inclusion into an EU emissions trading system of all CO_2 emissions from fossil fuels.

The results of the study serve as an input for the Commission's assessment of the various options for a possible inclusion of the CO_2 emissions from the use of fossil fuels in particular in the road transport and/or buildings sectors into an emissions trading system. The work was conducted between February 2020 and September 2020.

Relevant energy carriers in road transport and buildings

At present, the EU ETS covers CO_2 emissions from road transport and buildings[1] only in the form of indirect emissions, i.e. if emissions arise from the production of energy carriers such as electricity, hydrogen or steam, or from larger district heating plants. CO_2 emissions from combustion of road transport fuels, mainly petrol and diesel, and from the combustion of fossil fuels to heat buildings are generally not part of the EU ETS.

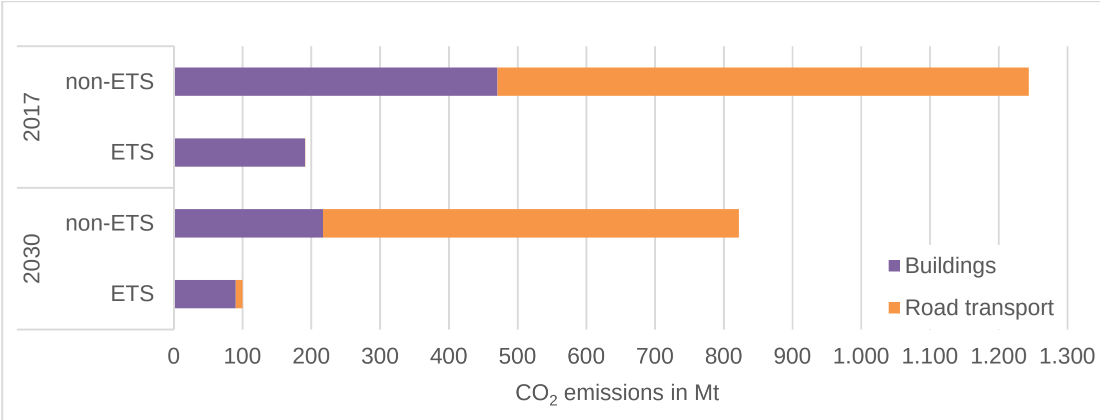
In 2017, the latest year of available inventory emissions when the quantitative analysis was conducted, non-ETS emissions made up by far the largest share of CO_2 emissions attributable to buildings and road transport (1,243 Mt CO_2, 87 %). The emissions mainly came from direct fossil fuel combustion (1,239 Mt CO_2) followed by district heating (5 Mt CO_2). ETS emissions were mainly those from electricity consumption (110 Mt CO_2) and district heating (82 Mt CO_2).

CO_2 emissions from buildings and road transport were about the same order of magnitude in the EU. However, emissions from road transport were almost completely non-ETS emissions (99.93 %) while around 70% (471 Mt CO_2) of emissions from buildings were non-ETS emissions and around 30% (191 Mt CO_2) was covered by the ETS.

From 2017 to 2030, CO_2 emissions from building and road transport are expected to decrease both in the EU as a whole and across all of its Member States. Based on the latest available Commission projection when the quantitative work was conducted, the so called EUCO3232.5 scenario representing the previously agreed 2030 targets starting from the EU Reference Scenario 2016, emission reductions are expected to be much larger in buildings than in road transport.

[1] Here, the energy consumption of buildings is defined as the energy consumption for space heating and cooling, for water heating and cooking. It does not include the energy consumption for electric appliances and lighting.

Figure 1. Forecasted EU emissions from road transport and buildings attributable to the existing ETS and the ESR (called non-ETS) in 2017 and 2030



Source: own calculations based on EUCO3232.5 modelling and own calculations. Note: ETS emissions are indirect emissions from electricity and heat consumption attributable to road transport and buildings.

In the used scenario, two thirds of the 2030 emissions are attributable to road transport and one third to buildings. In the EU and all of its Member States, non-ETS emissions will continue to dominate total emissions from the two sectors. Emissions from road transport will still be predominantly non-ETS emissions (98 % in the scenario used) while 70 % of emissions from buildings are expected to be non-ETS emissions against 30% covered by the existing EU ETS.

National measures in the road transport and buildings sectors and their relation to the EU ETS

Five national case studies (France, Germany, Poland, Spain and Sweden) assessed the existing national policies in the road transport and building sectors. The case studies show a range of policy and pricing instruments applicable to transport and housing, from countries with no or only minimal carbon pricing instruments (Poland, Spain) to Sweden as the other extreme, where a carbon price has been in place for almost three decades, and is widely credited as the dominant instrument that has brought about significant emission reductions and supported structural changes in the covered sectors.

Where they exist, carbon prices have found to be effective in reducing emissions. For the case of **France**, an OECD analysis showed that an increase of energy prices of 10% resulted in a 6% reduction of energy use in businesses, and a CO2 reduction of 9% on average. As a result, the existing carbon tax is estimated to have reduced (predominantly non-ETS) manufacturing CO_2 emissions in 2018 by 5% or 3.6 Mt compared to a reference scenario without the tax. In **Sweden**, the carbon tax is considered as the cornerstone of Swedish climate policy and the key driver behind Sweden's success in cutting emissions whilst maintaining economic growth. The Swedish tax is credited with reductions of 0.5 to 1.5 million tons annually in the early years of its introduction, mainly related to heating of buildings. For **Germany**, ex-ante modelling suggests a significant contribution particularly in the area of freight transport, where the national carbon price and other measures are expected to favour the shift from road to rail. The expected emission reduction contribution of the national carbon price in transport is estimated at 6 million tons in 2030 – compared to a total of 8 million tons for all other climate policy measures in the transport sector. What stands out from the carbon price case studies is the importance of a price signal that is not only strong, but also long-lived. In the case of Sweden, the fact that the carbon price has existed (and continuously increased) for almost three decades means that it could support the structural transformation of the building sector from fossil to bio-based fuels and electricity.

In France and Poland, white certificate schemes (tradable energy efficiency obligations) are an important part of the respective countries' portfolio of climate and energy policies. As market-based instruments, these systems share some commonalities with a carbon pricing instrument, in that they work through a financial incentive, the level of which depends on the distance-to-target. In principle, as market-based approaches, carbon pricing and white certificate schemes are able to coexist and complement each other.

The Member States that implement a carbon price have dedicated programmes for using their revenue – typically to address distributional impacts, to mobilise additional mitigation potentials, or a combination of both. France has placed great emphasis on addressing the equity implications, both through direct support to affected households, and by supporting energy-saving investments for vulnerable groups. Germany intends to use part of the carbon pricing revenue to lower the renewable energy surcharge, and hence the electricity price; the remainder of the revenue will be used to fund climate action programmes and measures across different sectors.

Experiences gained in ETS outside the European Economic Area

The study also provided insights from four case studies of ETS outside the European Economic Area that included transport and / or the building sector: these are the ETS in California, New Zealand and Tokyo, as well as the announced Transport Climate Initiative that brings together 13 northeastern and mid-Atlantic US States.

The experiences in New Zealand and in California both show that the use of upstream obligations for transport and heating fuels lowers the number of participants, keeping participant transaction costs and administrative costs low. Both systems – and also the forthcoming TCI programme on the US East Coast – have placed the point of regulation as high upstream as possible. As a result, the number of participants remains low, with 450 companies representing 600 installations in the case of California – for an economy that is larger than France or the UK. The NZ experience also documents the relatively low administrative costs, both for the public administration and for the covered entities.

The examples of NZ and California thus show that upstream regulation is a feasible option where markets are sufficiently liberalised to allow cost pass-through. By contrast, the Tokyo example shows that also a stand-alone ETS for buildings generally can work, even if applied at the downstream level. Despite some weaknesses – such as the low level of liquidity – the system has operated for a decade, and is generally viewed as a success, particularly in terms of reducing emissions.

The experience of all existing systems is that, even if ETS prices rise to relatively high levels, the emissions component of fuel costs will remain small: in the case of the NZ ETS, at current carbon prices the carbon price only adds about 3 cents, or 2.5%, to the pump price; and even for a much more ambitions carbon price of 60 Euro, petrol prices would still increase only by about 10%. The relative impact is somewhat larger in California. Still, the effect of the price signal remains limited, which means that additional measures are necessary to drive swift emission reductions.

One main function of the ETSs in either case has been to provide long-term orientation for owners of cars and buildings, for investors and consumers. For New Zealand, it has become clear that the overall impact of the scheme depends on its fundamental ability to generate a price incentive to act, which requires a binding and sufficiently stringent cap. Given the long-term time horizons for transport and building investments, long-term policy certainty is important to drive ETS impact. Yet the Tokyo ETS also shows that effective policy is not only a matter of a high-enough carbon price: covered entities have to report not only their emissions, but also the mitigation measures taken. They receive feedback on their emission mitigation performance and on the energy efficiency relative to others; in addition, the top-performing entities are publicly credited. These factors that work in support of and in conjunction with the ETS are believed to have enhanced the effectiveness of the system significantly.

Price elasticity of fuel demand and impact of a carbon price surcharge on fuel prices, fossil fuels use and CO_2 emissions

A brief literature review was conducted to gather evidence on price elasticities of fuel demand in buildings and road transportation. Results at EU-level show that average price elasticities of energy demand in road transport are -0.17 (short-term) and -0.34 (long-term), at Member State level long term elasticities vary between -0.30 and -0.98; in the buildings sector, the available EU level information is very limited but results indicate an average long-term price elasticity of -0.23, while Member State level data varies between -0.36 and -0.5.

An econometric assessment of historical thermal and electricity demand obtained short-term and long-term macroeconomic activity and price elasticities, for example at the EU-level in road transport the long-term price elasticities of energy demand vary between -0.08 (buses) and -0.62 (freight). In the buildings sector, long-term price elasticities of electricity and thermal energy vary between -0.20 and -0.38. Based on the statistical significance and R^2 value for each sector and energy type, a mix of econometric analysis and literature values were chosen to complete the following quantitative analysis.

To conduct the quantitative energy demand analysis, a frozen policy baseline energy scenario to 2030 was created with the EnerNEO model and included historical energy consumption by fuel type, international commodity fuel price forecasts, energy efficiency trends, population and household forecasts, and vehicle investment costs by technology. The EnerNEO model is based on a realistic representation of energy using equipment and stock turnover and represents policies beyond existing energy taxation only to the extent they have impacted the historical data; in particular, the model accounts for existing carbon taxes.

To complement the bottom up analysis of the potential for energy efficiency and to determine the potential for fuel switching in the buildings and road transport sectors, changes in fuel use at given levels of explicit carbon prices were calculated by comparing energy demand under each carbon price in 2030 to the baseline scenario; carbon price impacts were evaluated from €30/tCO_2 to €150/tCO_2.

Based on this model, in the buildings sector Member States see most energy and CO_2 reductions in the form of fuel switching; on average, about 72% of a country's reductions. This is largely due to the shift from coal to bioenergy and electric heating. Some countries with much higher baseline energy prices, like Finland and Sweden, see almost all their emissions reductions come from fuel switching. Other countries with lower baseline prices, like Poland, have a much more even split between fuel switching and increased energy efficiency. In the road transport sector, modelled CO_2 emissions reductions are primarily from energy efficiency with limited fuel switching apparent. This owes largely to the relatively short timeframe for reductions to occur by 2030, the lower purchase costs for internal combustion fossil fuel-based vehicles relative to alternative motor options, the small current fleet of hybrid and electric vehicles, and that bioenergy may need regulatory blending shares in addition to a price-signal to be included in significant amounts. Energy efficiency provides most of the emissions reductions because of the number of internal combustion engine vehicles still purchased before 2030.

Overall, this model suggests that a carbon price applied to the buildings and transport sectors as the only new policy measure can cause reduced emissions even within the

2030 timeframe. Emission reductions relative to the baseline in 2030 at the EU-level range from 2.9% at €30/tCO_2 to 11.7% at €150/tCO_2 in buildings, and 1.8% at €30/tCO_2 to 7.8% at €150/tCO_2 in road transport.

Integration of road transport and buildings into emissions trading

Different design elements need to be defined in the context of discussing the integration of road transport and buildings into an EU emissions trading. The design elements defined as most relevant for defining design options are the following:

- Inclusion into existing ETS or creation of separate ETS
- Full or partial inclusion of building and transport sectors
- Coverage by ESR

Other elements also considered are:

- Linking with other systems
- Immediate or gradual extension

Based on these elements, several options were defined, which are shown in Table 1.

Table 1. General design options regarding scope of the new system and legal implementation in the context of existing EU legislation

Design Options	Sectors	Flexibilities	ESR applies	Possibilities for extension
Option 0 (baseline)	No EU-wide extension of the EU ETS, potential opt-in by individual MS	n/a	yes	---
Option 1a - full scope extension	Full EU-wide scope extension of the EU ETS to include road transport + buildings	n/a	no	---
Option 1b - full scope extension under existing ESR	Full EU-wide scope extension of the EU ETS to include road transport + buildings	n/a	yes	Later extension to Option 1a possible (after 2030)
Option 1c - scope extension for freight transport and commercial buildings	EU-wide scope extension of the EU ETS to include freight transport + commercial buildings	n/a	no	Later extension to Option 1a possible
Option 2a - scope extension for road transport	EU-wide scope extension of the EU ETS to include road transport	n/a	no	Later extension to Option 1a possible
Option 2b - scope extension for buildings	EU-wide scope extension of the EU ETS to include buildings	n/a	no	Later extension to Option 1a possible
Option 3a - separate ETS for road transport + buildings with limited linking to the EU ETS	Separate ETS scheme for road transport + buildings	With (limited) linking between ETSs	yes	Later extension to Option 1a possible if design of the systems allows for a merger
Option 3b - separate ETS for freight transport + commercial	Separate ETS scheme for freight transport +	With (limited) linking between ETSs	yes	Later extension to Option 3a possible

Design Options	Sectors	Flexibilities	ESR applies	Possibilities for extension
buildings with limited linking to the EU ETS	commercial buildings			
Option 3c - two separate ETS, one for road transport, one for buildings with limited linking between new systems and with the EU ETS	Two separate ETS schemes, one for road transport, one for buildings	With (limited) linking between all three ETSs	yes	Later extension to Option 3a and option 1a possible if design of the systems allows for a merger

Source: Fraunhofer ISI

In addition to the design elements listed above that define the options considered under this study, there are several other important design elements that were analyzed in this Task. These include the point of regulation, which was not looked at based on the end users in the building and transport sectors, but for suppliers of fossil fuels, coal, gas, and mineral oil. This was done because due to the large number of emitters in the two sectors, a downstream approach, as in the existing EU ETS, was not considered practicable (short discussion on this topic in section 4.2.3) and therefore regulation further up the fuel supply chain was recommended.

For petroleum products, tax warehouses and refineries were identified as the most appropriate points of regulation. These are to a large extent able to identify the final use of their products, the number of entities is manageable and in the case of tax warehouses (some refineries are also classified as tax warehouses) there is already an existing MRV system at this stage of the supply chain due to the energy tax. This results in cost advantages over other possible points of regulation.

In the case of gas and coal, the most appropriate regulation point was identified as the supplier to the end consumer. Since there are no obligatory tax warehouses for both fuels in Europe, energy tax is also levied at this point in most Member States, which in turn has an advantage as the regulation for an ETS could be built on the existing MRV system. A regulation of TSOs for gas could also be a solution, but it is not clear from a legal point of view whether this is possible, as TSOs are usually not the owners of the gas that is transmitted.

For the emissions cap, four scenarios for the design options were calculated, taking into account the necessary reductions, emissions and emission shares in ETS and ESR.

- 40% GHG reduction target under current target setting rules
- Keeping current proportionality for higher ambition levels (-50% and -55%)
- Similar emission reduction requirements compared to todays' GHG levels (for -50% and -55%)

In all options, due to the change in scope, emissions covered by emissions trading remain unchanged or are significantly larger, whereas emissions covered by the ESR remain unchanged or are significantly smaller.

Carbon slippage can emerge where fuels are treated differently, depending on which sector they are used in, opening the possibility of evading the carbon price. In this way, carbon slippage is of concern for a hybrid system with a mix of upstream and downstream coverage. Avoiding slippage (as well as double counting) therefore requires that suppliers are able to discriminate between different fuels, depending on their intended use and destination, and particularly whether the fuels will incur a compliance obligation when combusted.

The analysis showed that this situation is most relevant for mineral oil products. For natural gas, the market structure limits the risk of slippage, whereas for coal, the use in buildings and transport is very limited. Possible solutions are to legally classify fuels that are destined for different categories of customers and used as different products, which would require that the different fuels are distinguished and tracked separately all the way down the supply chain; and to generally treat all fuels as if destined for a customer / use that is not covered by a downstream obligation, and to allow those customers / uses that have such an obligation to apply for a refund.

Accurate monitoring, reporting and verification (MRV) of emissions is needed for the effective functioning of an ETS. Implementing harmonized and cost-efficient rules considering the TACCC principles (Transparency, Accuracy, Consistency, Comparability, Completeness), but also considering the additional costs and administrative burden for the newly regulated entities and the competent authorities is a precondition to a robust monitoring, reporting and verification (MRV) system. Learnings from the application of the current EU ETS MRV rules on determining activity data, carbon content, biomass content, NCV, which are considered mature and robust when looking at the EU ETS available evaluations, is a strong basis to establish rules for the newly regulated entities. To optimize the system, regulators should also consider existing local environmental tax, regulations, and market systems where relevant. For example, for road transport, taking advantage of samples already done for other legal requirements such as the Fuel Quality Directive and the Fuel Quality Monitoring System would contribute to reduce the costs and administrative burden for the relevant entities.

According to the Monitoring Mechanism Regulation, the consistency of the emissions reported in the GHG inventory and the EU ETS must be ensured. For example, fuel combustion emission factors' units, NCV fluctuations, especially when monitoring blended fuels such as biofuels containing biomass and fossil fraction, can impact on the CO2 emissions reported. To enhance precision, the number of samples and analysis should be increased, considering the balance between CO2 emissions variations and related measurements costs. Furthermore, combining an upstream approach (refineries, tax warehouses, gas and coal distributors supplying the road transport and the building sector) with a downstream approach (fuel consumers such as existing EU ETS plants, district heating plants, excluded installations from the current EU ETS) may lead to double counting or omitting CO2 emissions if strong monitoring and verification rules are not implemented. In the meantime, some specific rules existing in the EU ETS, such as exclusion criteria for small emitters or hospitals (which could be the end-users in the new system) should be maintained in case of an extended EU ETS or separate systems to avoid distortion and unreasonable costs. Also, different situations with district heating installations can occur, and the identification of the end-user implying cooperation between the fuel supplier, the district heating and the end-users, would be necessary.

Increasing the number of regulated entities (by more than 100% compared to the current number of regulated entities under the EU ETS) will lead to an increase of costs and administrative burden related to the MRV requirements. The upstream approach assessed in this study leads to lower costs than the downstream approach, as there are less regulated entities, even if attention should be paid to the potential higher fuel product prices which would be passed through the consumers (end-users). MRV costs also depend on the size of the regulated entities, the cost per emitted ton of CO_2 decreases exponentially with the amount of verified emissions. This observation must be put into perspective regarding the lower expected complexity of the monitoring and reporting rules for the potential newly regulated entities, where only sales and distribution of fuels for combustion purposes would be reported.

Impact of the integration of road transport and buildings into the EU ETS on ESR, EU ETS, EU legal framework and households

Based on the design options defined and analyses conducted in the previous tasks, and using for 2030 projections the Commission's EUCO3232.5 scenario representing the previously agreed 2030 targets starting from the EU Reference Scenario 2016, the impact of these options on the EU ETS and ESR has been analysed. The different design options result in significant differences in the percentage of emissions covered by the ESR or ETS. For Option 3, which would implement an additional ETS alongside the existing EU ETS, the emission coverage of EU ETS and ESR does not change compared to Option 0, which represents the baseline option.

Option 1a, which extends the EU ETS to buildings and road transport and does not continue ESR for these sectors, increases the share of emissions covered by the EU ETS from 41% to 74%, while the share of emissions covered by the ESR decreases from 59% to 26%. Option 1b, which is the same as option 1a but continues to cover the two sectors under ESR, shows the same picture for the EU ETS but leaves the share of emissions covered by ESR untouched.

For Option 1c, which extends the EU ETS to cover commercial buildings and freight transport, the EU ETS-covered share of emissions increases to 53% and the share of ESR reduces to 47%. In options 2a and 2b, which extend the EU ETS to road transport (2a) or the buildings sector (2b), the EU ETS share increases to 62% respectively 54% and the ESR share decreases to 38% respectively 46%. Within the Member States, the shares vary considerably: for example, in Lithuania only about 15% of emissions are covered by the EU ETS in the status quo (Option 0), whereas in Estonia it is about 70% of emissions. The main reason for these differences is the emission intensity of electricity generation in the individual Member States. Also, the share of emissions from the building and transport sectors in the emissions of the ESR varies between Member States.

For Option 1a, against the background that in this option a significant part of the ESR emissions will be transferred to the EU ETS, the share of remaining ESR emissions are an important criterion. Because lower emissions in the ESR also mean that there is less flexibility for reduction measures. Especially in the remaining sectors of agriculture, waste, fugitive emissions and the non-ETS industry, emission reduction options currently seem to be available only to a limited extent or only at very high costs. These circumstances could make it necessary to renegotiate the reduction targets of the ESR if Option 1a is chosen.

Option 1b, which would extend the EU ETS to the buildings and transport sectors, but keep both sectors in the ESR at the same time, raises other issues that need to be addressed. This option raises in particular the question of how Member States can achieve compliance with the ESR. If the price signal of the EU ETS does not have enough impact on the emissions of the two sectors, it is likely that without additional measures the ESR targets will be missed, even though in the existing EU ETS sectors, more than without the integration of the two sectors has been mitigated.

It is therefore of central importance to understand the drivers of emission reduction in an ETS. On the one hand, there are the abatement costs, which mean that abatement under an ETS is always made where it is most cost-effective. Furthermore, the past has shown that larger companies with experience in exchange trading and with higher emissions are more likely to participate actively in emissions trading and are therefore more likely to invest in mitigation measures. However, such larger companies are mainly located further upstream in the supply chain and therefore can sometimes only influence or pass through prices but not directly influence emissions in such an approach.

A general problem raised by the possible changes in design options is the measurement of ETS and ESR emissions. To reduce complexity and ensure equal and fair conditions for all regulated entities under the EU ETS, current regulation on the monitoring and reporting of greenhouse gas emissions under the EU ETS could be applied also in case of the upstream regulated sectors. To be as far as possible compatible with the reporting under the UNFCCC annual inventories (national annual inventories (NIR) and related common reporting format (CRF) tables) and the ESR reporting, the approach chosen should also be as close as possible to those calculation methods. This is particularly relevant as emissions under the ESR are determined based on the difference between NIR emissions and EU ETS emissions (and minor corrections for NF3 emissions).

The analysis of the impact of including the road transport sector in the EU ETS (extension), or in a separated ETS, on the current EU legal framework for greenhouse gas emissions from the sector has focused on Vehicle CO_2 performance standards (Light-duty vehicles: Regulation (EU) No 333/2014; Regulation (EU) No 253/201; Regulation (EU) 2019/631), the Eurovignette Directive 1999/62/EC and its proposal for amendment, the Regulation (EU) 2019/1242 on Heavy-duty vehicles, the Renewable Energy Directive 2018/2001/EU and the Energy Tax Directive 2003/96/EC, as amended.

The analysis carried out on the interrelation of the existing regulatory framework applied to the road sector and the ETS integrating the road transport sector or in a separated ETS, evidences that the freight sector appears ill adapted to respond optimally to market mechanisms such as the ETS. Presumably, a separate ETS for transport as envisaged under Option 3a or 3b might be able to sustain the higher prices required to provide the necessary price signal. However, the “energy paradox” according to which consumers tend to significantly discount the value of future fuel savings in relation to the upfront cost of a vehicle, could still undermine the cost effectiveness of the ETS at achieving emissions reductions. This limitation also applies to the interactions of the Energy Taxation Directive and the ETS as they both provide a price incentive to consumers to reduce the CO_2.

Thus, as a general comment for all design Options, integration of the road transport in an extended EU ETS or a separated one would have to be carried out without weakening the existing standards, as these are more effective at lowering emissions in the transport sector than is possible for the ETS.

However, ETS coverage could be complementary to the CO_2 standards to the extent that it addresses potential rebound effects, whereby customers drive more as their vehicles become more efficient due to lower usage costs[2]. Indeed, an upstream or downstream ETS inclusion would increase the price of every additional kilometre driven. This aspect might however also be addressed by the revision of the Eurovignette Directive.

The analysis of the impact of including the building sector in the EU ETS or in a separated ETS, on the current EU legal framework for greenhouse gas emissions from the sector has focused on the Energy Performance of Buildings Directive 2010/31/EU (EPBD), as amended; the Energy Efficiency Directive 2012/27/EU, as amended); The Renewable Energy Directive 2018/2001/EU recast; the Ecodesign Directive 2009/125/EC, as amended and its implementing measures relevant to space and water heating and cooling; the Energy Taxation Directive (Directive 2003/96/EC).

[2] ICCT, *op. cit,* p. 5; CE Delft, *Analysis of the options to include transport and the built environment in the EU ETS* (2014), p. 60

Inclusion of the building sector within the ETS is broadly compatible with the objectives of the pieces of relevant EU legislation for emissions from the building sector analysed; however, the extent of this interaction is linked to the price signals sent by the EU-ETS. Any higher price signal for heating or cooling of buildings that results from the ETS will support the objectives of the analysed Directives. Similarly, these Directives will help to overcome market failures that impede emissions abatement that cannot be overcome by a price signal alone.

While the EPBD has triggered the tightening of building standards in EU Member States and the certification of commercial buildings, and inspections of boilers and air conditioning systems, the Directive's implementation has not delivered the full potential improvement of energy performance in the buildings sector. The inclusion of the buildings sector in the EU ETS supporting similar objectives could improve the situation. Should the building sector be included in the current EU ETS or a separate ETS, the EPBD may help to offset some of the negative social impacts of any increases in building heating/cooling costs on vulnerable groups (tenants of residential buildings), as the EPBD will have resulted in improved energy efficiency in some buildings and therefore in reduced emissions. Similarly, the ETS may incentivise investments for further achievement of the objective of the EPBD as increased energy costs will increase the costs effectiveness of building energy efficiency measures. The integration of the buildings sector in the ETS or in a separated system with an increased carbon price could be a complementary measure triggering the adoption of appropriate actions for retrofitting existing buildings which could not be achieved through the energy efficiency obligation schemes (EEOS).

The Energy Efficiency Directive 2012/27/EU (EED) requires in its Article 3 Member States to set binding national energy efficiency targets within the 32.5% overall target for 2030 and to establish policy measures and tools to achieve their targets such as national efficiency obligation schemes (EEOS) or alternative measures. The compatibility of the EED with an EU ETS extended to the building sector or integrating a separate ETS seems clear, as both Directives aim at similar objectives and they both currently cover the building sector with respect to electricity. There are potentially overlaps between a carbon price mechanism, such as an ETS and energy efficiency obligation schemes. EEOS requires obligated parties, generally energy utilities, to meet energy saving targets by delivering or procuring energy savings at the customer end of the energy system. Member States may decide to link EEOS to obligations placed on energy retailers or on energy distributors, or both[3]. Energy savings planned under the EEOS have to be additional to those which are expected from existing EU efficiency policies. According to recent studies, in practice, this means that most savings are likely to come from efficiency improvements to buildings (beyond those mandated in the Energy Performance of Buildings Directive).

The objectives of the Renewables Energy Directive are coherent with those of the ETS. If the building sector is brought within the scope of the ETS (both through EU ETS extension or a separated ETS) the price signal of the ETS may contribute to the objectives of the RED by increasing the cost effectiveness of renewable energy sources compared to fossil fuel energy sources. The emissions reductions achieved through the RED would potentially affect the scarcity of allowances and the price signal under the ETS. This would need to be factored during the design and cap-setting phases. Similarly, inclusion of the building sector in the ETS would possibly support the goals of the Ecodesign Directive which in turn could also partially assist in limiting the potential negative social impacts of including space heating and cooling in the ETS by providing final residential consumers with products that could aid in reducing the costs

[3] Ibid supra

of heating and cooling. Similarly, the objectives of the Energy Taxation Directive (ETD) are in line of those of the ETS and their coexistence could reinforce their effectiveness.

The study has also examined what impact an ETS extension to buildings and transport is expected to have on average household expenditure patterns across income deciles, in terms of their transport and heating costs. The analysis covered a representative sample of EU Member States at country-level and was based on the best and latest available household expenditure datasets. The analysis built on detailed consumer expenditure data for EU-27 by three income deciles provided for the analysis by the European Commission.

In assessing the viability of the policy design options for the ETS extension, two key social criteria were investigated:

- The impact on household spending on heating and transport and
- Distribution of final consumption expenditure across consumption categories.

In our analysis we assumed that – irrespective of the final design option – including the road and/or buildings sector in the ETS is likely to act like a small carbon tax on transport / heating fuels used, and as such, through an increased carbon price, will raise the fuel price for end consumers (including public transport).

As a starting point in the analysis of social dimensions of a potential ETS extension, it was investigated how final household expenditure is distributed in the EU-27 member states across the main relevant consumption categories. As expected, household energy costs (Electricity, gas and other fuels) and household transport fuel costs, that are expected to further increase as a result of a price change of fossil fuels, already give a significant share (~10-15%) of total final expenditure of poor households – even in rich countries, such as Denmark or Ireland.

The change in the distribution of disposable income across consumption categories as a result of an increase in natural gas price was then derived based on:

- Data on absolute consumer expenditure on transport and heating fuels
- The share of spending on transport and heating fuels within that total expenditure, per three income groups: Poor households (Decile 1), Lower-middle class households (Decile 3) and Middle-class households (Decile 5)
- A hypothetical increase in transport fuel price and household fuel price separately, both induced by an increase in natural gas price.

Using these data to investigate the impact of change in fuel prices, the following observations has been made. Poorest households (Decile 1) are expected to be impacted relatively the most negatively in case of household fossil fuel energy, mainly as a result of their initial large share of energy- / transport-related expenditure within total expenditure and the relatively low price elasticity of household fossil fuel energy demand.

Results are a bit more mixed for household transport fuel expenditure. It is important to highlight that the initial share of transport fuel costs within total final consumption expenditure, in contrast to the case of household fossil fuel energy costs, tend to be the highest for Decile 5 out of the three investigated income groups, and clearly lowest for Decile 1. Largely explained by this initial observation, an increase in transport fuel costs will have the relatively largest impact for Decile 5, while the relative increase in transport fuel expenditure (at the expense of other types of expenditure) is also notable for most countries' Decile 3 groups.

Possible inclusion of all fossil fuel emissions into an emissions trading system

A more radical extension of the current ETS would see it extended to cover all GHG emissions from the use of fossil fuels. This option would have the advantage that it would cover most man-made greenhouse gas emissions. Only the non-energy GHG emissions, e.g. from agriculture and waste in some cases also the process emissions from e.g. clinker production or from the chemical industry would not be covered by such an approach. At the same time, such an approach also affects very small businesses, for which additional costs may cause a disproportionate burden. According to the most recent GHG inventories of the EU, the most important additional (sub-) sectors are small emitters from the industry sector, not covered by the current ETS, as well as fugitive emissions from fossil fuel extraction, navigation and fossil fuel use in the agricultural and forestry sector (all with annual greenhouse gas emissions higher than 20 Mt).

In the non-ETS industry, natural gas is the most important fossil fuel, accounting for about two-thirds of all fossil fuels. This also means that greenhouse gas emissions from natural gas account for the largest share of non-ETS industry emissions. These amount to 49 Mt CO_2e, while petroleum products account for about 16 Mt CO_2e and coal-based fuels for about 15 Mt CO_2e. In the agricultural and forestry sector, by contrast, mineral oil is the most important fuel. Agricultural use of mineral oil accounts for 78% of fuel use and for about 55 Mt CO_2e, as it is used in most of the agricultural machinery. Fugitive CO_2 and methane emissions, which result in particular from the extraction of coal, mineral oil and gas as well as from the transport of gas and mineral oil, add up to about 80 Mt. CO_2e, of which about 44% is from coal and 56% from gas and oil.

While of rather minor importance in terms of the level of GHG emissions, mitigation options in the three sectors are limited and often costly. In the agricultural and forestry sector, for example, more efficient machines, electrical machines or biofuels are available, but these have not yet achieved any significant market penetration due to the high investment costs, long investment cycles and the limited usability of electrical machines. In the case of fugitive emissions, too, only partial reduction measures have been implemented to date due to costs and a difficult incentive situation (the owner of the gas is often not the transporter). In the non-ETS industry, most emissions are caused by heat generation. There are, for example, a number of electrical alternatives for this industry, yet the high price of electric heat in comparison to gas is the greatest barrier for companies.

Different design options were analysed, similar as described above for road transport and buildings, with a full extension of the EU ETS, to include all fossil fuel use with and without ESR for the sectors newly covered by the ETS, an option with a separate fuel ETS alongside the existing ETS and in addition a pure upstream option replacing the existing ETS. Under the pure upstream option, it would need to be ensured that process emissions from industry continue to be regulated, for which the existing EU ETS could continue to exist, whereas the upstream ETS would regulate fossil fuel use. Since the fuel supply chain is not very different from the supply chain for the options analyzed in the previous tasks, the recommended point of regulation for the options analyzed in this task are again tax warehouses in case of mineral oil and final suppliers in case of coal and gas. For a pure upstream ETS, on the other hand, refineries for petroleum products and extractors, producers and importers of gas and coal are suitable as point of regulation, since in this case the end customers need not be known to the regulated entities. The cap analysis for the design options described above shows similar trends to those for the design options in the previous sections but differs slightly in the numerical values. Remaining emissions under the ESR are very low in certain options. The options are assessed on the basis of the criteria developed for the buildings and road transport analysis.

One of the most noticeable impacts could be on the functioning and the role of the Effort Sharing Regulation: if the current structure is maintained, wherein the ESR regulates those emissions not covered under the EU ETS, the ESR would be relegated to a niche instrument in the case of an EU ETS covering all fossil fuels. By contrast, there is also the option of overlapping spheres of regulation between the ESR and the EU ETS, in which both would assume somewhat different political and economic functions.

An assessment of how the extension of the ETS to cover all fossil fuel emissions would affect several main pieces of related EU regulation, notably the vehicle CO_2 performance standards, the Eurovignette Directive, the Renewable Energy Directive, the Energy Taxation Directive, the Industrial Emissions Directive, and the Common Agricultural Policy, indicated that the findings regarding regulatory overlap are similar for the extension to all fossil fuels, as compared to the analysis for an ETS extended to road transport and buildings. However, an ETS extended to all fossil fuels would raise some additional challenges and questions: for instance, the existing system of partial exemptions for agricultural fuels specified in the energy taxation Directive could be questioned in a system extending to all fossil fuels; and the rules that specify exemptions from the coverage of the Industrial Emissions Directive would need to be revisited.

1 Introduction

This report provides an assessment of the *Possible extension of the EU Emissions Trading System (ETS) to cover emissions from the use of fossil fuels in particular in the road transport and the buildings sector*. The project was launched by DG CLIMA on 12 February 2020 and was undertaken by ICF in association with CITEPA, Ecologic, eclareon, Enerdata, Fraunhofer ISI, and Milieu.

1.1 Study objectives

The purpose of this study was to:

- Explore options for possible inclusion into an emissions trading system of the road transport and/or buildings sectors.
- Assess with qualitative and for selected questions also quantitative tools the relevance and the impacts of the identified options, in particular in terms of effectiveness (emissions reduction achieved in both sectors), of regulatory robustness (monitoring, reporting and verification), as well as distributional effects on households and SMEs and potential quantitative impacts on EU ETS and ESR.
- Explore the option for possible inclusion into an EU emissions trading system of all CO_2 emissions from fossil fuels.

The results of the study serve as an input for the Commission's assessment of the various options for a possible inclusion of the road transport and/or buildings sectors into an emissions trading system.

1.2 Structure of the Report

The contents and structure of this report are as follows:

- **Section 2** presents the general policy context with a review of current coverage of road transport and buildings in the EU ETS, existing road transport and buildings policy instruments and those under development in Member States that set an explicit or implicit carbon price, and a review of other emissions trading systems outside the European Economic Area (EEA) that include these sectors.
- **Section 3** presents the data analysis underpinning the study, including the energy use, emissions, abatement potentials and supply chain for the different fossil fuels used in the road transport and buildings sectors. The analysis also evaluates the price elasticity of fuel demand in the two sectors, and how a uniform carbon price surcharge across the EU would impact fuel prices in the short and long-term in Member States.
- **Section 4** details an analysis of the general architecture for the possible inclusion of the road transport and buildings sectors into the EU ETS, including design options for scope, emissions cap, different regulated entities, and monitoring, reporting and verification (MRV) of emissions. The analysis also assesses the risk of leakage, slippage, or double counting of emissions from the buildings sector.
- **Section 5** presents an assessment of the impact of the design options, defined in Section 4, on the current EU ETS, Effort Sharing Regulation (ESR), and existing regulatory framework, including existing taxation and excise schemes. Furthermore, an assessment is provided of the impact of each design option on the need for a just transition, as well as possible re-distributional mechanisms to address the impacts.

- **Section 6** analyses the option of including all solid, liquid, and gaseous fossil fuel-related CO_2 emissions into the EU ETS, including potential design options, and impacts on the existing regulatory framework (e.g., ESR, energy policies).

2 TASK 1: Policy Context

At present, the EU ETS covers CO_2 emissions[4] from road transport and buildings[5] only as indirect emissions, i.e. if emissions arise for the production of energy carriers such as electricity, hydrogen or steam consumed in road transport or buildings. CO_2 emissions from combustion of transport fuels, thereof mainly petrol and diesel, as well as from combustion of fossil fuels in buildings, mainly natural gas, are not part of the EU ETS.

2.1 Question 1.1: Relevant energy carriers in road transport and buildings

The consumption of energy carriers in road transport and buildings varies across Member States due to different market penetration rates of relevant technologies including electric vehicles as well as district heating, heat pumps and electric cooling. Energy balances (Eurostat, 2020a) help identify the energy carriers consumed at present. For 2030, two main sources can help to identify relevant energy carriers: first, the modelling for the EU 2030 energy targets - a share of at least 32 % renewable energy and an improvement in energy efficiency of at least 32.5 % (hereafter: EUCO3232.5); and second, the 2030 data in the in-depth analysis for the EU long-term strategy for a climate neutral economy (COM, 2018) (see Table 1).

Table 1. Identification of possible relevant energy carriers by 2030 and coverage of CO_2 emissions from their generation in the EU ETS

Energy carrier	Sector	Relevance at present	Relevance up to 2030	Covered by the EU ETS?
Electricity	Buildings	Key energy carrier for space cooling; limited use for space heating and water heating	Electric heating and cooling gain in importance (e.g. increasing use of heat pumps and electric air conditioning).	Yes
	Road transport	Limited use (< 1 % of transport energy consumption)	Large introduction of electric vehicles (share of electricity in road transport increases to 2.4 %)	
E-fuels and e-gas	Buildings	No consumption of e-gas or e-fuels	No consumption of e-gas or e-fuels	Yes
	Road transport	No consumption of e-fuels	No consumption of e-gas or e-fuels	
Derived heat	Buildings	Important fuel in some Member States but less relevant in the EU when	Reduction of derived heat consumption of around a third	Partly

[4] Here, we only consider CO_2 emissions.

[5] Here, the energy consumption of buildings is defined as the energy consumption for space heating and cooling, for water heating and cooking. It does not include the energy consumption for electric appliances and lighting.

Energy carrier	**Sector**	**Relevance at present**	**Relevance up to 2030**	**Covered by the EU ETS?**
		compared to gas or oil products		
	Road transport	*Not applicable*	/	/
Hydrogen	Buildings	No consumption of hydrogen in buildings	No consumption of hydrogen in buildings	Yes, from POX, steam reforming, and electrolysis
	Road transport	Very limited (less than 400 hydrogen-fuelled passenger cars and busses). Hydrogen consumption is not specified as separate entry in the energy balances.[6]	Gaining some importance as energy carrier for road-transport (especially for long-haul heavy goods vehicles and coaches)	

Source: own presentation based on Eurostat (2020a,b), EUCO3232.5 modelling, and COM (2018). E-fuel consumption is also reflected in Concawe (2019).

This qualitative assessment shows that only a small share of the overall energy consumption and related GHG emissions from road transport and buildings is currently covered by the EU ETS. For reaching the 2030 climate and energy targets one option is switching from solid fossil fuels and oil and petroleum products, which are directly consumed in road transport and buildings, to electricity. The resulting CO_2 emissions from additional electricity consumption are covered by the EU ETS.

2.1.1 Current ETS and non-ETS emissions from road transport and buildings

This section outlines CO_2 emissions covered by the ETS attributable to road transport and buildings in comparison to CO_2 emissions arising outside of the ETS. Data presented covers the time period 2013 to 2017, i.e. from the beginning of the third trading period to the last data point for available GHG emission inventories.

2.1.1.1 Road transport

CO_2 emissions attributable to road transport mainly come from internal combustion in petrol and diesel engines (Eurostat 2020a) (see also section 3.3.2), yet these are not covered by the EU ETS. In terms of CO_2 emissions attributable to road transport covered by the EU ETS, only the use of electricity has some relevance, while the other identified energy carriers (e.g. hydrogen) can be neglected (see Table 1).

CO_2 emissions not covered by the EU ETS amounted to 773 Mt CO_2 in 2017, which is an increase of 6.7 % when compared to 2013 (EEA, 2019, emission source 1.A.3.b). The rise is in line with the overall increase of energy consumption of road transport of 7 % over the same period of time. In particular, the consumption of diesel increased by 687 PJ, thus, also increasing its share in total energy consumption from 66 % to

[6] Hydrogen consumption is very limited and is currently not available from the energy balances as a single entry but it is included in “other hydrocarbons” if it is not part of another gas (see UN Stats, 2017).

68 % from 2013 to 2017. In contrast, petrol saw a reduction of roughly 22 PJ making up 26 % of total energy consumption in 2017 (Eurostat 2020a).

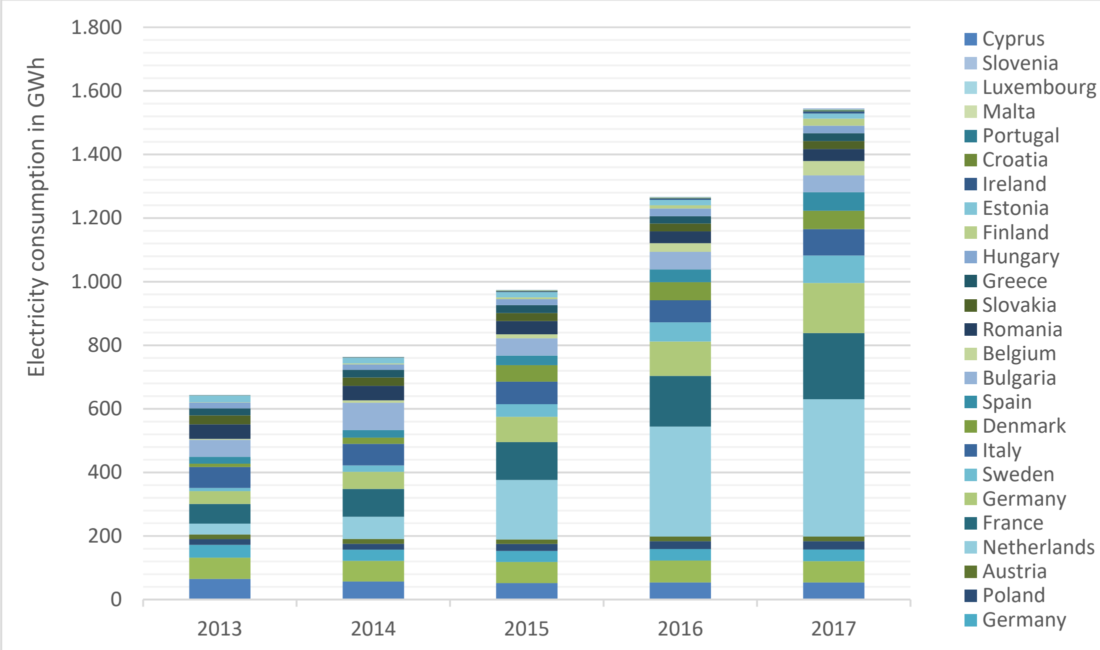
The largest emitters were Germany (160 Mt CO_2) and France (126 Mt CO_2), which also have the largest vehicle stocks in the EU. Both countries saw rising CO_2 emissions (6 % and 2 % increase from 2013 levels, respectively). Malta (0.6 Mt CO_2), Cyprus (2.1 Mt CO_2) and Estonia (2.3 Mt CO_2) registered the lowest direct CO_2 emissions. In these countries, emissions increased by 18 %, 12 % and 10 %. The largest increase was observed in Lithuania, where CO_2 emissions from road transport rose by 34 % over the four-year period. Only five countries realised emission reductions: Luxembourg (-13 %), Sweden (-9 %), Finland and Italy (both -4 %) and the Netherlands (-3 %) (see also Figure 5).

Since transport fuels are not covered under the EU ETS, **CO_2 emissions from transport will only be covered by the EU ETS as indirect emissions**, i.e. where they relate to the generation of electricity used in road transport. In 2017, these only accounted for a very low share of total transport CO_2 emissions, as electricity only contributed a mere 0.05 % of the overall energy consumption in road transport. However, this is a 140 % increase from reported electricity consumption of road transport of 643 GWh in 2013 (Eurostat 2020a). At that time, most Member States registered relatively low electricity consumption, except for Czechia and Latvia with comparably higher consumption rates of 67 GWh and 65 GWh, which can be explained by trolley busses[7] used in public transport. After 2013, electricity consumption began to rise, reaching 1,544 GWh in 2017. The Netherlands became the country with the highest electricity consumption (432 GWh) in 2017, followed by France (209 GWh) and Germany (157 GWh) (see also Figure 2). The rapid increase of electricity consumption in the past years is a result of an increased use of electric vehicles (cars, busses, vans and lorries). In 2017, the electric vehicle stock amounted to roughly 290 thousand, which is an almost 4-fold increase compared to 2013. Austria, France and Luxembourg reported the largest share of EVs in 2017, which made up roughly 0.3 % of their total vehicle stock. Romania, Bulgaria and Cyprus reported the lowest shares of around 0.01 % (Eurostat 2020b).[8]

[7] A trolleybus is an electric bus that gets its energy from overhead wires.

[8] Slovakia, Greece and the Netherlands did not report on their electric vehicle stock.

Figure 2. Increase in electricity consumption of road transport in the Member States



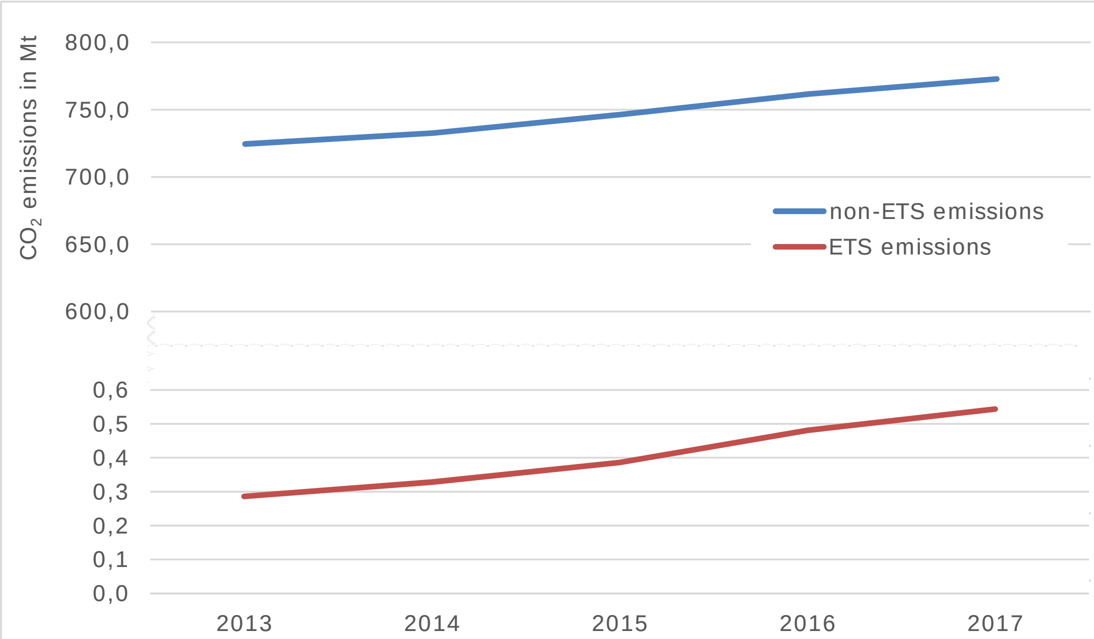
Source: own presentation based on Eurostat, 2020a. Note: own estimates for Croatia, Cyprus, Denmark, Malta and Sweden based on the EV stocks (Eurostat 2020b) and average electricity consumption of EVs in 2017 as these countries did not report on their electricity consumption in road transport.

The growth of electricity consumption in road transport resulted in a 90 % increase of related CO_2 emissions from roughly 286 kt CO_2 to 543 kt CO_2 from 2013 to 2017 in the EU. As the carbon intensity of electricity decreased over the same period of time (see also Box 1),[9] the rapid increase in electricity consumption did not lead to an equally rapid increase in emissions.

ETS and non-ETS emissions attributable to road transport amounted to 773.3 Mt in 2017 with 772.8 Mt CO_2 being non-ETS emissions and 0.5 Mt CO_2 ETS emissions. This means that non-ETS emissions made up 99.93 % of total CO_2 emissions attributable to road transport. Between 2013 and 2017, the ETS emissions attributable to road transport increased significantly faster (90 %) than the non-ETS emissions (7 %) (see Figure 3).

[9] The CO_2 emissions from the consumption of electricity are calculated by multiplying the electricity consumption of road transport with the average carbon intensity of electricity.

Figure 3. Attributable ETS and non-ETS emissions of road transport



Source: own presentation based on EEA (2019) and Eurostat (2020a,b); Note: ETS emissions are indirect CO_2 emissions from electricity consumption attributable to road transport. The interrupted line indicates a jump in the level of CO_2 emissions

Due to the limited use of electricity in road transport, attributable ETS emissions are a fraction of non-ETS emissions in all EU Member States (see Figure 5). In 2017, the difference was smallest in the Netherlands (where non-ETS emissions contributed 99.3 % of total attributable CO_2 emissions), followed by Bulgaria (99.6 %) and Czechia (99.8 %). However, between 2013 and 2017, the difference in Bulgaria grew as non-ETS emission increased while attributable ETS emissions slightly decreased. In contrast, the difference in the Netherlands was much lower in 2017 as the country reduced its non-ETS emissions while attributable ETS emissions increased. The largest difference between non-ETS and attributable ETS emissions was observed in Luxembourg, followed by Portugal and Slovenia, where non-ETS emissions were more than almost 20,000-times higher than ETS emissions. In Luxembourg, fossil fuel consumption was particularly high, which can be explained by the high number of commuters and transit traffic / fuel tourism (Eurostat 2020c).

Box 1: CO_2 emissions from the generation of electricity and heat

Emission reporting is available only for electricity and heat generation together under the emission category: "public heat and electricity generation" (EEA, 2019, emission source 1.A.1.a). To derive separate emission levels for electricity and for heat, the emissions attributable to electricity are calculated based on the CO_2-emission intensity from electricity generation from the EEA (2020) and the gross electricity generation from the energy balances (Eurostat, 2020a). Accordingly, emissions attributable to derived heat are calculated based on the difference between "public heat and electricity generation" and the derived emissions from electricity generation.

The results are reasonable for eleven countries for most of the years. However, for the rest of the countries, the related calculated CO_2 emissions from electricity generation are considered to be too high by about 11 % on average over the period from 2013-2017. This consideration is derived from the resulting heat emissions which are too low when compared to reported heat generation in the ETS. Therefore, the emissions from electricity generation are adapted to derive reasonable emissions from heat generation based on the reported heat generation under the ETS. For Malta, Cyprus and Ireland, which report to have no district heat generation, calculated emissions from electricity generation are about 1 %- 10 % higher than reported emissions; here, the reported emissions are allocated to electricity only.

The results show that CO_2 emissions from electricity generation decreased by 8 % from 907 Mt CO_2 in 2013 to 837 Mt CO_2 in 2017 in the EU. CO_2 emissions from heat generation decreased by 12 % from 98 Mt CO_2 to 87 Mt CO_2. In the Member States, the largest decrease in electricity and heat emissions took place in Luxembourg, Lithuania and Denmark. The largest absolute contribution to emission reductions from electricity generation came from Germany while it was Denmark for heat generation. However, in eight Member States emissions from electricity generation increased (AT, BG, CY, HU, IE, NL, PT, ES) while emissions from heat generation increased in five countries (IT, NL, PL, PT, ES).

For the average *carbon intensity of electricity consumption*, emissions from electricity generation are divided by the final available electricity. In the EU, the carbon intensity decreased from 2013 to 2017 by 9 % from 367 to 333 g CO_2/kWh. In 2017, Luxembourg registered the lowest emissions in the EU (23 g CO_2/kWh) and Estonia the highest (1,647 g CO_2/kWh). Lithuania realised the largest progress, reducing the intensity by 74 %, followed by Luxembourg (- 72 %) and Malta (- 64 %). In total, 22 Member States achieved to reduce their carbon intensity; however, three countries faced an increase, which were Portugal (+40 %), Spain (+12 %) and the Netherlands (+7 %) while the carbon intensity remained almost stable in Cyprus (+0.2 %) and France (-0.1 %).

2.1.1.2 Buildings

At present, CO_2 emissions that can be attributed to space heating and cooling, water heating and cooking in buildings mainly come from the combustion of natural gas, petroleum products and solid fuels (see section 3.1.1). Since the combustion installations fall below the threshold of 20 MW, they are not covered by the EU ETS. ETS emissions are those from the generation of electricity and also partly from derived heat while other energy carrier (e.g. hydrogen) do not play a role (see Table 1).

CO_2 emissions not covered by the EU ETS arise from combustion of fossil fuels in residential and commercial buildings for space heating and cooling, for water heating and cooking as well as from the generation of derived heat in installations that are not part of the EU ETS.[10]

CO_2 emissions from *combustion of fossil fuels* in residential and commercial buildings sum up to 466 Mt CO_2 in 2017 (EEA, 2019, emission sources 1.A.4.b and 1.A.4.a) as basically all fossil fuel combustion in households and in the service sector is attributable to space heating and cooling, water heating and cooking (Eurostat, 2019a; EU Building Stock Observatory, 2016).[11] This is a reduction of 7 % compared to 2013.

Residential buildings made up 70 % while non-residential buildings the remaining 30 %. This share is almost stable over the period considered here. 17 of the Member States reduced their non-ETS emissions from direct fossil fuel combustion in buildings, with the exemption of Croatia, Cyprus, Estonia, Greece, Hungary, Lithuania, Luxembourg, Malta, Romania and Spain. Emissions increased particularly in Malta (+54 %) and Greece (+22 %). In addition, in almost all countries the largest share of emissions came from residential buildings. Only in Malta and Sweden, commercial buildings emitted more CO_2 from the direct combustion of fuels than residential buildings (see Figure 5).

Derived heat or district heat is heat produced in heating plants or combined heat and power (CHP) units. It is supplied to buildings via a district heating network. The total derived heat is used in buildings and made up of roughly 11 % of residential and 6 % of the non-residential buildings' total energy consumption during the period from 2013 to 2017. The consumption of derived heat in buildings is used mainly for space heating, followed by water heating. Buildings in the EU consumed roughly 1,315 PJ in 2017, with residential buildings consuming more than twice as much as commercial buildings. Consumption rates since 2000 show some variability around 1,300 PJ, as efficiency gains were offset by an increase in buildings and living space. The variability can mainly be traced back to weather conditions (see e.g. Eurostat 2019a). District heating is a particularly important source for residential[12] space and water heating in Scandinavia: In Sweden, 50% of space and 58% of water heating is supplied by derived heat, similarly in Denmark (38% and 63%) and Finland (35% and 59%). District heating play hardly any role in Belgium, Cyprus, Ireland, Luxembourg, Spain, Malta and Portugal (all below 1 %) (all numbers for 2017) (Eurostat 2019b). In absolute terms, the derived heat consumption was highest in Germany, followed by Poland and Sweden.

CO_2 emissions from district heating slightly decreased from 98 Mt CO_2 in 2013 to 87 Mt CO_2 in 2017. In terms of total emissions, the highest emissions from the generation of heat were reported in Poland (20 Mt CO_2), followed by Germany (16 Mt CO_2) and Finland (8 Mt CO_2). In Sweden, emissions are comparably low at 3 Mt CO_2 despite a rather high heat generation (all numbers for 2017) (own calculations; see also Box 1).

[10] Here, we only consider residential and commercial buildings. Industrial buildings are neglected due to missing EU and Member State specific data on the energy consumption of industry for space heating, space cooling and water heating. Data from Germany suggest that the share of space heating and water heating in industrial buildings is below of 10 % of the total energy consumption in buildings (own calculations based on Fh ISI, 2019).

[11] For non-residential buildings, disaggregated data is only available for 2013-2015 for the EU-28 from the EU Buildings Observatory database (EU Building Stock Observatory, 2016) which was used as a proxy for the disaggregation made here. According to the source, 100 % of fossil fuels are consumed for space heating and cooling, for water heating and cooking.

[12] There is no specific disaggregation available for the service sector in each of the Member States.

Steam generation facilities are currently part of the ETS if they have a total rated thermal input of more than 20 MW (ETS-Directive, Annex I). About 90 % of the actual production of derived heat for district heating was covered by the EU ETS over the period from 2014 to 2018 (DG CLIMA, 2020). The reported CO_2 emissions amount to roughly 80 % of total emissions i.e. the share of covered emissions is lower than the share of covered heat generation. Main reason is that there are a range of district heating units that report the attributable CO_2 emissions being “not applicable”. These installations import heat from other ETS installations.

For the estimations here, we already aligned overall emissions from heat generation based on the reported ETS emissions when reported ETS emissions were higher than those derived from disaggregation of emissions from public heat and electricity generation (please see Box 1). Next to this, to better reflect the covered CO_2 emissions from district heating, we did not just take the reported CO_2 emissions but considered that:

a) For countries where 100 % of heat generation is covered by the ETS, 100 % of CO_2 emissions from heat generation are also covered by the ETS; similarly, for countries where more than 90 % of heat generation is covered by the ETS, the respective share of CO_2 emissions from heat generation is also covered by the ETS if the share of covered CO_2 emissions is lower;

b) No changes were made to the rest of the countries.

Bulgaria, Croatia, Greece, Poland, Romania, Slovenia and Sweden reported that the total derived heat comes from installations covered by the EU ETS.[13] Czechia, Denmark, Finland, Germany and the Netherlands report that at least 90 % of derived heat comes from installations covered by the ETS in 2017. For these two groups, the share of covered heat generation is used to define the share of covered emissions (see bullet point a)).

For the following countries, the reported ETS emissions are used (see bullet point b)): in Austria, Belgium, France, Italy, Latvia, Lithuania, Luxembourg, Poland and Spain, the share of emissions covered by the ETS was higher than the share of derived heat covered by the ETS. Slovakia reported a lower share of emissions of not more than 5 % when compared to the heat generation covered. Estonia, and Hungary reported covered emission shares of 40 % and 32 %, respectively, with reasonable heat generation emission factors. Cyprus, Ireland and Malta do not report on any district heat generation (see also Figure 4).

Based on these assumptions, in 2017, 5 Mt CO_2 or 6 % of emissions from district heating were non-ETS emissions, while 82 Mt CO_2 or 94 % of emissions from district heating were covered by the ETS. Comparing 2014 to 2016 values, this share remained almost constant.[14]

In sum, the non-ETS emissions attributable to buildings from direct combustion of fuels (466 Mt CO_2) and from derived heat consumption not covered by the ETS (5 Mt CO_2) added up to 471 Mt CO_2 in 2017, which is 7 % below the 2013 non-ETS emissions of buildings.

[13] The reported heat generation is slightly higher for all countries when compared to heat consumption data from the energy balances. This might be a result of reporting differences under the ETS and for the energy balances as well as to a limited extent also by the difference between heat generation and heat consumption from losses occurring during transmission.

[14] Data for district heating in the ETS is available only for 2014 to 2018. 2013 values are based on the average over the period 2014 to 2017.

Box 2: Free allocation to district heating in the EU ETS

ETS installations that generate heat for district heating (i.e. space and water heating in buildings) receive a free allocation of emission allowances based on the heat benchmark of 62.3 t CO_2/TJ. The installations do not belong to the sectors which are deemed to be exposed to a significant risk of carbon leakage which means that the free allocation of emission allowances is reduced from 80 % to 30 % of the calculated total benchmark allocation. In addition, installations suppling heat to households can receive an extra allocation in accordance with Article 10 (3) of the EU ETS Directive if the preliminary annual allocation for 2013 is lower than the median annual historical emissions from the production of heat exported to private households. The applicable median annual historical emissions are reduced by 10 percentage points each year.

The resulting free allocation in the Member States amounted to 56.8 Mt CO_2 in 2014 and sank to 39.0 Mt CO_2 in 2017: while free allocation fell (-29 %), heat generation increased slightly (+9 %) over that period. The largest share of free allocation was for the heat generated, which increased from 87 % of the free allocation in 2014 to 98 % in 2017. The remainder was additional allocation to heat exported to private households; this allocation dropped to about a tenth and now represents less than 5 % of the total allocation in all Member States except Czechia (7 %), Poland (7 %), Romania (6 %) and Estonia (5 %).

Free allocation covered 84 % of the *reported* emissions of 67.8 Mt CO_2 in 2014 and fell to 55 % by 2017, as reported emissions increased by 4.4 % to 70.7 Mt CO_2. In most Member States, installations received less free allocation than the reported emissions. Exceptions included Finland, Greece, Lithuania and Sweden where the sum of free allocation exceeded reported emissions in all years considered here (2014-2017) as well as Denmark (in 2014) and Estonia (in 2014 and 2015). In 2017, Greek installations generating district heat received free allocation amounting to 244 % of their reported emissions, Sweden 213 %, Finland 208 % and Lithuania 130 %.

However, as explained above (p.28), the emissions from the generation of district heat are expected to be higher, as installations that import heat to supply a network report the heat generation, but do not report the related emissions. When applying the proxies derived above, the ETS emissions from district heating were 16 % higher in 2017. Free allocation fell from 71 % of emissions to 48 % from 2014 to 2017. Free allowances would still exceed emissions in Estonia in 2014 and 2015 (on average +0.6 %) as well as in Lithuania and in Sweden in all years considered here (+35 % and +133 % on average).

CO_2 emissions covered by the EU ETS attributable to buildings include the covered emissions from heat generation (see above) as well as from the generation of electricity used for space heating and cooling, water heating and cooking.

In 2017, private households in the EU consumed roughly 2,537 PJ of *electricity* with roughly 14 % used for space heating, roughly 1 % used for space cooling, 12 % used for water heating and 12 % used for cooking (the remaining 61 % was for lighting and electric appliances which is not considered here. In some Member States, electricity played an important role in residential space and water heating, for instance in Malta (37% of space and 77 % of water heating is generated by electricity) and Sweden (29% / 31 %). For water heating, electricity was also the main energy carrier in Bulgaria and France (59 % and 50 %). In contrast, electricity was hardly used in Romania, Poland, Italy, Latvia and Hungary for space heating (all below 1 %) and hardly used for water heating in Denmark, Luxembourg, the Netherlands, and Romania (all below 5 %). All Member States reported that electricity is the only energy source for space cooling (see Eurostat 2019a). In the service sector, commercial buildings accounted for roughly 11 % of total electricity consumption in the period from 2013 to 2015 (i.e. for space heating and cooling and water heating) (calculated based on EU Building Stock Observatory, 2016 and Eurostat, 2020a).[15] The electricity consumption of residential and commercial buildings summed up to roughly 1,282 PJ in 2017, which is slightly less than the consumption of 1,306 PJ in 2013.

In 2017, the electricity consumed for heating and cooling buildings and for cooking corresponded to 109 Mt CO_2. This is 12 % below 2013 levels, due (to a lesser extent) to lower electricity consumption and (to a greater extent) to lower carbon intensity of electricity (own calculations based on EEA (2020), see Box 1). In the Member States, emissions related to electricity consumed in buildings were highest in Germany (39 Mt CO_2), followed by a considerable difference by Poland (12 Mt CO_2) and Spain and France (both 8 Mt CO_2). This considerable difference between Germany and Poland (besides that Poland has roughly half of the population of Germany (Eurostat, 2020d)) is mainly a result of the relatively higher consumption of electricity (in Germany, electricity supplied 11 % of the energy consumption while it was 3 % in Poland).

Summing up, the ETS emissions attributable to electricity and heat consumption in buildings for space heating and cooling, water heating and cooking, amounted to 109 Mt CO_2 and 82 Mt CO_2, respectively in 2017. Accordingly, the ETS emissions attributable to buildings summed up to 191 Mt CO_2 in 2017, 12 % less than 2013.

ETS and non-ETS emissions attributable to buildings amounted to 661 Mt in 2017. Of this, just below two thirds (471 Mt CO_2) were non-ETS emissions, whereas almost one third (191 Mt CO_2) was covered by the ETS. This share is similar from 2013 to 2017 varying from 31 % to 29 % mainly due to the variation in emissions from direct fossil fuel consumption in the buildings.

The largest share of these emissions is emitted in Germany, France, Italy and Poland. Three of these – Germany, Italy and France – have much higher non-ETS emissions (Germany with a share of 70 % and Italy and France with 88 % in total emissions) (see Figure 4). In contrast, at 58 %, the share of non-ETS emissions in Poland is below the EU average.

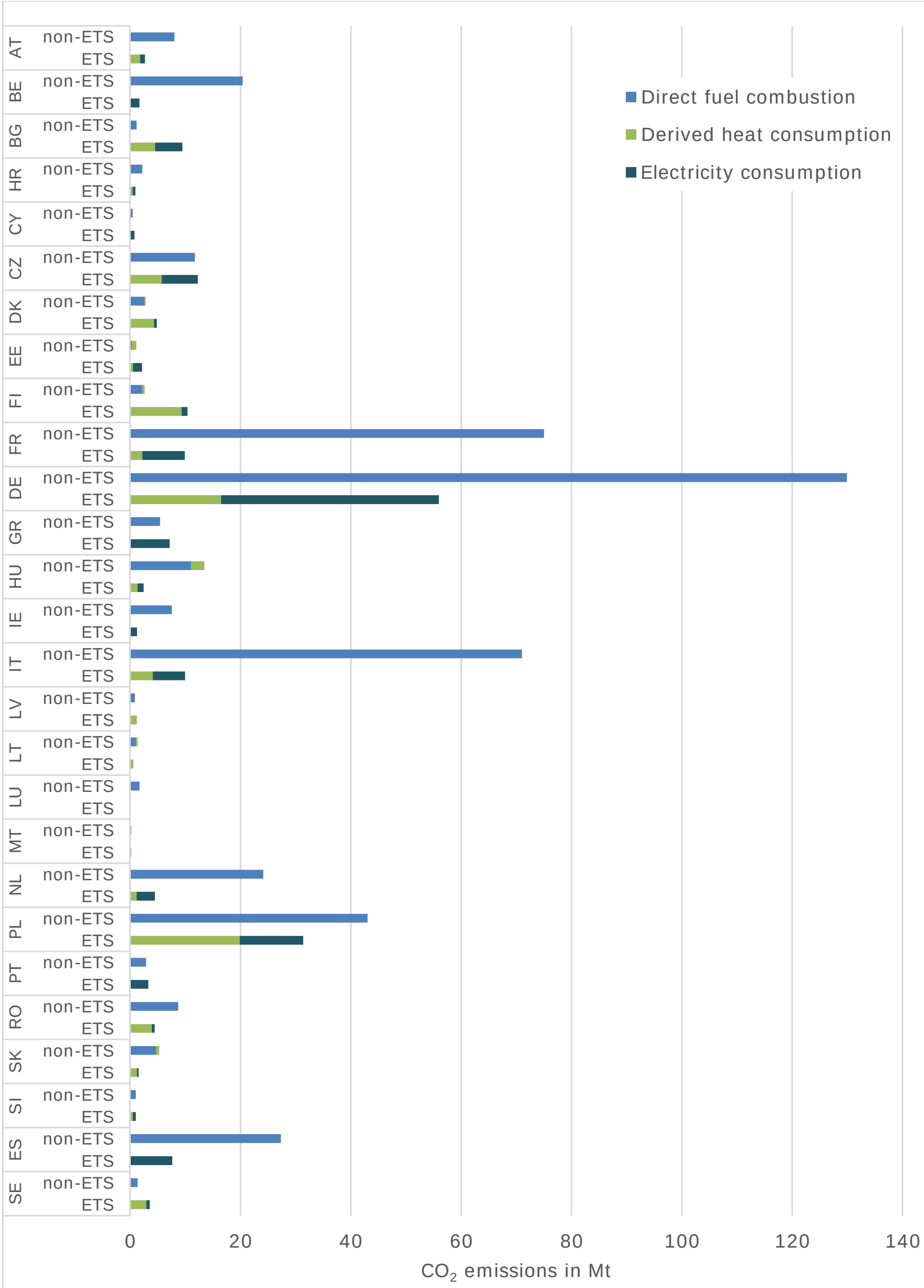
For the EU no clear pattern regarding the relative size of attributable ETS and non-ETS emissions exists: in 17 countries, non-ETS emissions exceed the attributable ETS emissions,[16] while 11 countries have larger attributable ETS than non-ETS emissions.[17] This absence of a clear pattern can mainly be explained with differences in the coverage of district heating systems, as well as diverging roles for electric heating and cooking in the Member States.

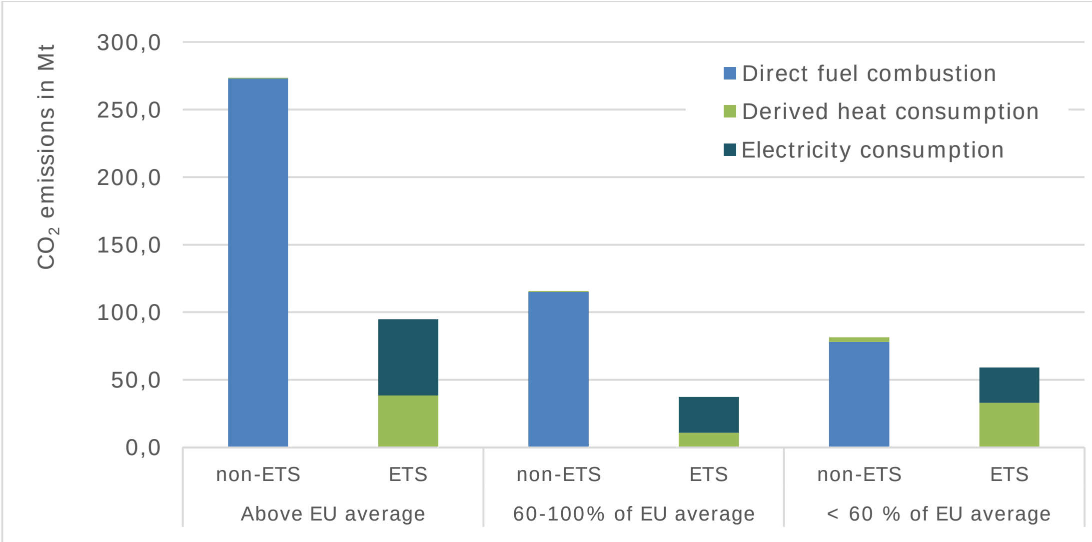
[15] The electricity consumption of residential buildings is based on the disaggregation of household consumption (Eurostat, 2019b) while a disaggregation for the service sector (EU Building Stock Observatory, 2016) available for the EU-28 for the period from 2013 to 2015 was used to calculate the electricity consumption attributable to commercial buildings over the period from 2013 to 2017.

[16] ETS emissions were higher in Bulgaria, Cyprus, Czechia, Denmark, Estonia, Finland, Greece, Latvia, Portugal, Sweden.

[17] Non-ETS emissions were higher in: Austria, Belgium, Croatia, France, Germany, Hungary, Ireland, Italy, Lithuania, Luxembourg, Malta, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain.

Figure 4. ETS and non-ETS emissions of buildings in 2017 in all Member States (above) and as group aggregates grouped by GDP per capita (below)





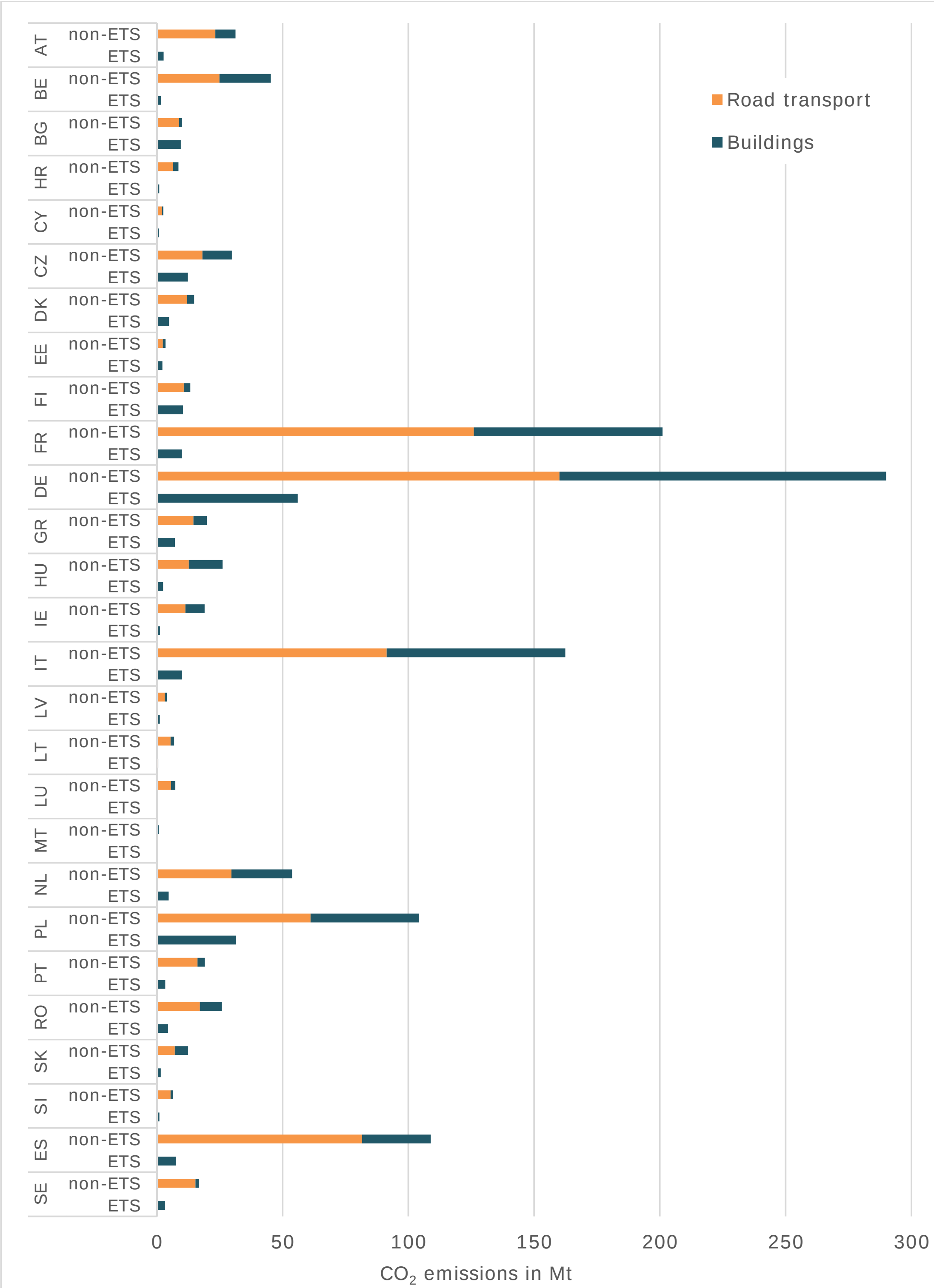
Source: own calculation based on EEA (2019), Eurostat (2019b, 2020a), EU Building Stock Observatory (2016), DG CLIMA (2020). Note: ETS emissions are indirect emissions from electricity and district heat consumption attributable to buildings

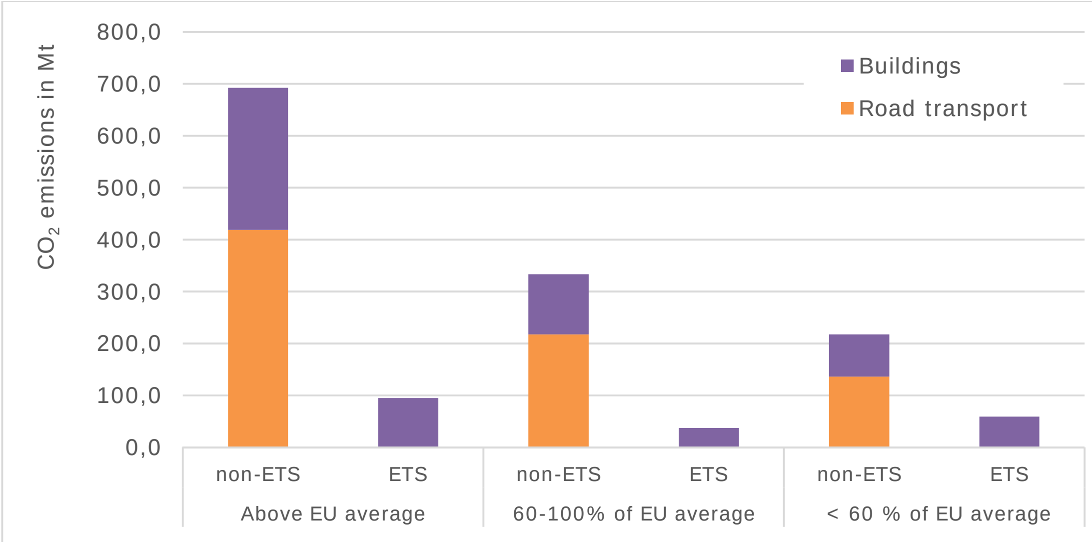
2.1.1.3 Comparison of road transport and buildings ETS and non-ETS emissions

In 2017, total CO_2 emissions attributable to road transport and buildings amounted to 1,435 Mt CO_2 with 773 Mt CO_2 coming from road transport and 662 Mt CO_2 from buildings. In the EU and all of its Member States, direct fossil fuel consumption dominates energy consumption in road transport and buildings. As a result, the bulk of CO_2 emissions from buildings and transport is outside the ETS, with non-ETS emissions exceeding attributable ETS emission by a factor of 6.5. The difference between ETS and non-ETS emissions is highest in Luxembourg, where non-ETS emissions make up 99 % of total attributable CO_2 emissions. Belgium and France follow with a non-ETS emission share larger than 95 %. Non-ETS emissions were only slightly higher than attributable ETS emissions in Bulgaria (51 % non-ETS emissions), Finland (56 %) and Estonia (61 %) (see Figure 5).

The difference between ETS and non-ETS emissions was stronger in 2017 when compared to 2013 as attributable ETS emissions fell by 11 % while the non-ETS emissions increased by 1 %. For the attributable ETS emissions, this development can be traced back to large emissions reductions realised in Germany. For the non-ETS emissions, Poland's significant increase was offset by reductions realised mainly in France, Italy and the Netherlands.

Figure 5. ETS and non-ETS emission of buildings and road transport in 2017 in all Member States (above) and as group aggregates grouped by GDP per capita (below)





Source: own compilation based on EEA (2019) and Eurostat (2019b, 2020a,b). Note: ETS emissions are indirect emissions from electricity and district heat consumption attributable to buildings and road transport

2.1.2 2030 ETS and non-ETS emissions from road transport and buildings

This section outlines estimates for CO_2 emissions covered by the ETS and attributable to road transport and buildings in comparison to attributable non-ETS emissions in 2030. The numbers given in the following section are generally based on the above derived values for energy consumption and CO_2 emissions and the *percentage change* given by the EUCO3232.5 modelling.[18]

2.1.2.1 Road transport

EU road transport emissions outside the ETS from the direct combustion of fossil fuels are expected to amount to roughly 605 Mt CO_2 in 2030, 22 % below 2017 levels (773 Mt CO_2). This reduction will be realised despite a general increase in private, public and freight transport activity by shifting to other energy carriers and increasing the energy efficiency. Except Luxembourg, which is expected to see a stabilised emission level, all Member States will reduce their emissions from 2017 to 2030 with Germany and Estonia observing the strongest emission reductions of 30 %.

ETS emissions attributable to transport across the EU are estimated to increase from 0.5 Mt CO_2 in 2017 to 10 Mt CO_2 in 2030,[19] an almost 18-fold increase. This is due to the expanded use of electric vehicles causing a massive rise in electricity

[18] A comparison of 2015 data and the 2015 EUCO3232.5 modelling estimates shows that data is inconsistent for CO_2 emissions from electricity generation and from the generation of derived heat which can be explained by the allocation of emissions from CHP installations only to electricity generation in the EUCO3232.5. In addition, large differences exists for the specific fuel consumptions in the sub-sectors: in road transport, there is little difference for the CO_2 emissions from the direct combustion of fossil fuels; however, for electricity consumption of road transport, the EUCO3232.5 modelling assumes 148 GWh while the reported consumption was twice as high. For buildings, the CO_2 emissions from direct combustion of fossil fuels are 12 % higher in the EUCO3232.5 for the EU with the largest deviation for single Member States being below 25 %. The electricity consumption of buildings is twice as high as in the EUCO3232.5 modelling when compared to the above derived consumption. The difference is lower for residential buildings (1.1-times higher) than for non-residential buildings (5.9-times higher).

[19] The electricity consumption in road transport is not based on the percentage change but directly taken from the EUCO3232.5 modelling as the very large increase and starting values of zero mean that a percentage calculation is not possible or results in meaningless values.

consumption: it is expected that electricity consumption for road transport will increase from 1.5 TWh in 2017 to 57 TWh in 2030. The assumed transformation of electricity generation – the carbon intensity of electricity consumption is assumed to decrease by 43 % to 184 g CO_2 / kWh by 2030 – will compensate this to some extent. Germany will record the highest absolute amount of ETS emissions attributable road transport (5,226 kt CO_2), contributing more than all other Member States combined. The second largest emitter will be Poland (1,329 kt CO_2), whereas the lowest share of ETS emissions attributable to transport will come from Latvia (9 kt CO_2), followed by Hungary (10 kt CO_2) and Malta (13 kt CO_2).

Accordingly, the **total CO_2 emissions attributable to road transport** are estimated to amount to 615 Mt CO_2 in 2030, roughly 20 % below 2017 levels. The share of ETS in total emissions will increase from 0.1 % to 1.6 % - i.e. non-ETS emissions will remain dominant for road transport emissions.

2.1.2.2 Buildings

Such as in 2017, **non-ETS emissions from buildings** will be composed of the CO_2 emissions from direct combustion of fossil fuels in buildings and from district heat generation in installations not covered by the EU ETS. Emissions from both sources are expected to decline markedly: the emissions from direct combustion of fuels are expected to drop by 54 % from 466 Mt to 216 Mt CO_2, those from district heating not covered by the ETS by 74 % from 5 Mt to 1 Mt CO_2.[20] The share of emissions attributable to derived heat outside the EU ETS will remain at roughly 6 %.

The total non-ETS emissions attributable to buildings are expected to fall accordingly by 54 % from 471 Mt to 217 Mt CO_2 over the period. Across all Member States, emissions are expected to fall by at least -40 % with the exception of Romania (-26 %) and Italy (-33 %). The most significant reductions are expected in Bulgaria (-80 %) followed by Malta (-78 %) and Finland and Cyprus (both -77 %). Germany and Italy will remain the key emitters, despite emission reductions of 59 % and 33 %, respectively. These two countries will contribute nearly as much as all other remaining Member States combined (46 %).

ETS emissions attributable to buildings include emissions from electricity and district heat consumption generated in installations covered by the ETS. Emissions from both sources are expected to decrease: the emissions from electricity consumption are expected to fall by 35 % from 109 Mt to 71 Mt CO_2 while the larger reduction of 70 % is expected for district heating (from 82 Mt to 19 Mt CO_2). In total, ETS emissions attributable to buildings are expected to decrease by 53 % from 191 Mt to 90 Mt CO_2.

All Member States contribute to this reduction, with 19 countries realising emission reductions of more than 70 %. Latvia, Portugal and Spain are expected to observe the most drastic reductions of at least 90 %, whereas emissions in Belgium, Malta and Luxembourg are expected to fall by less than 20 %. Despite reducing their emissions by more than a third, Germany and Poland will remain the largest emitter in this category making up roughly 60 % of the total ETS emissions attributable to buildings.

The **total CO_2 emissions attributable to buildings** are estimated to amount to 307 Mt CO_2 in 2030. Both ETS and non-ETS emissions are expected to decrease at the

[20] The distribution of emissions from district heating to ETS and non-ETS is based on the respective share of ETS and non-ETS emissions in total emissions over the period 2014-2017.

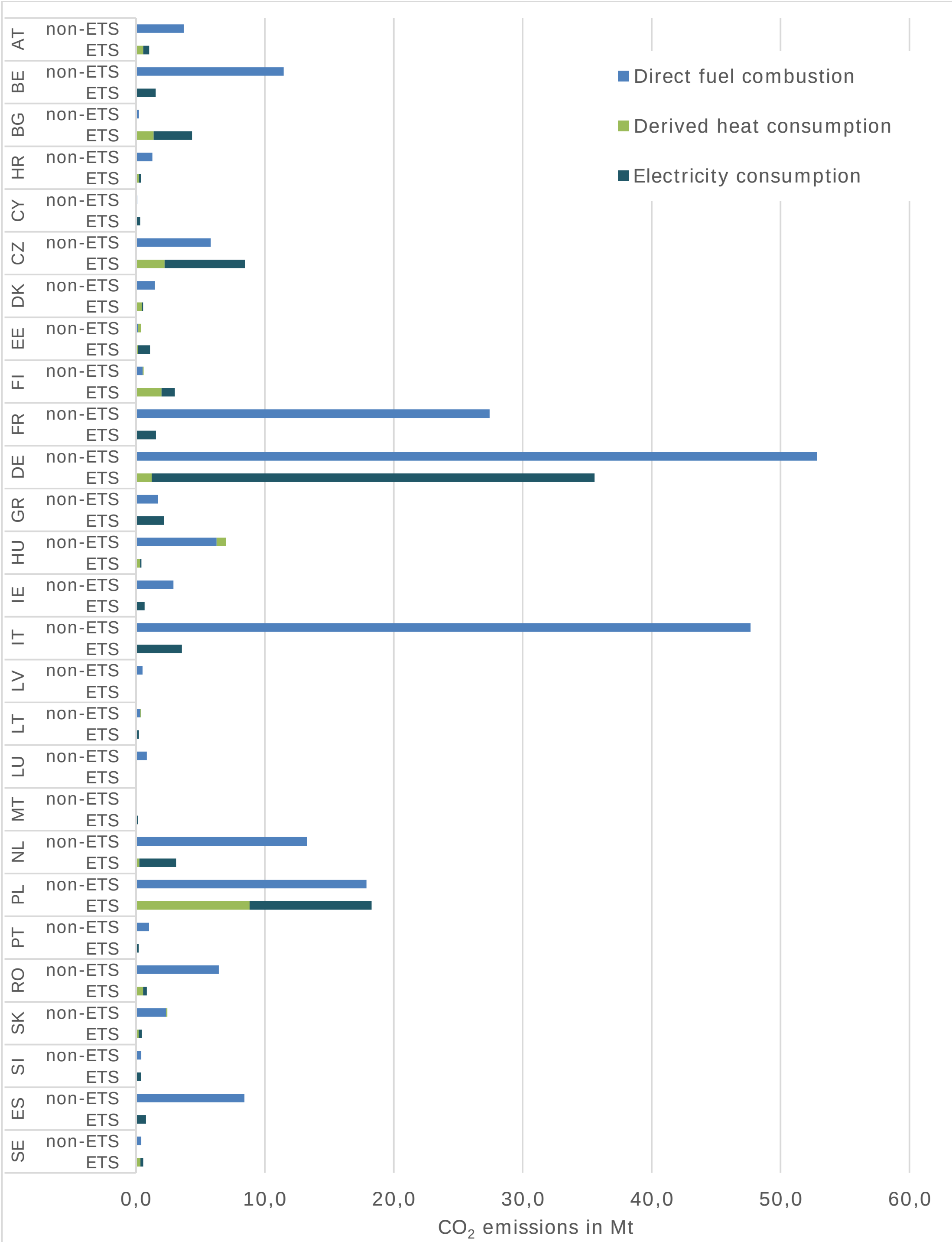
same order of magnitude (-53 % / -54 %) from 2017 levels. This also means that the share of ETS emissions in total emissions is expected to remain stable at 29 %.

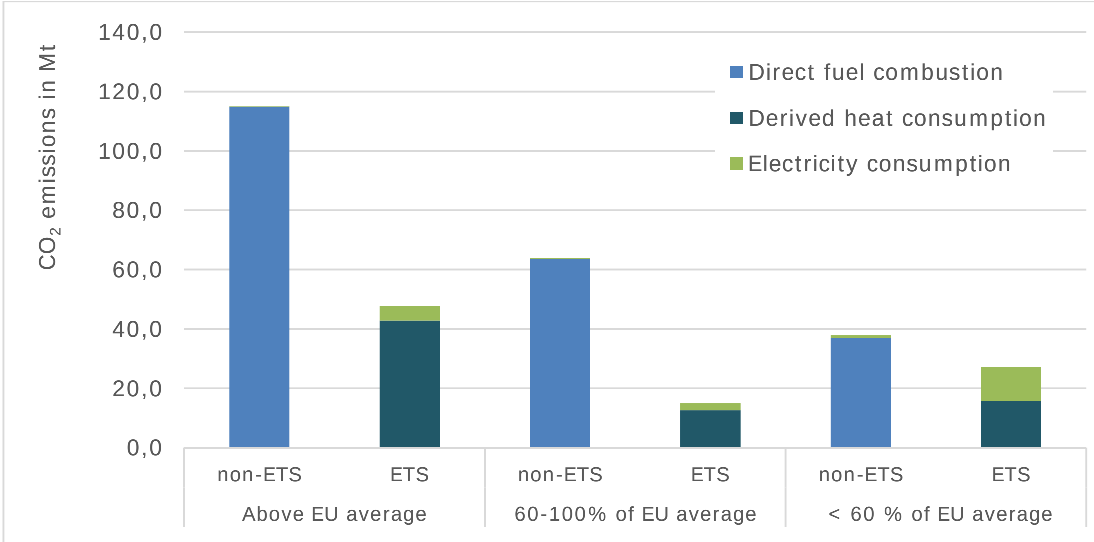
In the Member States, the relative weight of non-ETS emissions is expected to increase slightly: while in 2017, ETS emissions exceeded non-ETS emissions in 10 countries, this is expected to be the case in only 9 countries in 2030.[21] The relative weight is expected to change most significantly in Latvia where the share of ETS in total emissions will fall from 58 % to 8 %, followed by Portugal (53 % to 17 %) and Denmark (63 % to 27 %). The key reason for this is the assumed rapid decarbonisation of electricity and heat generation by 2030, whereas emissions from direct fossil fuel consumption in buildings are expected to fall at a slower rate. In contrast, ETS emissions will gain in relevance e.g. in Malta where the share is expected to increase from 47 % to 78 %. This is due to the assumed increased use of electricity for heating and cooling in buildings and a large reduction of direct fossil fuel use.

[21] ETS emissions were higher in Bulgaria, Cyprus, Czechia, Estonia, Finland, Greece, Malta, Poland and Sweden.

Non-ETS emissions were higher in: Austria, Belgium, Croatia, Denmark, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, Romania, Slovakia, Slovenia and Spain.

Figure 6. ETS and non-ETS emissions from buildings in 2030 in all Member States (above) and as group aggregates grouped by GDP per capita (below)





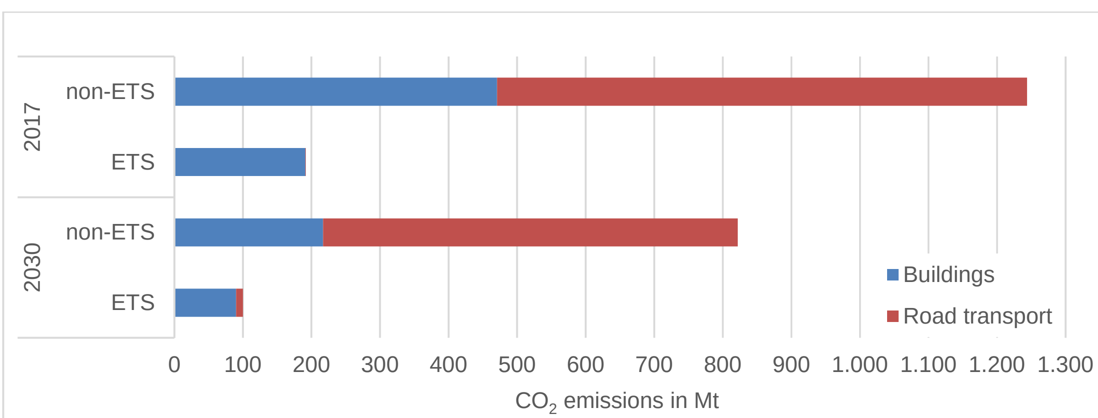
Source: own calculations based on EUCO3232.5 modelling and above derived values. Note: ETS emissions are indirect emissions from electricity and heat consumption attributable to buildings.

2.1.2.3 ETS and non-ETS emissions of road transport and buildings in 2030

In 2030, total CO_2 emissions attributable to road transport and buildings are expected to amount to 922 Mt CO_2 with almost two thirds (615 Mt CO_2) coming from road transport and the remaining third (307 Mt CO_2) from buildings.

Compared to 2017, the total CO_2 emissions will fall by 36 % or from 1,435 t CO_2 to 922 Mt CO_2. ETS emissions attributable to buildings and road transport will fall by 54 %, while non-ETS emissions from the two sectors will fall by 35 %. In 2030, emissions from buildings will be only half as high as those from road transport. While transport emissions will account for two-thirds of the non-ETS emissions, ETS emissions will predominately come from buildings.

Figure 7. Decrease of attributable ETS and non-ETS emissions from road transport and buildings in the EU from 2017 to 2030

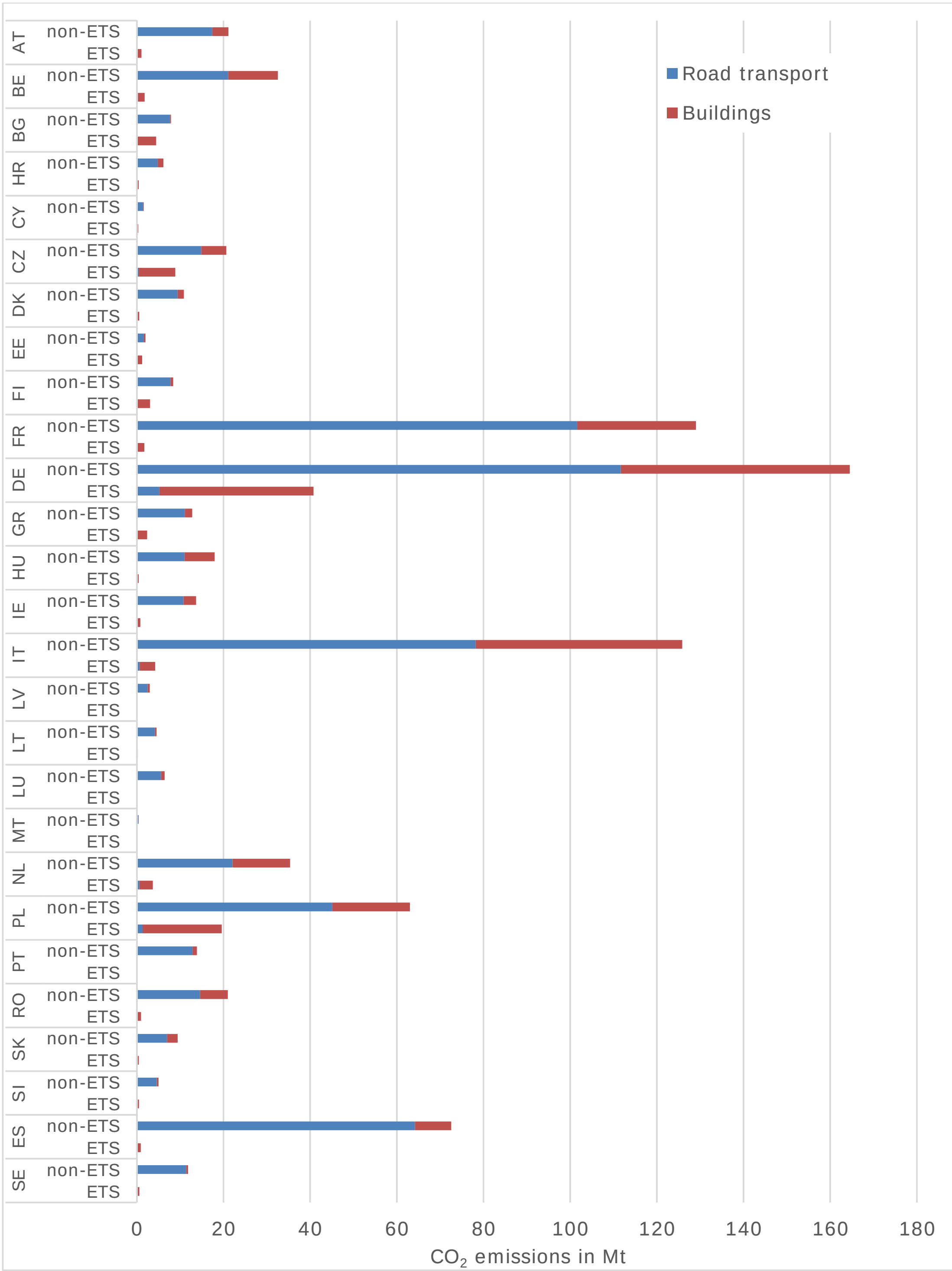


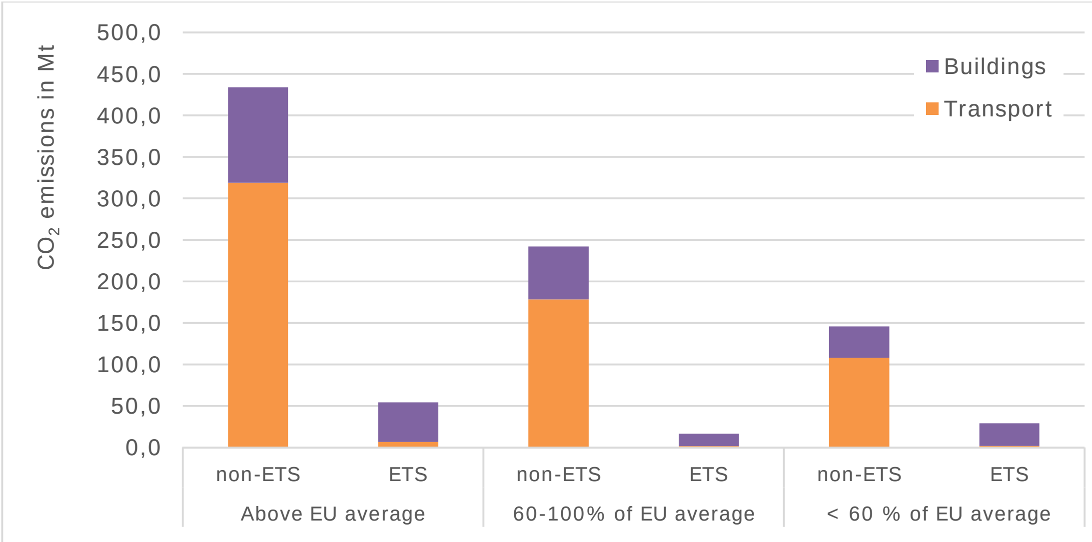
Source: own calculations based on EUCO3232.5 modelling and above derived values. Note: ETS emissions are indirect emissions from electricity and heat consumption attributable to road transport and buildings.

In 2030, in the EU and all of its Member States, non-ETS emissions will continue to dominate total emissions from the two sectors. The main reason for this is that fossil fuels are expected to remain dominant in road transport, whereas decarbonisation of electricity and heat generation is expected to proceed faster. The latter trend particularly affects emissions from buildings where the consumption of electricity and district heat play a more important role than in transport.

In the Member States (see Figure 8), the difference between ETS and non-ETS emissions is expected to be particularly high in Luxembourg followed by France, Spain, Portugal and Latvia where non-ETS emissions will make up more than 98 % of the total emissions. These countries are expected to reduce their emissions from electricity consumption below 55 g CO_2/kWh and shift to near-zero-emission district heating resulting in comparably low ETS emissions.

Figure 8. ETS and non-ETS emissions from buildings and road transport in 2030 in all Member States (above) and as group aggregates grouped by GDP per capita (below)





Source: own calculation based on EUCO3232.5 modelling and above derived values. Note: ETS emissions are indirect emissions from electricity and heat consumption attributable to road transport and buildings.

2.1.3 Conclusions

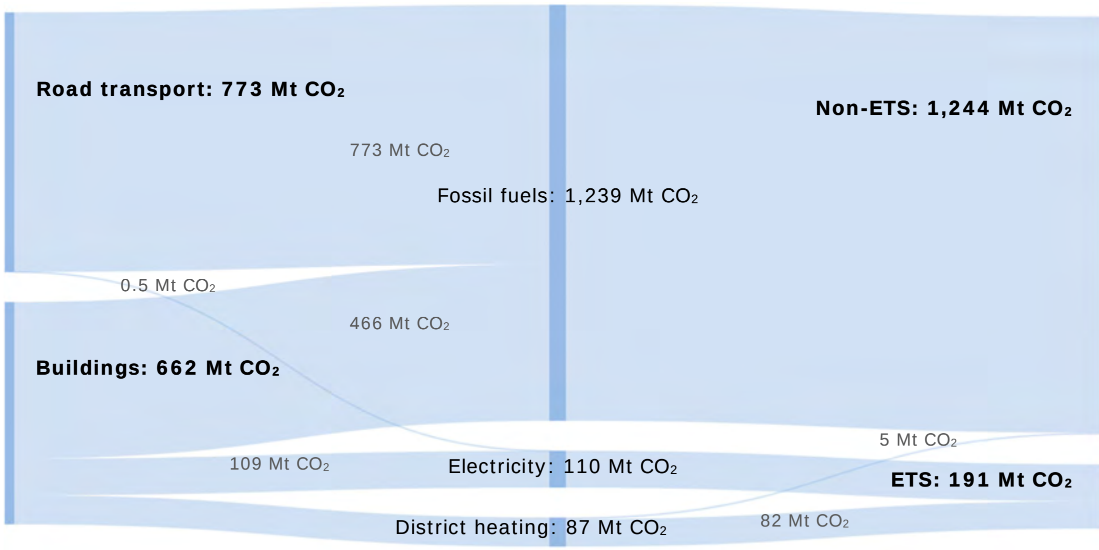
In 2017, the largest share of CO_2 emissions resulted from the combustion of fossil fuels by emitters outside the EU ETS. In the EU, fossil fuel combustion in buildings and road transport accounted for 1,239 Mt of CO_2 emissions in 2017. The emissions attributable to electricity consumption and district heating are considerably lower with 110 Mt CO_2 and 87 Mt CO_2 (see also Figure 9). Emissions from direct fossil fuel combustion dominate not only in the European average, but also in all Member States, although with nuances: in Luxembourg, Belgium, France, Italy and Ireland, emissions from fossil fuels are predominant, while in Bulgaria, Finland and Estonia, CO_2 emissions from district heating and electricity consumption in buildings and road transport are about a third of emissions from direct fossil fuel combustion in the two sectors.

The dominance of fossil fuel combustion means that non-ETS emissions made up by far the largest share of CO_2 emissions attributable to buildings and road transport (87 %). Non-ETS emissions were at 1,243 Mt CO_2 in 2017 while ETS emissions amounted to 192 Mt CO_2.

CO_2 emissions from buildings and road transport are about the same order of magnitude in the EU; however, the difference was significant in single Member States: for example, in Sweden and Luxembourg, the emissions from transport are more than 3 times higher than those of buildings. By contrast, in Estonia and Czechia, the emissions from buildings are more than 1.3 times higher than those from road transport. In total, CO_2 emissions attributable to road transport exceeded those of buildings in 20 Member States.[22]

[22] Transport emissions were higher in Austria, Belgium, Croatia, Cyprus, Denmark, France, Greece, Ireland, Italy, the Netherlands, Latvia, Lithuania, Luxembourg, Malta, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden. Emissions from buildings were higher in Bulgaria, Czechia, Estonia, Finland, Germany, Hungary, Poland.

Figure 9. Overview on attributable ETS and non-ETS emission from buildings and road transport in 2017



Source: own presentation using SankeyMatic

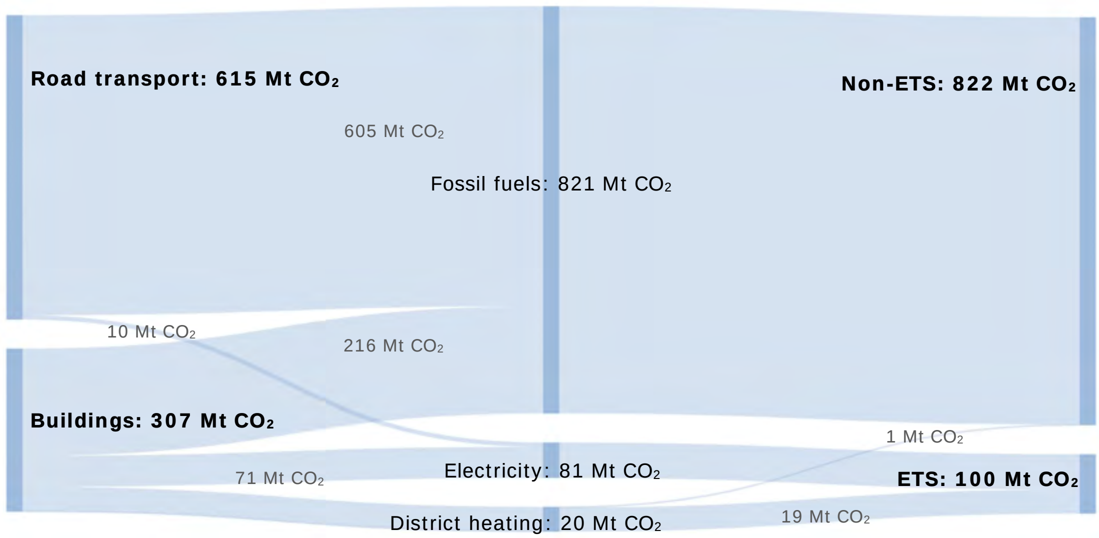
From 2017 to 2030, CO_2 emissions from building and road transport are expected to decrease both in the EU as a whole and across all of its Member States. Emission reductions are expected to be much larger in buildings (-54 %), whereas road transport emissions are expected to go down by 20 % (see Figure 7).

The overall emission reductions will be more marked for CO_2 emissions attributable to road transport and buildings that are covered by the ETS; these will fall by 48 % despite a significant increase in electricity consumption. Emissions from the sectors not covered by the ETS will fall by 35 %. As a result, the share of emissions of the two sectors covered by the ETS in total emissions is expected to decrease from 13 % to 11 %. This is mostly due to the significant reduction of emissions from electricity and heat generation and to the comparably lower emission reductions expected in the non-ETS.

Emission will be reduced by lowering overall energy consumption and by shifting from direct fossil fuel use to renewable energy carriers and electricity (predominantly from renewable sources). As a result, electricity consumption in buildings and road transport will increase in the EU and all Member States (with the exception electricity consumption in buildings in Estonia, Greece and Malta, which is expected to decrease slightly). The EU's emissions are nevertheless projected to decrease, as the specific emissions from electricity consumption are assumed to fall by 43 %. Only road transport will consume much more electricity at a rate that exceeds the expected reduction of the specific emissions from electricity consumption leading to a rise in ETS emissions between 2017 and 2030.

As a result, the combustion of fossil fuels will still represent the largest share of 2030 CO_2 emissions, amounting to 821 Mt CO_2 in 2030 or 34 % below 2017 levels. The emissions attributable to electricity consumption and district heating are considerably lower with 81 Mt CO_2 and 20 Mt CO_2 (see also Figure 10). However, emissions from electricity are expected to fall only by 26 %, following a large drop in the carbon intensity of electricity generation, but also a vastly expanded use of electricity in road transport and buildings.

Figure 10. Overview on attributable ETS and non-ETS emission from buildings and road transport in 2030



Source: own presentation using SankeyMatic

2.2 Question 1.2: National measures in the road transport and buildings sectors and their relation to the EU ETS

The different national systems and policy regimes, as well as their interactions with the EU ETS in its current form and a possible extended EU ETS, are described and analysed for the five countries presented above (France, Germany, Poland, Spain and Sweden). This covers, inter alia, the following aspects:

- **Type of system / regime:** explicit or implicit carbon price, role of the carbon price in relation to other relevant policy measures.
- **Current scope of the system / regime:** are there overlaps / interactions with the current scope of the EU ETS, how exactly is the current system / regime been delineated and are there explicit provisions to address overlaps (e.g. exemptions or compensation)? Particularly for those countries where no national carbon pricing system is in place, or where the scope of carbon pricing is limited (Poland, Spain), particular focus will be placed on overlaps and interactions between the EU ETS and other elements of national climate and energy policies, such as energy saving obligations or white certificate schemes.
- **(For carbon pricing instruments – tax / ETS) Price level / trajectory in the system and relation to the EU ETS price:** what is the current price and what is the projected future price? Have there been political statements, or are there technical references that would create an interrelation between the national carbon price and the EU ETS price?
- **(For instruments other than carbon pricing) Implicit carbon price and interactions with EU ETS:** For policy instruments that do not set an explicit carbon price, what is the implicit carbon price / effective carbon constraint, i.e. how does the ambition of the national policies compare to that of the EU ETS? How do the policies in question interact with the EU ETS?

The analysis was based on aggregated / overview studies performed by or on behalf of the OECD, EEA and the European Commission, information published by national bodies in the respective countries, and academic publications and grey literature. Where necessary, this included investigating the legislative basis of the different instruments to clarify design choices taken in the different Member States. The findings per Member State are summarised below.

2.2.1 Sweden

Sweden has been one of the pioneers for taxing carbon, with a carbon tax in place since 1991. Starting at the equivalent of 23 Euro per tonne of CO_2 in 1991, the rate for heating and transport fuels has since risen to the equivalent of 110 Euro per ton (Government Offices of Sweden, 2020) making Sweden the country with the highest explicit tax on carbon emissions (World Bank 2019, p. 15). As a result, around 90% of CO_2 emissions that are not included in the EU ETS are covered by the full level of taxation in Sweden (Swedish Climate Policy Council, 2019, p. 37). In addition, there are several other policy measures in place in the road transport and housing sectors, including a bonus-malus system for cars that rewards the purchase of fuel-efficient cars and penalises high-consuming ones, and an emission reduction obligation that obliges suppliers of gasoline and diesel to decrease emissions by continuously increasing the share of biofuels in the fuel-mix (Government Offices of Sweden, 2018, p. 16).

2.2.1.1 Description of the system / regime in place

Sweden's long-term climate target today is to transition society to net-zero greenhouse gas emissions by 2045 at the latest, and net negative emissions afterwards. (Swedish Environmental Protection Agency, 2020a)

In the past years, Sweden has introduced a range of policy instruments in order to decrease its carbon emissions and meet its climate targets. Economic instruments are a focus of Swedish climate change policy, which are supplemented with additional measures, targeting for instance the development and market introduction of technology or the elimination of barriers. Beyond explicit climate-related instruments, renewable energy- and energy efficiency policies also contribute to the reduction of greenhouse gas emissions in Sweden (Swedish Government Offices, 2018, p. 15).

The main economic instruments that influence greenhouse gas emissions in Sweden are the carbon tax and the energy tax on fuels.

The Swedish carbon tax, which is at the centre of Swedish climate policy, was introduced in 1991, in addition to the already existing energy tax, and as part of a major tax reform (Swedish Ministry of Finance, 2020, p. 5). Except for fuels used in commercial aviation and shipping as well as in rail transport, the tax addresses all fossil fuels used as motor fuels and heating fuels – oil products, natural gas, coal and coke – based on their carbon content. As the carbon content corresponds to the carbon dioxide emissions released into the atmosphere when the fuel is burned, the tax puts an explicit price on each tonne of CO_2 emitted into the atmosphere, without the need to measure actual emissions. Sustainable biofuels are not taxed (Government Offices of Sweden, 2020).

The energy tax applies to the same fuels, however at rates varying according to their energy content (OECD, 2018, p. 6). The carbon tax and the energy tax are therefore often regarded in combination, rather than as two separate taxes. (Hammar, 2011, p. 4) They are both regulated by the Swedish Energy Tax Act (Lag om skatt på energi, SFS 1994:1776). Both taxes have been levied on fossil fuels but with different policy objectives in mind. While the carbon tax focuses on the reduction of CO_2 emissions, the energy tax is intended to internalise other external effects as noise, congestion and road wear from traffic, and at the stimulation of energy efficiency, in addition to its original focus of generating revenues (Hammar, 2011, p. 4). When the carbon tax was introduced in 1991, the energy tax rates were halved, which still led to an overall increase in taxation for all fuels (Åkerfeldt, 2015, p. 2).

Since its introduction, the carbon tax has increased gradually and step-wise. This has given households and businesses the opportunity to adapt. From the beginning of the system in 1991, industry has faced a significantly lower tax rate at 6 EUR per tonne of emitted CO_2, one quarter of the regular rate, to secure competitiveness and avoid carbon leakage (Government Offices of Sweden, 2020).

After the introduction of the EU ETS, industrial emissions that were covered by the EU ETS have been exempt from the carbon tax (from 2011), while the tax rate for the remaining industrial emissions continued to increase gradually. As of 2018, the tax rate for industrial emissions not covered by the EU ETS is the same as the general tax rate (110 EUR / tonne) (Government Offices of Sweden, 2020).

Figure 11. Development of the Swedish carbon tax levels in EUR/t 1991-2018 – general level and industry level (from 2011 outside of EU ETS)

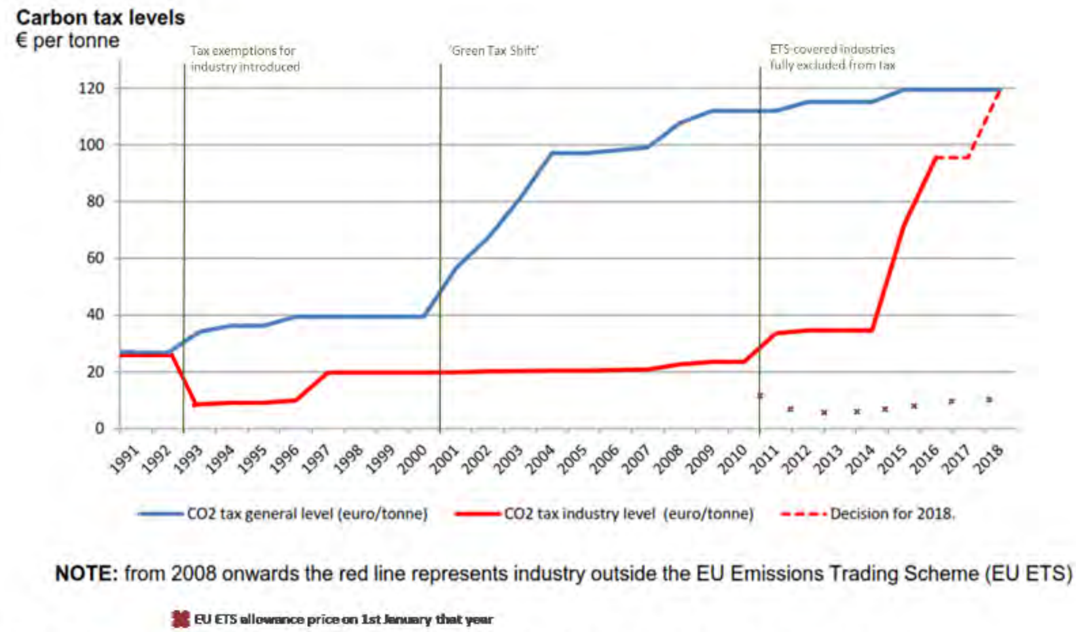


Figure 3: Carbon tax levels in EUR/t 1991–2018 (based on Raab, 2017; p. 7); adjusted and extended with own research

Source: Ackva, 2018, p. 5, based on Swedish Energy Agency 2017, p. 7

The carbon tax is administered and collected by the Swedish Tax Agency (Skatteverket) together with the energy tax. Taxes are paid by about 300 registered tax payers, typically distributers, such as oil companies, or large industrial consumers. Taxes need to be declared when the fuel is delivered to the consumer or retailer; until then, these companies are authorised to produce and hold energy products without tax being charged (Hammar, 2011, p. 9). Both energy tax and carbon tax are collected via the same mechanism which eases the administrative burden for tax authorities and operators (Åkerfeldt, 2015, p. 2). The customer purchasing the petrol will likely be aware that she is paying a large amount of taxes, but not necessarily of how large the CO_2-tax is in relation to the energy- and the sales tax. (Scharin, 2018, p. 8-9)

While tax revenues are not earmarked in Sweden, a significant share of the national budget has been allocated over the years to projects of relevance for the reduction of greenhouse gas emissions, such as improved public transportation systems, an increase in biofuels in district heating and improvements in the insulation of buildings (Åkerfeldt, 2015, p. 3) as well as the alleviation of unwanted distributional effects (Government Offices of Sweden, 2020). Until 2004 revenues from the carbon tax increased steadily, stabilised in the following years and even decreased in some years, likely due to the increased tax level (Scharin, 2018, p. 9).

In addition to the climate and the energy tax on fossil fuels, a number of further climate-relevant taxes apply. An aviation tax on domestic and international air travel was introduced in pursuit of climate and environmental objectives. The tax is paid per passenger according to the distance of the flight (Skatteverket, 2020b). Fuels for electricity production are not taxed, but are covered by the EU ETS. In addition, electricity is taxed when delivered to the consumer, as part of the energy tax system (Hammar, 2018, p. 13).

The **building sector** is affected by the carbon- and energy taxes through their effect on fossil-based heat generation. Both taxes apply to all fossil heating fuels, liquid and gaseous, as well as coal and coke, while sustainable biofuels are exempt from taxation. For combined heat and power plants (CHP) covered by EU ETS, the full energy tax rate applies. The carbon tax for these installations is set at 91% of the regular tax rate. The same applies for other heating plants than CHPs covered by EU ETS. (6a kap, 1 §) (SFS 1994:1776). No carbon tax is charged for heat production by industrial installations that are part of EU ETS (Swedish Government Offices, 2018, p.18).

In agriculture, forestry and aquaculture, an energy tax exemption of 70% applies (30% of the regular tax rate must be paid) for colored heating oil, natural gas and gas oil used for heating. No exemptions from the carbon tax are granted for heating fuels in these sectors (6a kap, 2a §, 9 kap., 5 §, Skatteverket 2020c).

In the **transport sector**, carbon- and energy taxes are levied on both petrol and diesel. The carbon tax also covers natural gas. (Swedish Government Offices, 2018, p.18).

For motor fuels that are more than 98% biomass-based, so-called high-blended biofuels (e.g. E85, ED95, pure or high-blended RME/FAME, pure or high-blended HVO, Bio DME), both the energy tax and the carbon tax can be deducted on the proportions of the fuel volume produced from biomass. No tax deductions apply on the fossil-based proportion of the fuel (e.g. ignition enhancers or other additives). Also, as is the case with heating fuels, biofuels in the transport sector must be classed as 'sustainable biofuels' in order to be eligible for tax deductions. For biogas, the energy- and carbon tax can be deducted 100%. Low-blended biofuels, motor-fuels with a biomass-based content of less than 98% by volume (e.g. low-blended ethanol, ETBE, RME/FAME, HVO), are subject to the same carbon tax and energy tax rates as their fossil-based counterparts. (Skatteverket 2020a)

Rail transportation is fully exempt from carbon and energy taxation (but electricity used in rail is subject to ETS), as is commercial aviation and shipping (6a kap, 1 §). Carbon emissions from aviation are covered by the tax on air travel, and inner-European flights are part of the EU-ETS (Skatteverket 2020b).[23]

In agriculture, forestry and aquaculture, a carbon tax refund of 1930 SEK (177,5 EUR)[2] is granted per m³ diesel consumption in boats and other work-related vehicles, such as tractors (except cars, trucks or buses), while the full energy tax applies.In agriculture, forestry and aquaculture, a carbon tax refund of 1930 SEK (177,5 EUR)24 is granted per m³ diesel consumption in boats and other work-related vehicles, such as tractors (except cars, trucks or buses), while the full energy tax applies. (6a kap, 2a §, Skatteverket, 2020c).

Context in which the instrument was introduced

Until the 1980s, the Swedish energy tax was an instrument with primarily fiscal purposes to increase the state's revenues (Swedish Ministry of Finance, p. 3). At the time, marginal income tax rates had reached very high levels and Swedes demanded a drastic reduction, while at the same time environmental awareness was increasing in the Swedish population. (Åkerfeldt, 2015, p. 2)

Established in 1988, a commission on economic instruments in environmental policy (the Environmental Charge Commission) began to investigate the use of economic instruments in environmental policies. Its task was to propose policy instruments

[23] SFS 2017:1200 Tax on Air Travel Act

[24] 177,52 EUR according to currency converter https://sek.currencyrate.today/eur/1930 on 11 April 2020.

aimed at emissions from energy and transportation. The commission included representatives from a wide range of stakeholder groups. After a broad hearing of different interests in the Swedish society, a bill was submitted and the parliamentary decision made to implement a CO_2 tax by law. (Scharin, 2018, p. 11-12)

The carbon tax was introduced in 1991 as part of the 'tax reform of the century' (Scharin, 2018, p. 11) along with a reduction in marginal income taxes on capital and labour and other major changes (Åkerfeldt, 2015, p. 2). At the time, the carbon tax was Sweden's first instrument with the objective to steer the country towards reduced emissions (Swedish Climate Policy Council, 2019, p. 18).

As citizens and the Swedish Government increasingly gave priority to environmental concerns, the level of the carbon tax increased in the following years (Swedish Ministry of Finance, 2020, p. 5). Starting off at modest levels, it has taken over twenty years to reach the current high tax levels (Åkerfeldt, 2015, p. 3). This has been possible due to the broad, cross-party political consensus around the Swedish carbon tax. Stakeholders are involved by public consultations before bills are presented in parliament, and major changes to the tax structure are introduced with early notice and in a step-by-step fashion (Åkerfeldt, 2015, p. 3).

Until today, popular commitment to solving the climate crises and support for climate measures remains strong in the Swedish population (Gullers Grupp Rapport, 2018, p. 4). An important factor for the broad acceptance of the carbon tax in Sweden has been the provision of low-carbon alternatives, available to choose when moving away from carbon intensive options. (Åkerfeldt, 2015, p. 3)

Role of the carbon price in relation to other relevant policy measures

In addition to the carbon tax, a large number of other climate policy instruments and measures have been employed since the early 1990s to achieve the country's climate targets. For example, the state has contributed to investments in emission reduction measures at local and regional level through various public-funded initiatives. Currently, a number of cross-sectoral instruments are in place, such as legislation (e.g. the Climate Act, the Environmental Code, and the Planning and Building Act), local and regional investment programmes (such as Climate Leap), climate change communication, dialogue and trainings in different sectors, municipal energy and climate advisory services, regional climate and energy strategies, as well as support for market introduction, technology procurement and networks (Government Offices of Sweden, 2018, 19-21)

For the **building sector**, a particular feature in the Swedish context was the expansion of district heating systems, which started already in the 1970s. Today district heating is mainly based on burning various wood residues and household waste, which has almost lead to an entire phase-out of fossil fuels in the heating sector (Schiebe, 2019).

Today, the following national policy instruments are of relevance (besides the carbon tax): emission performance standards; building regulations for new buildings and buildings that undergo changes, to limit energy use, thermal transmittance and air leakage; energy declaration obligation for owners of buildings to declare the energy performance; support for energy efficiency renovations in apartments; training programmes in building for low energy consumption; the technology procurement support to initiate a market transition and disseminate new, more efficient technology (Swedish Government Offices, 2018, p. 34-37).

For the **road transport sector**, the following national policy instruments play a key role (besides the carbon tax): climate Leap, local and regional investment programmes; urban environment agreements as investment schemes in public transport and cycling infrastructure; a differentiated vehicle tax, either basing the tax rate on CO_2 emissions (vehicles built 2006 or later) or weight (vehicles built before 2006); requirements to provide renewable fuels; electrical bus premium for public transport agencies purchasing electrical buses; an emission reduction obligation to increase biofuel blending into petrol and diesel; a bonus-malus system providing a bonus at purchase of low emission vehicles and a three-year tax-increase for high emission vehicles; electrical vehicle premium for electric bicycles or electric scooters; charge at home grant for households that invest in charging points for electric vehicles, an eco-bonus system for heavy transport to stimulate the transfer of freight transport by road to shipping, and the fossil free Sweden initiative supporting key actors in their climate efforts by providing a platform for dialogue, cooperation and inspiration between themselves and the Government (Swedish Government Offices, 2018, p. 16).

Yet, among all instruments that are in place to reduce Sweden's carbon emissions, the Swedish carbon tax has been the dominant instrument since its introduction in 1991 (Ackva 2018a). It is considered as the cornerstone of Swedish climate policy (Scharin, 2018, p.6), as the 'key driver' behind Sweden's success in cutting emissions whilst maintaining economic growth (Swedish Energy Agency, 2017, p. 8) and it is credited for having 'strongly contributed to Sweden's climate leadership in reducing emissions in hard-to-decarbonize sectors– building, transport and industry' (Ackva 2018b). For these reasons, the carbon tax has been regarded as a cost-effective and technically neutral instrument to internalise climate-related external effects. (Martinsson and Fridahl, 2018, p. 2)

Against this background, many of the instruments that are in place today, and of the measures that have been put in place in the past, can be seen as complementary to the carbon tax, with the intention to make lower-carbon or fossil-free options available to consumers and businesses, and thus to offer choices to move away from carbon-intensive options and avoid paying the carbon tax. Examples are subsidies for electric cars, energy efficiency legislation, support for energy efficiency renovations in apartments and certificates for renewable electricity.

Although other factors have played a role, empirical research indicates that the carbon tax along with the energy tax have been driving factors in achieving the emission reductions over the past three decades, not least because they have pushed for the phase-out of fossil fuels for heating. The carbon dioxide tax has been gradually increased during this period while the exemptions have become fewer, to further strengthen the incentives to reduce emissions. (Climate Policy Council, 2019, p. 19)

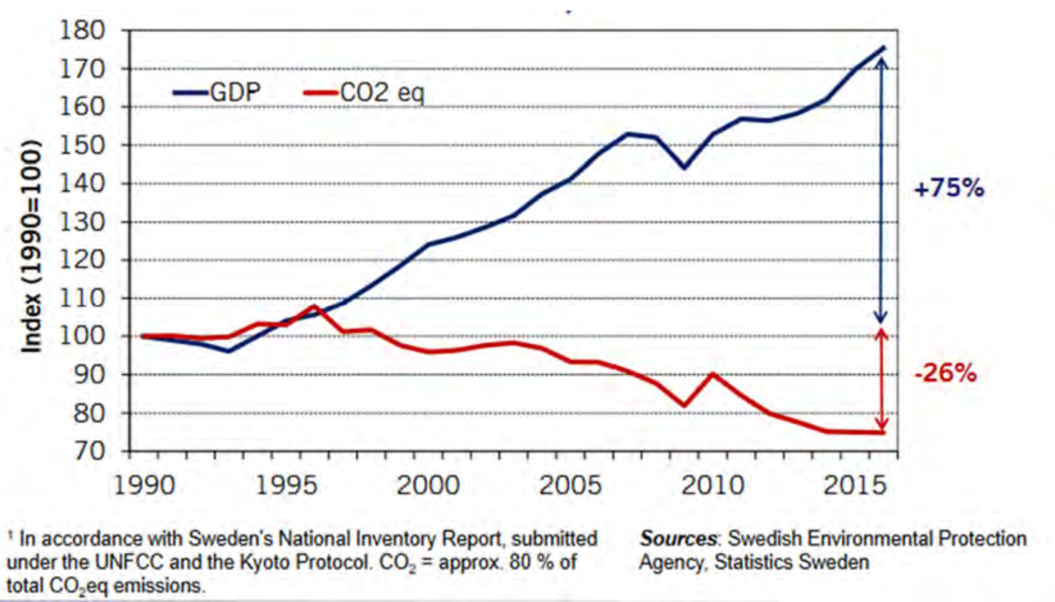
Results of the instruments in place

During the period between 1990 and 2018 Swedish greenhouse gas emissions have decreased by 27 % (Swedish Environmental Protection Agency, 2020b). In 2017, Sweden was among Europe's top three countries with the lowest greenhouse gas emissions per capita (after Liechtenstein and on the same level as Malta). (Eurostat 2020)

The main emissions reductions occurred between 2003 and 2014. The largest reductions were seen in the building sector by reduced emissions from heating of homes and premises, and in recent years, in industry and domestic transport. Emissions from waste treatment, electricity and district heating have also decreased but are less contributing to the overall trend. The decrease can be partly explained by measures such as the transition to renewable energy and increased energy efficiency and partly by stagnant growth in industry. Several measures that have had an impact on emissions development were introduced already before 1990, such as a low-carbon electricity mix, an expansion of the district heating networks and an increased use of biofuels. (Swedish Environmental Protection Agency, 2020b)

While emissions have decreased, the Swedish GDP has increased since 1990 (Swedish Government Offices, 2020), meaning that economic growth and greenhouse gas emissions have been decoupled from 1996 on. Moreover, the World Economic Forum ranks Sweden eighth globally in terms of competitiveness (World Economic Forum, 2019).

Figure 12. Decoupling of Swedish economic growth and greenhouse gas emissions



Source: Swedish Ministry of Finance, 2018

While it is difficult to attribute the **effects of the carbon tax** in separation from the other policies in place, the carbon tax is often considered as one main explanation for Sweden's emission reductions since 1990 For instance, Nilsson et al., 2013 (p. 65/66) find that it had clear effects by leading to changes in behavior and investments, above all in the heating sector, and that it is seen as a main explanation for the reduced emissions in Sweden since 1990.

Mainly for driving demand for alternatives fuels, above all in the residential sector, and for promoting alternatively powered transport, the carbon price signal has been highlighted as a successful instrument in Sweden (Ricardo Energy and Environment 2018, p. 12).

Looking at the initial period after the introduction of the tax (1990-1995), Bohlin, 1998 (pp. 283, 289) finds that the effects of the carbon tax vary across the different sectors, with its main effects on district heating. Also, he emphasises that the tax must be looked at in interaction with other relevant policy instruments, that were in place already, and paved the way for a change in the energy supply system. Overall, he concludes that by triggering a change of behavior in the desired direction, the tax has had a positive effect on emission reductions in Sweden with yearly abatements range between 0.5 and 1.5 million tons CO_2 from 1990 to 1995 (pp. 286, 287, 289, 290).

In their study based on 59 interviews with decision-makers and officials in Swedish climate policy, Kronsell et al., 2011 (p. 3) conclude that the carbon tax is identified as the single most successful factor for the emission reductions achieved so far and for driving the development towards a climate-smart society in Sweden.

Buildings

Greenhouse gas emissions from heating of homes and premises have decreased by 90 percent since 1990, and emissions continue to decline. This makes the building sector the biggest contributor to the reduction of Sweden's total greenhouse gas emissions. This development is due to the fact that heating with oil has been replaced by mainly district heating and heat pumps (Swedish Environmental Protection Agency, 2020e) and emissions were reduced were due to a profound transformation from fossil-based to bio-based fuels.

With the tax reform, biomass became the most competitive fuel in heat production. From an economic perspective, the shift to biomass was self-evident for many utilities. (Johansson 2009, p. 32). This can be seen reflected in the sharp increase of biomass use in the years after the carbon tax had been introduced.

A reduction in fossil fuel consumption could be noted mainly in the household and service sectors, that were subject to the full carbon tax. District heating systems had been expanded and gradually replaced fossil fuels with biomass and other non-fossil energy sources exempted from the carbon tax (such as energy from waste), as well as using surplus heat from industrial processes. (Hammar, 2011, p. 9-10).

In the years 1990-1995 the total use of biofuels within the district heating sector doubled from 36.7 PJ to 73.4 PJ, substituting fossil fuels, primarily coal, as it had become more expensive than forest fuels. Thus, the carbon tax, in interaction with other beneficial policy measures already in place, has been a key factor in the switch to biofuels in district heating and has had a positive effect on CO_2 emissions from the sector (Bohlin, 1998, pp. 287-290).

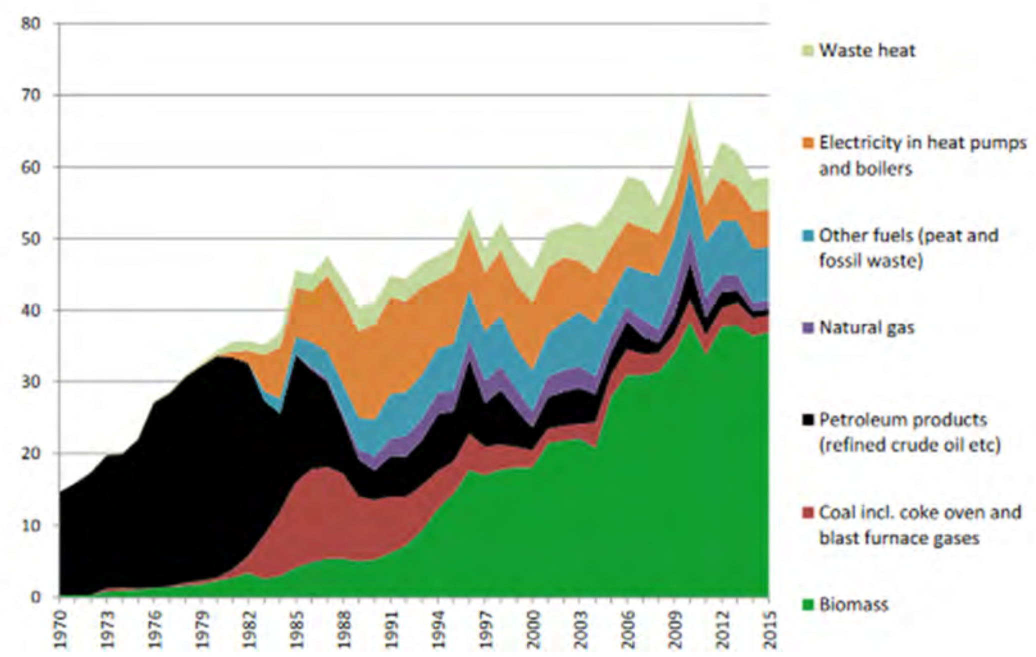
Over the last three decades, fossil heating fuels have largely been phased out. Since the introduction of the carbon tax, their use has dropped by 85 % and now accounts for only 2% of Sweden’s total greenhouse gas emissions (Swedish Ministry of Finance, 2020, p. 15).

In the more remote areas, which are not connected to a district heating system, fossil heating fuels were replaced by wood pellets burners and heat pumps (Swedish Ministry of Finance, 2020, p. 15), leading to an overall increase in electricity-based heating from about 30% to about 35% (Ackva, 2018, p. 7-9). At the same time, household energy decreased slightly (by 2.1 % per capita between 1990 and 2008) (Ackva, 2018, p. 7-9).

Other factors and policy instruments that contributed to the shift towards fossil fuel free heating include government-funded temporary aid schemes to support the conversion to biomass, the ban on landfilling combustible and organic waste, and the availability of large amount of biomass (such as residues from forestry). Yet of all factors, the carbon tax (together with the energy tax) has been identified as the most important driver (e.g. Johansson 2009, p. 32, Ackva, 2018, p. 7-9, Scharin, 2018, p. 23).

With today's policies in place, especially the carbon tax and energy tax, the Swedish Climate Policy Council expects that the remaining fossil fuels for heating and electricity generation will be phased out by 2045 (Swedish Climate Policy Council, 2020, p. 69)

Figure 13. Energy input sources for district heating in Sweden in TWh, 1970-2015



Source: Swedish Ministry of Finance, 2017, p. 20 (based on Swedish Environmental Protection Agency)

Transport

After several years of increasing emissions in domestic transportation, 2007 marked a turning point and the beginning of a slightly decreasing trend until 2018, when recorded emissions were 15% lower than in 1990. At the same time, passenger car traffic has been increasing since 2013. (Swedish Environmental Protection Agency 2020c). Preliminary statistics show that this trend of decreasing transport emissions continued in 2019 with a 2% reduction compared to 2018. (Trafikverket, 2020, p. 1)

The decrease in emissions seen since 2007 is mainly attributed to the fact that road transport is operated with an increasing proportion of biofuels (Swedish Environmental Protection Agency 2020c, Trafikverket, 2020. p. 1). The proportion of biofuels increased from 22% to 23% percent in 2019. This increase is attributed to the emission reduction obligation, a policy instrument introduced in 2018, which obliges fuel manufacturers to mix certain proportions of biofuels into their products (Trafikverket, 2020).

Energy efficiency has also contributed to reducing fuel consumption and carbon dioxide emissions. However, the average fuel consumption of passenger cars registered in Sweden has recently increased for two years in a row (Swedish Environmental Protection Agency 2020c).

A third factor is the increased role of electric mobility: In 2019, the number of new electric-powered passenger cars doubled compared to the previous year, along with an increase in hybrid cars reducing average emissions from the new passenger car fleet. At the same time, the average emissions from cars powered by gasoline or diesel are increasing. Emissions from new gasoline-powered cars have increased to 130 g / km and are the highest since 2013. For new diesel-powered cars, emissions are now at 137 g / km, which is the highest value since 2011. (Trafikverket, 2020)

Andersson (2017) finds that the introduction of the carbon tax in Sweden had a significant effect on CO_2 emissions from transport in the years 1990 to 2005. Without the tax in place, he concludes, emissions would have been between 8.1% and 10.9% (depending on the method he employs) higher than they actually were during those years (Andersson, 2017, pp. 3, 4, 33).

Plans for the future evolution of the system

The carbon tax has brought about actual changes in behavior and investments, and at the same time has also strengthened confidence that economic and market-based instruments are adequate in climate policy (Nilsson et al., 2013 pp. 65-66). Due to its achievements in emission reductions in the past decades, the Swedish government regards it as a powerful tool and the major economic instrument to achieve emission reductions in sectors outside the EU ETS also in the future (e.g. Åkerfeldt, 2015, p. 3).

Reaching the climate targets of transitioning society to net-zero emissions by 2045 would require emission reductions between 5% and 8% per year. Current reduction levels of less than 1% per year are thus clearly not enough, as the Swedish Climate Policy Council points out in its 2019 report. It concludes that the emission reduction policies in place do not suffice for Sweden to achieve its targets (Swedish Climate Policy Council, 2019, pp. 10-11). In its Climate Policy Action Plan presented in December 2019, the Swedish government states that the carbon tax remains a basis for reducing CO2 emissions outside of EU ETS. The plan suggests that the tax level should be adjusted in scale and pace, together with changes in other instruments. The 2030 target should be reached by cost-effective emission reductions, while keeping the competitiveness of the business sector in sight. Along with a number of other trans-sectoral and sector-specific policy instruments, the plan announces the implementation of an extensive tax reform that shall contribute to achieve climate and environmental goals. and to an increased share of tax revenues from environmental taxes. (Government Offices of Sweden, 2019, p. 3 and Government Bill 2019, p. 53-57). The plan does not provide any concrete numbers or indications of what the adjustments in taxation could look like. It states that 'which changes in carbon taxation are justified should be considered gradually' (Government Bill 2019, p. 53-57)

Over time, especially after the year 2000, both the tax level has been increased and exemptions and reductions have been removed or reduced. However, there are still exceptions to uniform taxation, for instance for fuels used in machines in agriculture and forestry. Today, about 90 percent of carbon dioxide emissions (outside of EU ETS) are covered by the full carbon tax level. In its 2019 report, the Climate Policy Council asks for a complete phase-out of remaining exemptions, ultimately leading to uniform taxation of carbon dioxide emissions for all activities outside the trading system. (Swedish Climate Policy Council, 2019, pp. 37-38)

In its 2020 report, the Climate Policy Council finds that the EU ETS and the energy- and carbon tax create a basic economic incentive for transformation, but are too weak to achieve fast enough change to reach net zero emissions by 2045, which calls for the introduction of supplementary, targeted measures to address obstacles (Swedish Climate Policy Council, 2020, pp. 56-57).

In a jointly produced report published in March 2020, six Swedish authorities (the Swedish Energy Agency, the Swedish Housing Agency, the Swedish Environmental Protection Agency, the Traffic Analysis, the Swedish Transport Administration and the Swedish Transport Agency) put forward seven recommendations on how to speed up the transition of the Swedish transport sector. Among other proposals, the authorities see great potential in an increase and redistribution of the carbon tax to provide incentives for a number of new measures that reduce emissions in the transport sector. They do not provide details on numbers, but recommend to get started with a review of the carbon tax promptly, so changes can have effects on the 2030 target for the transport sector (Swedish Energy Agency et al. 2020, p. 49)

However, the carbon tax is never regarded in isolation, but as a key instrument that needs to be complemented by a mix of additional policy instruments and measures in order to achieve the required emission reductions.

2.2.1.2 Current scope of the system and overlaps

Today, approximately 95% of Swedish carbon emissions from fossil fuels are covered by the Swedish carbon tax or the EU ETS. (Swedish Ministry of Finance, 2020, p. 10).

Carbon tax scope

The Swedish carbon tax is regulated in the Energy Tax Act (SFS 1994:1776), which is the foundation of energy taxation in Sweden, and covers both the energy tax and the carbon tax.

The law constitutes which fuels are covered by these taxes, defines the price levels for different fuels for each tax, and lays down which fuels, sectors and processes are exempted from the taxes, and to which degree. It also regulates in which cases reduced rates apply, and in which circumstances taxes on fuel can be deducted.

Carbon and energy tax cover all fossil fuels used as motor fuels and heating fuels – liquid and gaseous, as well as coal and coke (2 kap, 1 §). Sustainable biofuels and biogas are exempt from taxation (6a kap, 2 b/c §). Fuel consumption in commercial shipping, fishing and aviation, in rail transportation, as well as in electricity generation are not subject to energy or carbon taxation. Industry that falls under EU ETS, is fully exempt from carbon taxation and pays 30% of the energy tax.(6a kap, 1 §). (SFS 1994:1776). Exemptions from energy- and carbon taxation remain for certain fuel uses in agriculture, forestry, and aquaculture (6a kap, 2a §, SFS 1994:1776, Skatteverket, 2020c). In the **building sector,** the carbon tax as well as the energy tax apply for fossil fuels used in heat production. For fuels used for heat production in CHPs, and other heat production covered by the EU ETS, the full energy tax, and 91 % of the general carbon tax rate apply (6a kap, 1 §). (SFS 1994:1776)

In the **transport sector**, the carbon tax and energy tax are levied on both petrol and diesel. The carbon tax also applies to natural gas. Low-blended biofuels (motor-fuels with a biomass-based content of less than 98%, e.g. low-blended ethanol, ETBE, RME/FAME, HVO; Skatteverket 2020a) are covered by the reduction obligation scheme, an instrument that obliges suppliers of gasoline and diesel to increase the share of biofuels in the fuel-mix. Therefore, low-blended biofuels are subject to the full carbon tax and energy tax rates as their fossil counterparts. High-blended biofuels (motor fuels that are more than 98% biomass-based, e.g. E85, ED95, pure or high-blended RME/FAME, pure or high-blended HVO, Bio DME; Skatteverket 2020a) are not covered by the reduction obligation scheme. Therefore, tax exemptions apply. The proportion of the fuel that is of biomass origin in high-blended sustainable biofuels is exempt from both carbon tax and energy tax (Swedish Government Offices, 2018, pp.17-18). Also, as is the case with heating fuels, biofuels in the transport sector must be classed as ‘sustainable biofuels’ in order to be eligible for tax deductions. (Skatteverket 2020a)

Fossil fuels used in rail transportation is fully exempt from carbon or energy taxation, as is commercial aviation and shipping (6a kap, 1 §).[25] Carbon emissions from aviation are covered by the tax on air travel, and inner-European flights are part of the EU-ETS (Skatteverket 2020b).[26]

In agriculture, forestry and aquaculture, a carbon tax refund of 1930 SEK (177,5 EUR) is granted per m³ diesel consumption in boats and other work-related vehicles, such as tractors (except cars, trucks or buses), while the full energy tax applies (6a kap, 2a §, Skatteverket, 2020c).

In agriculture, forestry and aquaculture, a carbon tax refund of 1930 SEK (177,5 EUR)[27] is granted per m³ diesel consumption in boats and other work-related vehicles, such as tractors (except cars, trucks or buses), while the full energy tax applies (6a kap, 2a §, Skatteverket, 2020c).

All **industry** that is not covered by the EU ETS is covered by the carbon tax, that is combustion plants with an installed thermal capacity below 20MW (SFS 2004:1205). Industry was originally taxed with reduced rates. From 2011 onward the energy-intensive industry within the EU ETS was no longer covered by the Swedish carbon tax in order to avoid the application of two parallel economic instruments to reduce greenhouse gas emissions. Carbon tax levels for less energy-intensive industries not covered by the EU ETS have gradually been increased to the same level as for the other sectors today. (Åkerfeldt, 2015, p. 4)

Fuels used for **electricity production** are not subject to the carbon tax, but the produced electricity is taxed by the electricity tax. Generally, all installations that generate electricity from fossil fuels are covered by the EU ETS (Swedish Government Offices, 2018, p.18).

EU ETS scope

Close to 40% of Sweden's greenhouse gas emissions are covered by the EU ETS. (Swedish Climate Policy Council, 2019, p. 11) The greenhouse gas emissions trading system comprises approximately 750 Swedish industry- and energy production plants. (Utsläppshandel, 2018)

How exactly is the current system delineated, and are there explicit provisions to address overlaps (e.g. exemptions or compensation)?

Several provisions of the Energy Tax Act (SFS 1994:1776) address installations covered by EU ETS and define to which degree these are exempt from the carbon tax and energy tax.

- Chapter 6a §1. 9. a exempts industry that is covered by EU ETS from the carbon tax. It is however subject to the energy tax with 30 % of the general tax rate.
- Chapter 6a §1. 17. a defines reduced rates of carbon tax for a) CHP (91% of the general rate must be paid) and b) other heat production (91% of the general rate must be paid) that are covered by EU ETS. Both are subject to full energy taxation.

---

[25] Electricity that is used in rail transportation is covered by the EU ETS, and thus carries a carbon price. Since 75% of railway lines in Sweden are electrified, and since these lines contribute a higher share of transport volume, this accounts for the bulk of energy used for railway transport in Sweden.

[26] SFS 2017:1200 Tax on Air Travel Act

[27] 177,52 EUR according to currency converter https://sek.currencyrate.today/eur/1930 on 11 April 2020.

The participation of installations in the EU ETS is transposed into Swedish Law by the Law (SFS 2004:1199) and the Regulation (SFS 2004:1205) on Emissions Trading.

Annex 2 of the Regulation contains an overview of which plants and activities are covered. These are combustion plants with an installed thermal output above 20MW and smaller combustion plants connected to district heating networks with a total installed thermal output over 20 MW. Activities include cogeneration and district heating plants, combustion units belonging to an industrial plant, waste energy plants (with the main purpose of producing energy), clean biofuel plants if they are connected to district heating networks with total installed power supply over 20 MW. In addition to combustion plants, a large number of other plants are included in the trading system, such as mineral oil refineries, coke ovens iron and steel industry, mineral industry (cement, lime, glass, ceramics), paper and pulp industry and some chemical industry. Generally, a production volume threshold must be exceeded for the plant to be included in the system. (SFS 2004:1205)

Which sectors are affected by overlap (direct or indirect) and which share of emissions / energy use do they represent?

The affected sectors are industry and buildings (heat generation in CHP), while road transport is exclusively subject to the carbon tax and therefore not affected.

With 62% of Sweden's total energy-related emissions, the industry sector accounts for the bulk of emissions. Approximately one-third of these are covered by the carbon tax, while two-thirds fall under the EU ETS. (Ackva, 2018, p. 3)

In the building sector, CHP is affected by a certain degree of overlap, see above. The building sector (residential and service buildings) represents roughly 8% of the total emissions. (Ackva, 2018, p.3)

2.2.1.3 Price level / trajectory and relation to the EU ETS price

The general carbon price in Sweden in 2020 is SEK 1 190 (EUR 110) per tonne fossil carbon dioxide emitted.[28] It was raised in a stepwise fashion over the years, with the purpose of achieving cost effective emission reductions (Åkerfeldt, 2015, p. 2). While there are no definite statements to this effect, there are indications that the trend of increasing carbon tax rates will continue.

The carbon tax was highlighted in the Climate Policy Action Plan**,** presented by the Swedish government in December 2019, as a base of Swedish regulation of carbon emissions (outside of ETS). It finds that the taxation level will need to be adjusted in the future, in order to provide a continued incentive for a cost-effective decrease of non-ETS GHG emissions so that the 2030 targets can be met. (Government Offices of Sweden, 2019, p. 3; Government Bill 2019, p. 53-57)

Swedes are generally willing to contribute and have a positive attitude towards societal climate initiatives and corporate climate work. There is a positive attitude towards climate solutions in general, and government instruments that limit climate impact in particular (Gullers Grupp Rapport, 2018, p. 4). However, there are indications that public support for additional climate-related taxes and fees on goods and services such as petrol, oil and flights is declining (Gullers Grupp Rapport, 2018, p. 4, p. 20) which could make it more difficult to increase the carbon tax. Also, public opposition against increasing fuel prices has been growing, mainly in rural areas (Schiele, 2019).

With regard to the EU ETS, the Swedish Climate Policy Council stated in 2019 that the EU ETS is not equipped to reach net-zero emissions in all member states, and

[28] Currency conversion: exchange rate of SEK 10.80 per EUR

criticizes that progress within the EU ETS is not in line with what Sweden is required to achieve with its zero emissions target by 2045 (Swedish Climate Policy Council, 2019, p. 11).

2.2.2 Germany

Germany has decided in December 2019 to launch a national ETS for heating and transport fuels, as well as for small industry emitters that are not covered by the EU ETS. The upstream national ETS will start with a fixed price of 25 Euro per tonne of CO2 in 2021, before gradually rising to 55 Euro in 2025. As of 2026, the system will transition to a flexible price, with a price corridor of 55 to 65 Euro. This corresponds to a price increase of about 7.5 cents for gasoline and diesel in 2021 and about 16.5 cents by 2025. The national emissions trading system for fuels will cover about 4,000 companies that sell heating oil, LPG, natural gas, coal, gasoline and diesel.

2.2.2.1 Description of the system

For a long period, Germany had not introduced any new price-based climate policies for transport and buildings. Before the newly adopted measures, the latest round of tax increases for fossil fuels in these sectors dated back almost two decades, to the period 1998-2002. At this point, Germany's ecological tax reform took effect, raising existing taxes on liquid fossil fuels, gas, coal and electricity. Yet while this "ecotax" was also seen as contributing to climate goals, it was not an explicit carbon tax, and in fact did not tax different energy carriers in line with their carbon content.

Since the tax rate increases instituted during the ecological tax reform were fixed in nominal terms and have not been adjusted since, the real effect of the tax declines. This came in spite of the fact that Germany set itself increasingly stringent climate targets. While overall greenhouse gas emissions in Germany had fallen by x% since 1990, it looked increasingly unlikely that Germany would meet its national target of reducing GHG emissions 40% below 1990 levels by 2020: at the end of 2018, total GHG emissions had fallen to 858 million tons of CO_{2e}. Compared to 1990, this represents a reduction of 31.4%, and thus far short of the envisaged national goal of a 40% reduction. In addition, Germany also was not on track to achieving its national target foreseen under the EU Effort Sharing Regulation.[29]

One key reason for this were consistently high and rising emissions from the transport sector. As pointed out by numerous advisory bodies, government agencies and academic scholars, the failure to reduce transport emissions was one key reason for the insufficient progress towards Germany's stated climate goals (Löschel et al. 2019; 2018; Sachverständigenrat für Umweltfragen (SRU) 2017). At 162 million tons of CO_{2e}, emissions from transport were effectively unchanged from their 1990 level of 164 million tons – whereas other sectors such as energy or buildings had managed to decrease their emissions significantly below 1990 levels. For these reasons, it had become clear that Germany would need to take additional efforts to reach its climate goals. A suite of climate policies was tabled as the climate protection programme 2030 (Klimaschutzprogramm 2030), including a climate protection law, the legal

[29] While it had long been anticipated that Germany would not be able to meet its emission reduction goal for 2020, this may still change due to the impact of the Corona crisis on economic activity, energy consumption and emissions. Already in 2018 and 2019, Germany had seen drastic emission reductions, particularly in the energy sector, driven by high carbon prices and a demise of coal plants. Preliminary estimates suggest that the partial lockdown since March 2020, and ensuing effects on industrial production, transport demand and other factors, could lead to an emission reduction of 50 to 120 million tons in 2020, which would bring the GHG reductions to 40 – 45% below 1990 levels, and thus help to achieve the 2020 target of a 40% reduction. Yet, as the authors also point out, this could be a short-lived achievement, as emissions would most likely rise again during the recovery after the crisis (Hein, Peter, and Graichen 2020).

implementation of a process to phase out power generation from coal, and – as one cornerstone of this package – a new carbon pricing instrument.

Over the summer of 2019, several scientific advisory bodies, government agencies, academic bodies and think tanks had issues statements and proposals for a reform of carbon pricing in Germany (Edenhofer et al. 2019; Bach et al. 2019; Leprich 2019; Burger, Lünenbürger, and Kühleis 2019; Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (SVR) 2019; Nationale Akademie der Wissenschaften Leopoldina, acatech - Deutsche Akademie der Technikwissenschaften, and Union der Deutschen Akademien der Wissenschaften 2019). Based on these, the first proposal for a new carbon pricing instrument was tabled in September 2019. In November 2019, political agreement on a new carbon pricing instrument was reached at cabinet level; some amendments were introduced in the parliamentary process in December 2019. Between the different alternatives that had been proposed and discussed, Germany in the end opted for a national-level upstream emissions trading system (Brennstoffemissionshandel), which covers transport and heating fuels and which operates independent of the existing EU ETS. The main legal basis for the new national emissions trading system (Brennstoffemissionshandelsgesetz) entered into force on 20 December, 2019.

As stipulated in the law, the national ETS is to take effect on January 1, 2021. It will cover all fuels that are relevant for transport and heating, i.e. gasoline and diesel, natural gas, heating oil, liquefied gas and coal (which plays a marginal role as a heating fuel). In principle, it also covers biofuels (liquid and solid), yet emissions for these fuels are merely reported, and do not oblige the emitter to surrender allowances. The compliance obligation falls on all entities that bring the covered fuels into circulation. These are typically wholesale fuel traders, fuel producers which also engage in wholesale trade, and fuel importers. The point of obligation follows the energy tax law, i.e. the obligation arises for the same actors that are also obliged to report and pay energy taxes on fossil fuels. Throughout the year, compliance entities need to monitor the fossil fuels that they bring into circulation (i.e. sell), report these amounts to the German Emissions Trading Authority, and to surrender a corresponding amount of allowances. Cases of non-compliance will be sanctioned with a penalty of twice the allowance price in the respective year per missing allowance (during the fixed-price period) or 100 Euro (as of 2026).

The national ETS was introduced with the explicit intention (as laid out in the law establishing the system) to contribute to the achievement of national climate targets, including the target of long-run climate neutrality by 2050, of the targets laid out in the effort sharing regulation, and to improve energy efficiency. The law also stipulates that the national ETS should be evaluated regularly – starting in November 2022, in November 2024 and then in four-year intervals. The evaluation should also assess the effectiveness of the system with respect to the stated objectives, and issue recommendations for the future evolution of the system, particularly with respect to the price corridor. There is, however, no explicit mechanism linking the price level in the fixed-price or the price corridor phase to the over- or underachievement of emission targets.

As a pure upstream method, all allowances will be sold – either at a fixed price or through auctions. While some companies may be eligible for monetary compensation to address the risk of carbon leakage or avoid undue hardships, there will be no free allocation. This means that the system will be generating substantial revenues: with an estimated emissions volume of roughly 280 million tons in 2020 (pre-corona), the revenue would amount to 7 billion Euro. By 2025, while emissions in the two sectors are projected to fall to below 250 million Euro, revenues could rise to more than 13 billion Euro. The use of these revenues is not regulated in the law establishing the national emissions trading system (other than that they should cover the costs of administering the system). There was, however, a political agreement that much of the revenue should be recycled back to private households: first, part of the revenue will flow towards the system of renewable energy feed-in-tariffs, and thus lower the renewable energy surcharge and hence the electricity price. Second, revenue will be used to expand an existing tax relief for commuters, arguing that they are particularly affected by rising fuel prices. In total, however, scholars have pointed out that the majority of funds will flow towards funding concrete climate-related measures and programmes, and only a relatively smaller share will be used to compensate households (Knopf 2020). In total, however, scholars have pointed out that the majority of funds will flow towards funding concrete climate-related measures and programmes, and only a relatively smaller share will be used to compensate households (Knopf 2020).

Since the national ETS will only be entering into force in 2021, there is as yet no evaluation of its effects. However, two recent modelling studies have estimated the expected effect of the Climate Protection Programme 2030 – including the national ETS – on Germany's greenhouse gas emissions and the achievement of its sectoral emission targets (Kemmler et al. 2020; Harthan et al. 2020).[7]

In a modelling study by Prognos, Fraunhofer-ISI and others commissioned by the Federal Ministry of Ecoomics and Energy, the authors estimated that the climate protection programme in its entirety will reduced German GHG emissions to just below 600 Million tons in 2030, 52% below 1990 levels – and thus only a little short of the 55%-target (Kemmler et al. 2020, 68). Progress is uneven across sectors, however: while emissions in energy and buildings would be more than 60% below their 1990 levels in 2030, transport emissions in 2030 would only be about 23% below 1990 levels; the transport sector would only achieve slightly more than half of the reduction that the sector would be expected to deliver by 2030 under Germany's climate protection law. The building sector, by contrast, is expected to achieve almost all of the reduction required by the law (Kemmler et al. 2020, 69).

In both sectors, the carbon price is expected to play an important role – yet the authors do not disclose how much of the reduction is due to the carbon price. Thus, for instance, the authors expect that, in the transport sector, the carbon price will be a key driver for shifting freight transport from road to rail, with rail transport increasing by more than 10% (Kemmler et al. 2020, 75). By contrast, in passenger transport, the increased market penetration of electric vehicles is assumed to be a main driver - for which dedicated support instruments are assumed to be more important. For buildings, the authors expect a market reduction in energy and emissions, driven e.g. by improved insulation of buildings, phase-out of oil heating and increased electrification. The authors refer to the national emissions trading system as the most important individual policy in the programme of measures, yet do not disclose its actual effect (Kemmler et al. 2020, 86).

The modelling is based on a relatively steep price path: after the fixed-price period, the carbon price is assumed to increase sharply to reach 180 Euro in 2030 (corresponding to a price increase of 33 cent per litre of petrol, and 37 cent per litre of diesel). The authors also assume that consumers will anticipate the higher future prices in their investment and consumption decisions.

A second study arrives at more modest results. The estimation by Öko-Institut, Fraunhofer-ISI and others estimates that the climate protection programme will reduce German GHG emissions to 614 million tons in 2030, 51% below 1990 levels – but still about 70 million tons short of the target level of 543 million tons (55% below 1990 levels). The two sectors that are expected to be furthest off course for target achievement are transport (assumed to be 33 million tons above its 2030 sector target) and buildings (+ 17 million tons) (Harthan et al. 2020, 75).

The authors estimate that the biggest contribution to emission reductions in the transport sector will come from the tightening of vehicle emission standards, which is expected to reduce transport emissions by about 8 million tons below the baseline in 2030. The national ETS is expected to be the second biggest driver of emission reductions in transport, contributing 6 million tons in 2030. All other measures of the climate protection programme combined are expected to deliver another 8 million tons of emissions in the transport sector (Harthan et al. 2020, 46).

For the building sector, the authors underline that the national ETS has a double effect on emissions: by increasing the price of fossil energy, it strengthens the incentive for lowering heating demand and investing in improved insulation; and by lowering the price of electricity, it makes electrified heating (e.g. heat pumps) relatively more attractive. Yet, despite this, the overall effect of the national ETS on building sector emissions is estimated to be insufficient (Harthan et al. 2020, 42). In parallel, there are also plans to increase and differentiate the existing system of highway levies for heavy vehicles. From 2023, the Federal Government's Climate Protection Plan 2030 foresees that a CO_2 surcharge is added to the existing highway tolls, which would amount to a levy of 80 Euro per ton of CO_2. In parallel, heavy goods vehicles that use alternative fuels would expect to benefit from a reduction of highway tolls of up to 75%.

2.2.2.2 Current scope of the system and overlaps

In principle, the German national ETS should operate without overlaps with the EU ETS, in that the EU ETS covers the energy sector, energy-intensive industries and aviation, whereas the national ETS explicitly addresses the emitters not covered by the EU ETS, particularly land-based transport and buildings. Thus, at least in theory, it should indeed help to overcome some existing distortions – e.g. in transport, the EU ETS price incentive covered rail (which is predominantly electrified) and inner-European aviation, yet it did not cover road transport. Likewise, there is a price signal for electric mobility and electric heating, yet there is none for fossil transport and heating fuels. In this way, the introduction of a carbon price for fossil fuel emissions from land transport and buildings can help to correct some of the existing distortions and imbalances.

At the same time, due to the different regulatory approaches (upstream vs. downstream), it is inevitable that the two systems will overlap at the margin, as some fuels that are subject to the national ETS could also be used in installations covered by the EU ETS. Thus, if natural gas or heating oil that was intended for home heating (and thus covered by the national ETS) is instead delivered to an industrial facility that is covered by the EU ETS, the resulting emissions would in effect be priced twice. By contrast, if fuels that were intended for installations covered by the EU ETS – and which hence do not create a compliance obligation for the fuel distributor – are instead used in transport or to heat buildings, this would constitute a loophole to evade pricing altogether. The law establishing the national Emissions Trading System provides for these cases, in that fuels delivered to installations covered by the EU ETS can be exempted from obligations under the national ETS. In instances where such an exemption would result in disproportionate administrative effort, there could also be the option to compensate installations for such double taxation (Bundesministerium für Umwelt, Naturschutz und Nukleare Sicherheit (BMU) 2019b). A corresponding by-law is to be adopted by the end of 2020, yet specific provisions are not known yet. This also pertains to the legal liabilities involved, i.e. whether the fuel supplier or the customer is liable if fuel that was destined for an EU-ETS installation (and thus exempt from the national ETS) should end up being used in a transport or heating installation.

Other than a carbon tax, an ETS opens up the possibility of linking to other systems – both to the existing EU ETS, or to systems in other EU Member States, which would eventually lead to a common carbon price across countries and sectors (Edenhofer, Kalkuhl, and Ockenfels 2020). However, as yet, there are no concrete steps foreseen into this direction: as no other EU Member States appear inclined to move towards a national ETS for transport and housing, there are no national markets to link to. A possible link of the national ETS to the EU ETS through an opt-in raises legal questions, and was ruled out by the German government as legally not feasible (Bundesministerium für Umwelt, Naturschutz und Nukleare Sicherheit (BMU) 2019a). This leaves the political intention to work towards a common carbon price: in its cabinet decision on the cornerstones of a national ETS in October 2019, the Federal Government emphasised its intention to work with the EU Commission towards a European wide emissions trading system across all sectors (Bundesregierung 2019).

It should be noted that the German national Emissions Trading System was introduced as part of a much broader package of measures, several of which will also affect the incentives in the transport and housing sectors. Thus, for instance, an immediate step in the climate protection package was to lower the VAT rate on inner-German train travel from the standard rate of 19% to the discounted rate of 7%, in order to make this climate-friendly transport mode more attractive, and to provide offer an alternative to those affected by higher fuel prices. At the same time, the aviation tax on flight tickets was increased on 1 April – by 5.53 Euro to 13.03 Euro per ticket for inner-European flights, by 9.58 Euro to 33.01 Euro for medium-range flights up to 6,000 kilometres, and by 17.25 to 59.43 for long-haul flights.

In addition, the German government also announced that it will modify the vehicle tax in a way that makes high-emitting cars costlier. The CO_2 component of the vehicle tax should increase for cars emitting more than 95 grams and in a second stage from 115 grams output per kilometre for newly registered cars starting in 2021. With an output between 95 grams and 115 grams, the component should be doubled to € 4 per gram. Above 115 grams, an increase of € 5.50 is planned.

2.2.2.3 Price level / trajectory and relation to the EU ETS price

The national ETS will start with a period of five years, in which allowances will be sold at a fixed price. This price starts at 25 Euro in 2021, increases in 5-Euro steps to reach 35 Euro in 2023, and from there in 10-Euro steps to reach 55 Euro in 2025. In the fixed-price period, allowances will only be valid in the year in which they were issued, i.e. banking will not be possible for allowances issued in 2021 – 25. As of 2026, certificates will be auctioned. For 2026, a price corridor between 55 and 65 Euro is foreseen. For 2027 – unless the regulation should change – the price would be allowed to fluctuate freely. For petrol, the carbon price established in the national ETS corresponds to an increase of 6 cent per litre in 2021, increasing to 13 cents in 2025; for diesel and light heating oil, the price per litre rises by 7 cent in 2021, increasing to 15 cents in 2025. For natural gas, the price per kWh would increase by 0.5 cent in 2021, and by 1 cent in 2025.

The entry price of 25 Euro was the result of a negotiated procedure between the two chambers of parliament; the initial legislative proposal by the German government had foreseen a price of 10 Euro. The increased price level is close to the prices observed in the EU ETS at the time of the agreement – yet this linkage was at best a political one: while the legal text emphasises the need to introduce an effective carbon price in the sectors outside the EU ETS, it does not contain any references to the level of the EU ETS price as a consideration for setting the national ETS price.

Compared to the different proposals for a carbon pricing system that had been issued throughout 2019, the selected price pathway is below the range that different authors had identified as necessary to achieve the relevant climate targets (suggesting a starting price at around 40 Euro, increasing to 100 – 130 Euro by 2030). Thus, different scholars expect that the prices in the national ETS will need to increase significantly after 2026 (Edenhofer, Kalkuhl, and Ockenfels 2020; Harthan et al. 2020; Kemmler et al. 2020).

2.2.3 Poland

There is no economy-wide carbon tax in Poland. However, there are two taxes on energy use in place: (1) the excise duties that apply to liquid, gaseous and solid fossil fuels, as well as to electricity; and (2) the fuel surcharge (opłata paliwowa), taxing gasoline, diesel, biodiesel, natural gas, and liquefied petroleum gas (LPG) when used for automotive purposes (I4CE, 2019).

The implicit carbon tax rates in Poland cover 4% of the country's total greenhouse gas (GHG) emissions, and are the lowest among the European countries where carbon taxes were introduced (Tax Foundation, 2019).

In 2011, Poland introduced the so-called white certificates scheme (energy performance certificates), which is the key instrument to support energy efficiency. The scheme is operational since 2013, with substantial amendments from 2016. The energy efficiency obligation of 1.5% annually is imposed on all companies selling electricity, heat or natural gas to energy end-users.

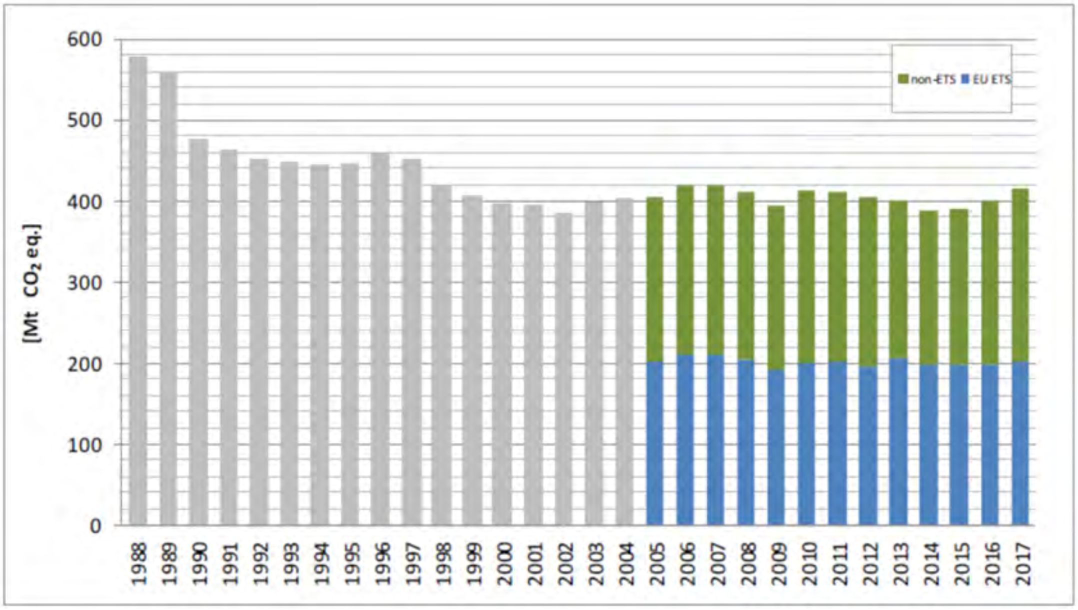
Polish NGOs have been lobbying for an economy-wide carbon tax, but so far there are no political commitments in this direction. The Polish National Energy and Climate Plan (MoSA, 2019) does not mention the possibility of introducing it either.

2.2.3.1 Description of the system / regime in place

CO_2 is the main greenhouse gas in Poland, accounting for 81.34% of Poland's GHG emissions in 2017 (336.56 Mio tonnes, excluding LULUCF). The trend of aggregated GHG emissions follows the trend of emissions of CO_2 and is demonstrated in Figure 1 below (KOBIZE, 2019). Between 1990 and 2017, Polish GHG emissions decreased with small ups and down. This reduction is mainly due to the public electricity and heat sector, as well as waste and agriculture (Transport & Environment, 2018). A slow decline in emissions (up to 2002) is related to the implementation of energy efficiency policies and measures. From 2014, GHG emissions in Poland started to rise again. The key reason for the significant increase in GHG emissions in the years 2016-2017 was, in addition to the economic development, a substantial increase in fuel consumption in road transport, which was triggered by an effective fight against shadow economy at fuel market started in 2016, as well as favourable fuel prices and an increase in the amount of vehicles (KOBIZE, 2019).

Transport is the fastest growing sector in Poland (Transport & Environment, 2018). It contributed around 63.4 Mt CO_2 to total GHG emissions in 2017 (15.1% of total). Of this, road transport was responsible for 97% (MI, 2019). Since 1990, when the share of traffic emissions was only 5%, domestic transport emissions have increased by 260% (KOBIZE, 2019; Transport & Environment, 2018). This rapid trend is a key obstacle to reducing overall emissions. With a Polish target to reduce CO_2 emissions from passenger cars by 30% below 2021 levels in 2030 (MoSA 2019), the entire sector finds itself under great pressure to innovate and decarbonise.

Figure 14. Trend of aggregated GHGs emissions (excluding LULUCF) for 1988–2017 according to source categories



Source: KOBIZE, 2019

As can be seen in Figure 14, in the period 2005-2017, on average, approximately 50% of the national emissions came from installations that fall under the EU ETS (ibid).

While there is no explicit economy-wide carbon tax in Poland, the country has implemented several measures to reduce CO_2 emissions in the transport and buildings sectors, which amount to an implicit carbon price. Thus, there are two taxes on energy consumption in Poland: (1) the excise duty that applies to liquid, gaseous and solid fossil fuels, as well as to electricity; and (2) the fuel surcharge (opłata paliwowa), taxing gasoline, diesel, biodiesel, natural gas, and liquefied petroleum gas (LPG) when used for automotive purposes (I4CE, 2019). These two energy taxes have been levied in Poland since 2004. They were introduced in the course of Poland's accession to the EU and the associated obligation to implement the Energy Tax Directive 2003/96/EC.

Excise duty

The objective and scope of the **excise duty** is laid down in the Polish Excise Duty Act (Sejm, 2004). The tax aims to make energy sources more expensive in view of their adverse effects on the environment. However, the tax rates are differentiated according to the type of fuel and not to their carbon content (and thus resulting CO_2 emissions).

There are two categories of excise duty that are of interest for this study: (1) excise duty on all types of fossil fuels (solid, liquid and gaseous) and (2) and excise duty on electricity. The excise duty is levied on energy carriers and electricity when used as motor fuel or fuel for heating.

The excise duties currently amount to 0,35-0,41 Euro/litre[30] for motor fuels including biofuels, around 0,27 Euro/litre for diesel incl. biodiesel, and around 0,01-0,05 Euro/litre for liquid heating fuels. For gaseous fossil fuels: around 2,4–3,3 Euro/GJ or

[30] Currency exchange rates of 4 March 2020 (www.xe.com)

3,14 Euro/GJ for gases intended for propulsion of internal combustion engines (LPG); 0,30 Euro/GJ for natural gas and other gaseous hydrocarbons intended for heating purposes. For solid fossil fuels, a tax of 0,30 Euro/GJ applies to coal and coke, however only for businesses that are not covered by the EU ETS, and not for households. Electricity is taxed with 1,16 Euro/MWh (Art. 88-89 Excise Duty Act).

Thus, the excise duties do not differentiate between the fossil component and the biofuel component for motor fuels. The excise duty is charged per 1,000 litres of motor fuel independently of its composition. Biodiesel is taxed at the same statutory rates as its fossil fuel equivalent. However, because the energy content of biodiesel per litre is lower, same statutory rates result in higher effective tax rates for biodiesel (OECD, 2019).

The excise duty on electricity, coal and gas products is regulated in Art. 9.1, 9a.1, and 9c.1 of the Excise Duty Act. The subject of this tax is the intra-Community acquisition, sale and consumption of these electricity, gas and coal products. There are also certain exceptions to this general rule. Thus, electricity generated from renewable energy sources is exempt (Art. 30.1 Excise Duty Act). Also, taxable transactions involving coal products shall be exempt from excise duty (Art. 31a.1 Excise Duty Act):

- when coal products are used in the process of electricity production
- when coal products are used by households, public administration bodies, educational institutions, kindergartens, medical institutions, social organisations, etc.
- when coal products are used for combined heat and power (CHP) generation

Similar to coal products, taxable operations involving gas products are exempt from excise duty when used in electricity production or in CHP generation (Art. 31b.1 Excise Duty Act).

In addition, biofuels used for heating in the residential and commercial sector, and LPG used for heating in residential sector are not taxed in Poland (OECD, 2019; OECD, 2018).

Excise duty is also levied on the purchase of passenger cars. Here, the excise duty rates are differentiated according to the engine capacity measured in cubic centimeters (cc). The following excise duty rates are applicable in Poland (Art. 105 Excise Duty Act):

- 3.1% for cars with engine cubic capacity below 2,000 cc
- 18.6% for cars with engine cubic capacity that exceeds 2,000 cc

Excempt from excise duty in Poland are electric vehicles and hydrogen powered vehicles (Art. 109a. 1 Excise Duty Act). Until 2021, owners of hybrid vehicles with a capacity of an internal combustion engine equal to or lower than 2,000 cc also do not need to pay an excise duty (Art. 163a.1 Excise Duty Act).

Fuel surcharge

The fuel surcharge applies to energy sources used in transport. This tax was not introduced for climate change considerations, but to generate financial income for the state. The proceeds from the fuel surcharge go to the National Road Fund (80%) and the Railway Fund (20%).

The fuel surcharge is regulated by the Act on toll roads and the National Road Fund (Ustawa o autostradach płatnych oraz o Krajowym Funduszu Drogowym) dated 27 October 1994, with subsequent amendments (Sejm, 1994). According to this act, the obligation to pay the fuel surcharge lies with

- the manufacturer of motor fuel or gas
- the importer of motor fuel or gas
- a company making intra-Community acquisition within the meaning of the provisions on excise duty on motor fuels or gas
- other companies that are subject to the excise duty on motor fuel or gas under the Excise Duty Act

Companies that are obliged to pay a fuel surcharge need to provide the customs office with information about the fuel surcharge. Companies are exempt from paying this fee if it results from international agreements on international road transport (Govt, 2019).

The amount of the fuel surcharge for road transport (applies to domestic and international road shipments) is determined on the basis of average market prices of fuel. Fuel prices fluctuate, so the fee is regulated up or down every month. Its amount is set one month in advance. From March 2020, the fuel surcharge rates for motor fuel and gas have increased. According to the Ministry of Infrastructure, the new rate for 1,000 liters of gasoline increased by 12.3% from PLN 138.49 (around Euro 30.53) to PLN 155.49 (around Euro 34.28). The fuel surcharge for 1,000 liters of diesel oils and products resulting from the mixing of these oils with biofuels and biofuels will increase by 5.5% from PLN 306.34 (around Euro 67.53) to PLN 323.34 (around Euro 71.28). Finally, the rate for 1,000 kg of gas will increase from PLN 170.55 (around EUR 37.60) to PLN 187.55 (around Euro 41.35), which means an increase of almost 10% (MI, 2020). According to the Ministry of Infrastructure, drivers will not feel these changes because the increase in the fuel surcharge is linked to a reduction in the excise duty (businessinsider, 2020).

Fuel taxation in Poland is not only a means of increasing the state budget, but also contributes to the internalisation of externalities. In transport sector, these externalities include societal costs of infrastructure, congestion, health problems related to pollution, etc. Moreover, it affects the long-term behaviour and choices of passengers and freight operators. Yet, in terms of environmental tax revenue as a share of GDP, Poland ranked in the bottom third among 34 OECD and 5 partner countries in 2014. Environmental tax revenue was 1.79% of GDP, compared to an average of 2.0% in the 39 countries. In Poland, almost all of this revenue came from energy taxes (92% of total environmental tax revenue) (OECD, 2019).

White certificates scheme

In addition to the tax instruments described above, Poland introduced the so-called white certificates scheme (energy efficiency obligation scheme) in 2011, which is the key instrument to support energy efficiency. The scheme was introduced to implement Article 7 of Energy Efficiency Directive (2012/27/EU; EED) (ENSPOL, n.d.). The EED required Member States to set national indicative energy efficiency targets. It also proposed a set of measures to facilitate the achievement of this objective and laid down rules for energy suppliers and end users. The proposed solutions became the basis of the Polish system based on energy efficiency certificates, the so-called white certificates scheme.

The Polish scheme was introduced by the provisions of the Energy Efficiency Act of 15 April 2011 (Sejm, 2011), which implements both the Energy Service Directive (2006/32/EU) and The Energy Efficiency Directive (2012/27/EU). According to the Energy Efficiency Act, the Polish white certificate scheme is an instrument to support investments to improve the energy efficiency of the Polish economy, to increase its competitiveness, and reduce energy consumption and CO_2 emissions.

Under the white certificate system, an energy efficiency obligation of 1.5% annually is imposed on all companies selling electricity, heat or natural gas to energy end-users (Stefaniak, 2017). It means that these obliged parties need to save at least 1.5% of energy sold to end energy consumers every year. The scheme covers the residential, commercial, and industrial sectors in respect of (ENSPOL, n.d.; IEA, 2019):

- energy efficiency end-use;
- energy savings in power stations;
- reduction of energy losses in electricity and natural gas transmission and distribution systems, and;
- heat losses in district heating.

The Polish white certificate scheme deals with energy efficiency in both the public and private sectors. In practice, however, individual households are excluded due to the minimum threshold of 10 tonnes of oil equivalent (toe), which makes the scheme inaccessible to individual users (ibid.).

Certificates are issued by the Energy Regulatory Office (ERO). An energy efficiency certificate can be obtained for an energy efficiency measure that results in an annual energy saving of at least 10 t_{oe} (minimum threshold), or for a group of measures of the same type with a combined energy saving effect of more than 10 t_{oe} (NIK, 2020).

When requesting the white certificate, a company declares how much less energy it will consume due to the planned investment in energy efficiency measures or modernisation, i.e. through rebuilding or renovating a building, including renovation of installations and technical devices or modernisation of local district heating systems. If they have surpassed their energy efficiency improvement obligation, companies can sell the white certificates issued by the ERO on the Energy Commodity Market. On the other hand, companies can also meet their energy efficiency obligations by paying substitution fee to National Fund for Environmental Protection and Water Management. The substitution fee amounted to PLN 1,500/t_{oe} (Euro 329,55/t_{oe})[31] in 2017. The fee increases by 5% annually, and thus reached PLN 1,736.43/t_{oe} (Euro 380,60/t_{oe}) in 2020 (Deloitte, 2016).

It has to be noted that the Polish white certificate scheme did not work well before 2016. The main shortcomings included:

- complicated and confusing formal procedure of application for white certificates
- lack of possibility to correct formal mistakes in the process of application
- short application time (complete application needed to be submitted within 30 days after the announcement of the tender)
- long procedure of evaluating and granting certificates
- exclusion of projects that were implemented in installations covered by the ETS from the tender
- the scheme insufficiently contributed to development of energy services market related to increasing energy efficiency (Skoczkowski/ Węglarz, n.d.)

In 2016, the Polish white certificate system was amended fundamentally. As a result, white certificates are granted only for planned energy efficiency investments or those finished after 2013. In addition, the auctioning system has been replaced with a

[31] Currency exchange rates of 4 March 2020 (www.xe.com)

continuous and permanent call for energy saving investment. White certificates are now granted to everyone who implements an energy efficiency measure. The 2016 Energy Efficiency Act also introduced many changes to the substitution fee. It envisaged a gradual phase out of the possibility to pay the substitution fee instead of carrying out the energy efficiency investments (30% in 2016; 20% in 2017; 10% in 2018). The Substitution fee was increased by 50% in 2017 and an annual increase by 5% was introduced. Finally, the possibility to meet the obligation by paying a substitution fee has been limited only to situation when there are not enough white certificates on the market. One of the key amendments was that from June 2016, installations covered by EU ETS are also covered by the white certificate scheme. It was not the case before (Skoczkowski/ Węglarz, n.d.; WysokieNapięcie.pl, 2020).

Due to the amendments to the Polish white certificate scheme in 2016, the market value of white certificates in Poland is expected to be around 1 billion Euro in the years 2016-2020. It corresponds to an increase in electricity price increase of 1.3% in 2020 (Innopaths, 2017).

Effectiveness/ efficiency of the national implicit carbon pricing instruments

No studies or reports could be found that would analyse the effectiveness or efficiency of the national implicit carbon pricing instruments in Poland. However, the GHG emission trends in transport and buildings in the past decades suggest that, together with other policy instruments, they did not effectively contain the growth of GHG emissions, let alone reduce them: Between 1990 and 2017, however, the country's emissions increased by 230%, which is the largest increase among all EU member states. The EU average is 24% (EEA, 2019).

Regarding the white certificate scheme, the Supreme Audit Office (SAO) concluded in 2020 that, despite the changes to the Energy Efficiency Act in 2016, it does not function properly. Companies that are obliged to obtain the so-called white certificates prefer to pay a substitution fee, which is currently permitted under the Energy Efficiency Act and is a convenient alternative to buying white certificates from the market or by investing in energy efficiency measures. Moreover, the rules on the issue of white certificates favour investments that bring the greatest energy savings in the shortest time, and provide less incentives for projects that lead to savings in the long term. According to the data published by SAO, from October 2016 to the end of 2018, the Energy Regulatory Office received nearly 2,422 applications for white certificates. As of end of 2018, ERO issued 595 white certificates (38 application were refused and the remaining once were still under review). 369 certificates were issued for planned projects totalling 104,973.994 t_{oe} of energy savings and 226 certificates for completed projects totalling 28,860.899 t_{oe} of energy savings (NIK, 2020).

The greatest number of white certificates in the period from October 2016 to the end of 2018 were issued for:

- the reconstruction or renovation of a building, including technical installations and equipment (204 white certificates), and
- the reduction of losses in heating (107 white certificates) (ibid.)

2.2.3.2 Current scope of the regime and overlaps

The EU ETS covers power stations and other combustion installations with >20MW thermal rated input (except hazardous or municipal waste installations), industry (various thresholds) including oil refineries, coke ovens, and iron and steel plants, as well as production of cement, glass, lime, bricks, ceramics, pulp, paper, and board (ICAP, 2020). Thus, a large share of the CHP plants and district heating are regulated under the EU ETS. When discussing the extension of the EU ETS to buildings sector, the question is whether to include emissions also from combustion installations below the threshold, the so-called small emitters or installations. Most of the energy used in heating, like single boilers and heating of individual buildings with fossil fuels, fall outside the scope of the EU ETS. In general, emissions from the non-ETS sector are regulated with other means, typically a combination of taxes and command-and-control regulations, like energy efficiency measures (GreenStreem, 2015).

In the case of Poland, energy used for heating in buildings in Poland is taxed with the excise duty. Moreover, the white certificate scheme aims at increasing energy efficiency both in the public and private sectors (see Section 1.3.1).

While the consumption of electricity, coal and gas products for heating is taxed with the excise duty, certain exemptions apply to households. With regard to coal products, the excise is not applied if these energy carriers are used for heat generation by any private households. This exemption covers both heating devices in individual houses and multifamily buildings connected to district heating systems. In addition, the excise tax is not applicable when coal is used for heating purposes in certain public institutions/organisations (e.g. public administrative bodies, educational institutions, kindergartens, medical institutions). Finally, coal and gas products are exempt from excise duty if they are used to generate energy in CHP plants (Art. 31a.1, Art. 31b.1 Excise Duty Act).

This means that many of the so-called small emitters or installations that do not fall under the EU ETS are also not taxed with excise duty in Poland. However, small, coal-fired district heating systems are not only CO2 emitters, but are also a key source of air pollution in Polish urban areas. Poland has more than 400 small district heating systems; 90% of these rely on coal (Bayer/ Cowart, 2018). The Polish heating sector is responsible for 62 Mio. tonnes of CO2 emissions every year – about 15% of total emissions, contributing about as much as the entire transport sector. Since 80% of district heating systems are inefficient according to Energy Efficiency Directive standards, they will not be able to benefit from public aid. Without financial support from the state, owners of district heating systems will increase heat prices to cover their financial loses (Forum Energii, 2019).

The role of coal in power and heat generation in Poland far exceeds that of any other energy source 86% of heat is generated from coal, even more than for electricity (81%). Gas and biofuels account for 7% and 5% of heating energy respectively. The role of oil, hydro and other sources is nearly insignificant (ibs, 2018).

With regard to the white certificates scheme, from 2016 every installation covered by the EU ETS is also included in the certificate scheme, provided that their owners take measures to improve their energy efficiency. The aim of this amendment was to accelerate the process of increasing energy efficiency in Poland (Skoczkowski/ Węglarz, n.d.). The white certificate scheme covers the residential, commercial, and industrial sectors in terms of energy efficiency for end-use; energy savings with additional equipment in power plants; reduction of energy losses in electricity and natural gas transmission and distribution systems; and heat losses in district heating networks. In practice, however, due to the minimum threshold of 10 t_{oe}, individual households are not eligible for the white certificate scheme (see Section 1.3.1). So, with regard to heat generation, the small emitters and installations (e.g. private single-familiy homes) are covered neither by EU ETS nor by the excise duty, nor the white certificate scheme.

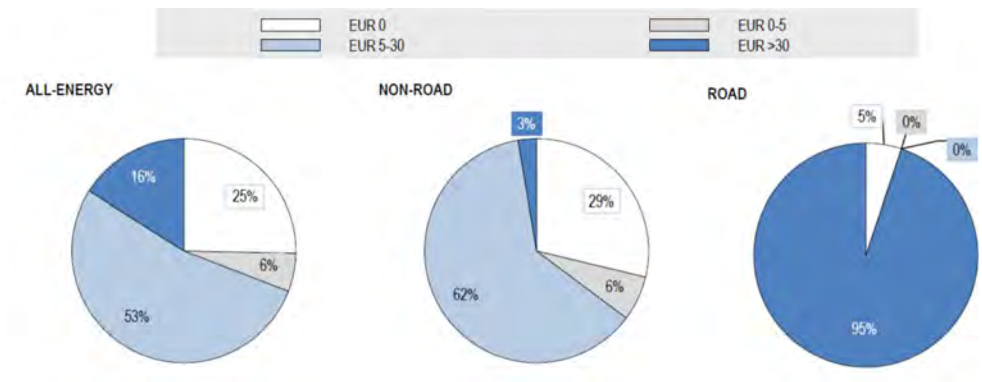
In terms of transport sector, there are no overlaps with the EU ETS, while road transport is exclusively subject to the national tax instruments (excise duty and fuel surcharge).

2.2.3.3 Implicit carbon price and interactions with EU ETS

In Poland, tax instruments price 62% of CO_2 emissions from energy consumption, while the EU ETS prices 53% of CO_2 emissions (see Table 1 below). The sectors with the highest tax coverage are electricity with 100% and road transport with 95%. The sectors with the highest price coverage by the EU ETS are electricity with 93% and industry with 67% (OECD, 2016).

According to OECD's 'Effective Carbon Rates' (OECD, 2016), 25% of CO_2 emissions from energy use in Poland face no price signal at all, while 69% face a price ≥ Euro 5 per tonne of CO_2; and 16% face a price ≥ Euro 30 per tonne of CO_2. If road use is excluded, no price signal at all face 29% of CO_2 emissions from energy use, while 65% face a price ≥ Euro 5 per tonne of CO_2 and 3% face a price ≥ Euro 30 per tonne of CO_2 (see Figure 15 below).

Figure 15. Distribution of Effective Carbon Rates (ECR) on CO_2 emissions from energy use in Poland



Source: OECD, 2016

Table 2 below shows the average price signals from taxes and trading systems, and the share of emissions priced by these instruments.

Table 2. Distribution of Effective Carbon Rates (ECR) on CO_2 emissions from energy use in Poland

	CO_2 emissions by sector (in t CO_2)	Tax		ETS		Overlap of tax and ETS[5]	Emissions not priced by tax or ETS
		Average price (in EUR/tCO_2)	Share of emissions priced	Average price (in EUR/tCO_2)	Share of emissions priced		
Agriculture & Fishing	12 473	127.1	45%	7.2	1%	0%	55%
Electricity	120 520	5.3	100%	7.2	93%	93%	0%
Industry	87 644	10.6	30%	7.2	67%	20%	24%
Offroad transport	1 012	127.2	35%	7.2	56%	19%	29%
Residential & Commercial	56 826	9.0	8%	7.2	0%	0%	91%
Road transport	47 301	137.7	95%	0.0	0%	0%	5%
Total[4]	**325 774**	**24.2**	**62%**	**3.8**	**53%**	**40%**	**25%**

Access the data for all 41 countries: http://oe.cd/emissionsdata

[4]Total average prices are weighted by the share of emissions in each sector that is priced in the country.

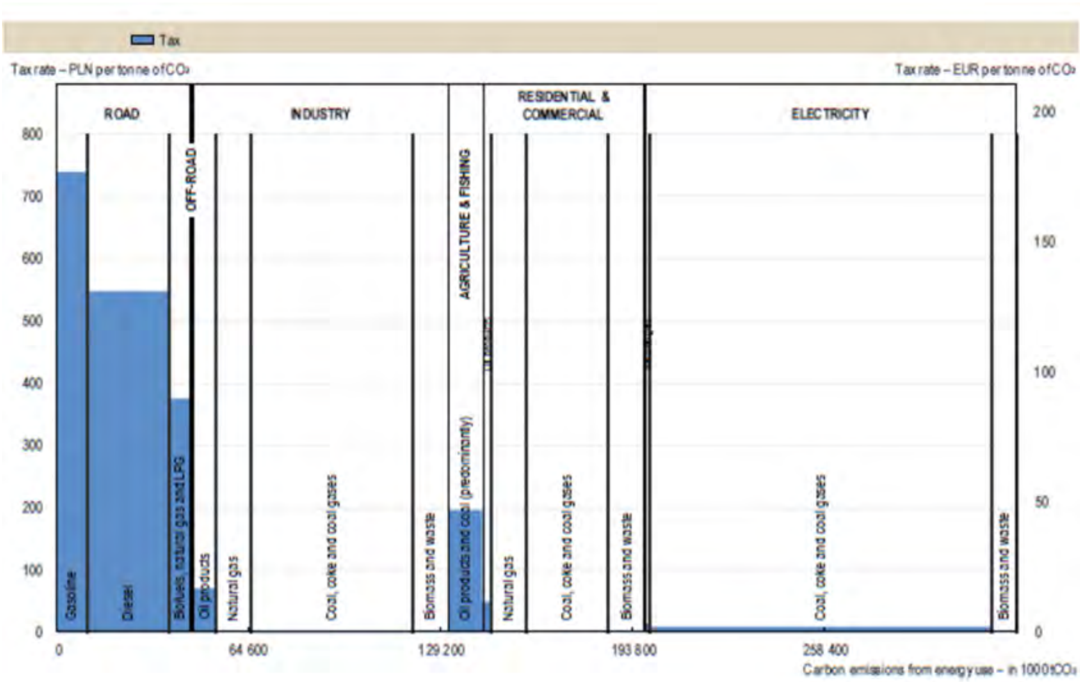
[5]Tax and ETS can apply to the same emissions base. The overlap describes the percentage of emissions in a sector that is priced by both tax and ETS.

Source: OECD, 2016

In Figure 16 below, effective tax rates are presented that were applied on energy use in Poland in 2015 (in Euro/tCO_2). The rates include electricity output taxes and carbon emissions from biomass. As can be seen from Figure 2, road sector is taxed at the highest rates, both in terms of the fuels' energy and carbon content. Gasoline is taxed at the highest effective tax rate of around 180 Euro/tCO_2, diesel and LPG are also taxed, but the effective tax rate is lower than the rate on gasoline in terms of TJ and in terms of CO2. Diesel is taxed with around 137 Euro/tCO_2 and LPG with around 92 Euro/tCO_2. Biodiesel is taxed at the same statutory rate as its fossil fuel equivalent. Biogasoline, however, is not taxed (OECD, 2018).

Oil products used in the buildings sector are taxed, but there are a number of exemptions. Coal and coke, for example, which are used in CHP generation or for households' heating, are not taxed. LPG is also not taxed if it is consumed for heating purposes in households (see Section 1.3.1) (ibid.).

Figure 16. Effective tax rates on energy use in national currency and EUR/tCO2, 2015, including electricity output and carbon emissions from biomass



Source: OECD, 2018

The implicit carbon tax rates in Poland are the lowest among the European countries where carbon taxes were introduced (see Figure 3). According to data from OECD and World Bank, as of 2019, Sweden levied the highest carbon tax rate at Euro 112.08 per ton of carbon emissions, followed by Switzerland (Euro 83.17) and Finland (Euro 62.00). The lowest carbon tax rates could be observed in Poland (Euro 0.07) and Estonia (Euro 2.00) (Tax Foundation, 2019; OECD, 2019a; WB, 2019). This means that the explicit carbon price in Poland is $^{1}/_{300}{}^{th}$ of the current price in the EU ETS, and $^{1}/_{1,600}{}^{th}$ of the highest carbon price found in Europe.

Thus, it can be concluded that both taxes on energy consumption – the excise duty and fuel surcharge - are way too low to drive the decarbonization of both relevant sectors - transport and buildings (Third Way, 2020). Although carbon pricing is widely recognized as one of the most effective tools for reducing greenhouse gas emissions, Poland currently has no plans to introduce an explicit economy-wide carbon tax (MoSA, 2019). Polish NGOs support the idea of introducing an explicit carbon tax in Poland, but there are no concrete proposals on the scope and design of this tax. So far, NGOs have only popularized this idea. In addition, Polish and European think tanks recommend gradually increasing the excise duties on fossil fuels to strengthen the existing implicit carbon pricing policy in Poland and call for taxation of gas and coal used by Polish households. However, the exemption for coal and gas consumed in households is still in place (ECF et al., 2012).

The Polish white certificate scheme, with its annual energy saving obligation of 1.5% imposed on companies selling electricity, heat or natural gas to energy end-users, seems to be a more impactful instrument compared to the implicit carbon taxes. In practice, however, obliged companies prefer to pay a substitution fee instead of buying white certificates from the market or investing in energy efficiency measures (see Section 1.3.1).

2.2.4 Spain

While there is no economy-wide carbon tax in Spain, several relevant policies and legislation are in place. In 2014, Spain adopted a tax on emissions of fluorinated greenhouse gases, which is considered to be a carbon tax, but limited in scope (Law 16/2013). In addition, the Autonomous Community of Catalonia approved a carbon tax for vehicles emitting CO_2 in 2019 (Law 9/2019).

Several taxes are levied on energy consumption (OECD, 2019):

- Tax on **Hydrocarbons** (Impuesto sobre Hidrocarburos) applied to liquid and gaseous fuels (incl. biofuels), coal tar, crude oil, waste oils and coal and coke-related gases;
- Special Tax on **Coal** (Impuesto Especial sobre el Carbón), which taxes coal and coke products (excl. peat); and
- the Special Tax on **Electricity** (Impuesto Especial sobre la Electricidad), an ad-valorem tax addressing electricity consumption by end users.

Different academics (Jofra Sora et al, Villar, Carretero, Buñuel González, Montes Nebreda) have been pushing for a national carbon tax, but so far there are no formal political commitments in this direction. The National Energy and Climate Plan (NECP, 2019) does not include an explicit commitment to a carbon tax, but states that the Ministry of Finance will analyse whether to carry out a comprehensive revision and reform of the country's environmental taxation, which could contribute to a low-carbon economy by internalizing the negative externalities arising from the use of certain fuels and technologies.

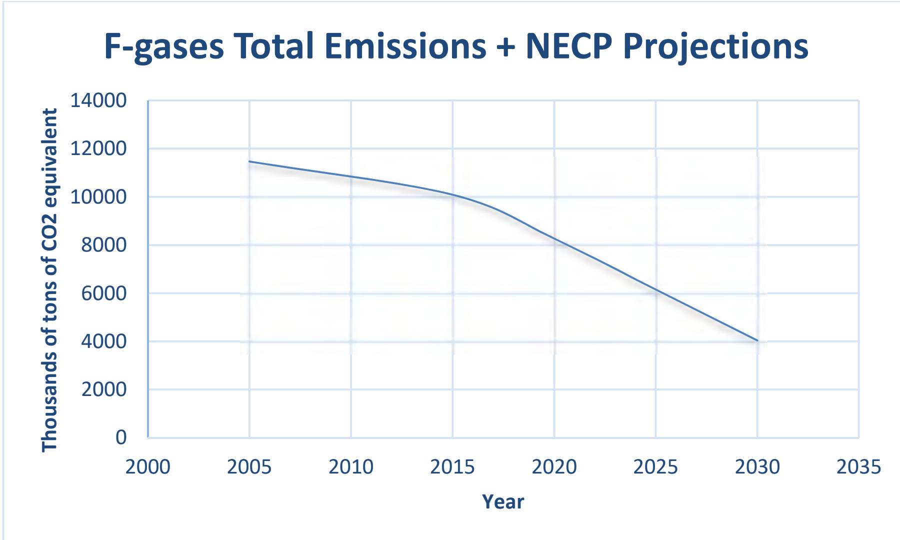
2.2.4.1 Description of the system / regime in place

Spain is part of the EU ETS and it has neither a national ETS, nor an economy-wide carbon tax. However, Spain has several other pieces of regulation on GHG and other relevant policy measures. In this section, both explicit carbon price and implicit carbon price measures are explained.

Explicit carbon price

While Spain does not have a general tax on CO_2 emissions, there has been a tax on fluorinated greenhouse gases since 2014, introduced by Law 16/2013 (Measures in the field of environmental taxation and other tax and financial measures). It is an indirect tax levied on the consumption of certain F-gases according to their global warming potential (Sastre, 2016). The tax applies to the following fluorinated greenhouse gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and preparations containing these substances, including regenerated and recycled gases and excluding those substances in Regulation (EC) No. 1005/2009 of the European Parliament and of the Council, of 16 September 2009, on substances that deplete the ozone layer (Sastre, 2016). Since it only applies to fluorinated gases, it taxes only 3 per cent of the country's total greenhouse gas emissions (Asen, 2019). Despite the small percentage, according to the Spanish National Energy and Climate Plan (NECP, 2020), this tax has had a positive effect reducing and transforming the sector, as it can be appreciated in the graph below.

Figure 17. Tax impacts on fluorinated gas emissions in Spain



Source: Ecologic elaboration based on NECP (2020)

To put this carbon tax in context, Sastre (2016) explains that the adoption of the tax followed a top-down approach led by the Ministry of Agriculture, Food and Environment. The high costs of Spain's GHG emissions and pressures from EU and domestic tax experts for a green tax reform contributing to budget consolidation were relevant elements that explain the adoption of the tax. Although the EU and national stakeholders were advocating for a deeper green tax reform, the outcome was a tax that only covers the 3 per cent of Spain's total GHG emissions.

The stated purpose of the Law 16/2013 is to introduce a fiscal mechanism to correct environmental externalities caused by the emission of GHG, which is fundamental for a sustainable economy. In addition, in the case of Spain, environmental tax measures are justified by the provisions of Article 45 of the Spanish Constitution, which enshrines the protection of the environment. Environmental taxation is, therefore, a complementary means of contributing to the protection and defence of the environment, and is based on tax figures whose purpose is to stimulate and encourage behaviour that is more respectful of the natural environment (Law 16/2013).

The tax is levied on the 'final consumer', which is defined by the law as: a) the person or entity purchasing the F-gases for incorporation into products or for end-use in their plant or equipment; b) the person or entity acquiring the F-gases for use in the manufacturing of equipment, as well as for charging, recharging or maintaining their customers' equipment. In addition, the tax only applies to companies which install or repair equipment for refrigeration using less than 3kg of F-gases and companies installing air conditioning in vehicles (Sastre 2016). For these purposes, vehicles are understood as any means of transport for persons or goods, except for railways, boats and aircraft.

The taxable events are: a) the first sale or delivery of F-gases after production, import of intra-community acquisition (including resales between companies), and b) the self-consumption of F-gases by producers, importers and intra-community purchasers. The first entry of all F-gases into the Spanish market has to be declared to the Spanish Tax Agency. Exports from Spain and F-gases with a warming potential equal or below 150 are not subject to the tax. Law 16/2013 includes exemptions, for instance, the first sale or delivery of F-gases by economic agents devoted to resale only, i.e. not using F-gases in their production processes.

Moreover, the consumer of the F-gas pays the tax to the provider of it, which collects revenues and pays annually to the Ministry of Finance. (Sastre, 2016). The tax is paid by about 7419 installations, such as Manufacturers, importers and intra-community purchasers and other resellers (Tax Agency, 2015).

The tax is charged according to the warming potential of F-gases. The tax rate is the result of applying the coefficient of 0.02 to the warming potential corresponding to each fluorinated gas, with a maximum of 100 euros per kilogram (Law 16/2013). For example, for sulphur hexafluoride, with a warming potential of 22,200, the tax rate equals 100 EUR/Kg. To avoid strong negative impacts in the competitiveness of the refrigeration industry, Spain decided to gradually increase the tax on F-gases. During 2014, the tax rate was reduced to 33 EUR per kilo, and during 2015-2016 the tax rate equalled 66 EUR per kilo. In 2017 the full tax rate of 100 EUR per kilo was implemented. However, in 2018, the coefficient of 0.02 was reduced by law to 0.015.

According to the World Bank (2019) the Spanish carbon tax rate was originally equal to EUR20/tCO2e, and was reduced to EUR15/tCO2e in 2018 (due to the reduced coefficient introduced by Law 6/2018).

The revenues collected by the tax on F-gases is not earmarked, hence, the revenues are assigned to the general budget. The Tax Agency published information on the tax collection, that can be appreciated in the table below.

Table 3. F-gas tax collection revenues

Tax Revenues (in million euros)						
2014	2015	2016	2017	2018	2019	2020
31	99	95	120	110	81	22

Source: Ecologic elaboration based on data from the Tax Agency (2020).

While there is no nation-wide carbon tax in Spain, the region of Catalonia was the first Spanish Autonomous Community to introduce an **explicit carbon tax on cars, vans and motorcycles** that emit CO_2. The law was passed in 2017 (Law 16/2017, Catalan Climate Change Law), but the central government considered the law to be unconstitutional and appealed to the constitutional court. Following the court's ruling that the Catalan law was partly unconstitutional, the Catalan government amended it through Law 9/2019 (Amendment to Catalan Climate Change Law).

The Catalan tax levies the carbon dioxide emissions produced by mechanical traction vehicles. The taxable event is, therefore, the $C0_2$ emissions of vehicles that are suitable for use on public roads and which fall in one of the stated categories of Article 41 of the Catalan Law. It's a periodic tax, paid every year.

The tax base is constituted by the CO_2 emissions of the vehicle, which coincides with the official emissions stated in the certificate issued by the manufacturer or importer of the vehicle. All vehicles that emit 95 g CO_2/km or more will be taxed. The amount to pay varies according to the quantity emitted. For instance, the owner of a vehicle that emits between 95g/km and 120g/km will pay 0.70 EUR/gCO_2/km, and the owner of a vehicle that emits more than 200g/km will pay 1.40 EUR/gCO_2/km.

As stated in Law 9/2019, taxation will be applied retroactively for 2019 (Manthey, 2019). The Catalan government expects to raise about 150 million euros a year, which will be allocated to both the Climate Fund and the Natural Environment and Biodiversity Fund. The Climate Fund will incentivise and subsidize the purchase of clean vehicles, improvements to public transport, the promotion of renewable energies and energy-efficient housing (Government of Catalonia, 2019).

Implicit carbon price

According to the Country Note elaborated by OECD (2019), the main taxes on energy use in Spain are: a) the Tax on Hydrocarbons that applies to liquid and gaseous fuels, including biofuels, as well as to coal tar, crude oil, waste oils, and coal and coke-related gases; b) the Special Tax on Coal applied to coal and coke products (excluding peat); and, c) the Special Tax on Electricity, an ad-valorem tax applied to electricity consumption by end users.

The objective scope of the tax on hydrocarbons, introduced by Law 38/1992, is hydrocarbons and products used as fuels, as additives or to increase the final volume of certain fuels. The tax rate of the tax on hydrocarbons depends on the type of oil concerned and is expressed in euro per litre or euros per ton or euros per gigajoule. For example, for unleaded gasoline with 98 octane rating or more, the tax rate is 0.50392 EUR per litre; for the remaining unleaded gasoline the tax rate is 0.47269 EUR per litre; and for diesel the tax rate is lower at 0.379 EUR per litre. LPG has a tax rate of 57.47 EUR per tonne if it is for general use, and a tax rate of 15 EUR per tonne for non-fuel purposes. Natural gas is taxed at 1.15 EUR per GJ, for general use; 0.65 EUR per GJ for use as fuel in stationary engines and 0.15 EUR per GJ for commercial purposes, provided that it is not used in combined heat and power processes and direct or indirect electricity generation.

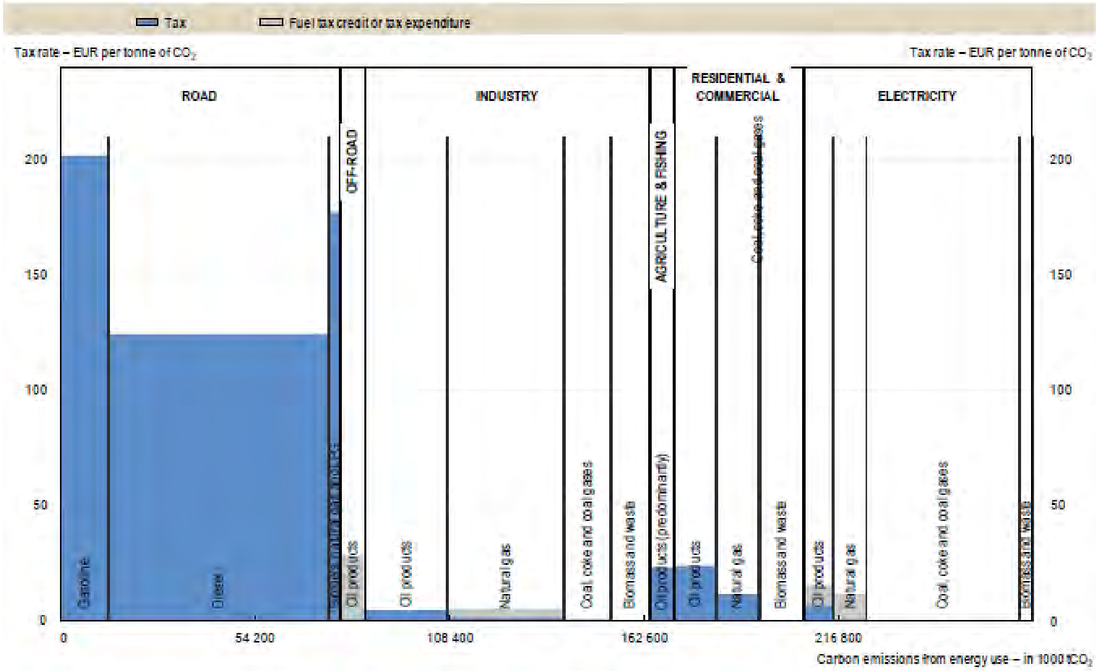
In addition, in 2018, the Royal decree-law 15/2018 modified the tax on hydrocarbons, by introducing an exemption for energy products intended for use in the production of electricity or for combined heat and power generation in power stations (mainly natural gas plants). The reason, according to the decree-law, is to avoid that natural gas power plants transfer the tax to the wholesale market price (when they are the marginal plants setting the price). However, this exemption does not include coal-fired power plants, which are subject to the special tax on coal.

The special tax on coal was introduced as a consequence of the transposition of Directive 2003/96/EC, and was included in Law 38/1992 in 2005. The taxable event is configured by the consumption of coal, meaning the first sale or delivery of coal within the territory, after production or extraction, import or intra-Community acquisition of coal. As the Directive allows for non-liability or exemption, the introduction of the coal tax should not, in general, represent a tax burden effective for the coal consumed in Spain. Its tax rate equals 0.65 EUR per GJ (REAF, 2019).

The special tax on electricity (Law 38/1992), taxes in a single phase the supply of electricity for consumption, as well as consumption by producers of the electricity generated by themselves. The law 38/1992 prescribes that the tax shall be charged at the rate of 5.11269632%. In addition, the payments resulting from the application of the tax rate may not be less than: a) 0.5 EUR per MWh for electricity supplied for industrial purposes, and b) 1 EUR per MWh for electricity supplied for other purposes.

In the following figure elaborated by OECD (2018), it can be appreciated the effective tax rates on energy use in EUR/tCO_2 for 2015, including electricity output taxes and carbon emissions from biomass. In the road sector, gasoline has an effective tax rate of 200 EUR/tCO_2 and diesel has a lower tax rate that equals 125 EUR/tCO_2. The reason behind this difference is that the special tax on hydrocarbons differentiates between them and puts a lower tax rate for diesel. However, the government is planning to reform the environmental tax system and increase the tax rate on diesel to be at the same level as gasoline (El Economista, 2020). LPG, natural gas and biofuels have an effective tax rate of 175 EUR/tCO_2. In the residential and commercial sector, oil products have an effective tax rate of approximately 24 EUR/tCO_2 and natural gas approximately 11 EUR/tCO_2.

Figure 18. Effective tax rates on energy use in EUR/tCO_2, 2015, including electricity output taxes and carbon emissions from biomass



Source: OECD, 2018

Moreover, Spain taxes the road, off-road, industry, agriculture, residential and electricity sectors with taxes (OECD, 2019). On the one hand, the effective fuel excise tax rate for the road sector was 10 EUR per GJ for diesel and 15 EUR per GJ for gasoline. On the other hand, for the residential sector, the effective fuel excise tax is lower than 5 EUR per GJ for diesel, liquefied natural gas (LPG) and natural gas (OECD, 2019).

2.2.4.2 Current scope of the carbon pricing regime

As introduced in the previous section, there is neither a national ETS, nor a nation-wide carbon tax in Spain. However, this section explores if there are overlaps and/or gaps between the Spanish taxes and policies with the EU ETS.

The EU ETS affects around 900 industrial and electricity generation facilities in Spain, as well as more than 30 active air operators. The GHG emissions subject to this regime account for around 40% of the national total (NECP, 2020).

The EU ETS also includes PFC emissions, but only from aluminium production. Duran (2015) concludes that the Spanish tax does not overlap with the EU ETS, since the specific events taxed at the national level (companies which install or repair equipment for refrigeration using less than 3kg of F-gases and companies installing air conditioning in vehicles) are not included among the cases charged at the European level.

At the Spanish regional level (Catalan Autonomous Community), Law 9/2019 (Amendment to Catalan Climate Change Law) introduced the first carbon tax for vehicles based on CO_2 emissions. The regulation contains neither an explicit nor an implicit mention of the EU ETS, so the legislator did not consider the possibility of overlaps or gaps with the EU ETS. However, the taxable event is indeed the CO_2 emissions of vehicles, so an overlap would occur if the EU ETS scope is expanded to include emissions from the road transport sector.

If non-EU ETS emissions are considered, the transport and building sector demands special attention. In Spain, the non-EU-ETS sectors were responsible for 61% of total GHG emissions in 2018 (GHG Inventory Report, 2020). The remaining 39% corresponds to sectors covered by the EU ETS.

Building and Transport sectors

As a general principle, all fossil fuels for transport, as well as heating and industrial fuel oil, are subject to taxation (OECD, 2015).

Firstly, the GHG emissions from the **building sector** in Spain originate from fuel combustion in residential, public and commercial buildings (typically from heating and warm water). Emissions from electricity consumption and fluorinated gas emissions are not part of the building sector.

In 2017, the Ministry of Transport, Mobility and Urban Agenda published a report on the heating sector. Non-renewable energy sources represent the 65.5% of the total energy used for heating in the building sector. The most important source is natural gas (and oil products), followed by electricity and carbon is practically inexistent. The remaining percentage (34.5%) corresponds mainly to biomass. The NECP (2020) points out that energy consumption for thermal uses in 2015 accounted for more than 33% of total final energy consumption. In the same year, the contribution of renewable energies to the consumption of heating and cooling was around 16.8%.

According to OECD (2019), while fossil fuels used for heating in the residential and commercial sectors are taxed, biofuels are not. Fossil fuels are taxed by the special tax on hydrocarbons and the special tax on coal. However, the Royal decree-law 15/2018 introduced an exemption in the special tax on hydrocarbons for the production of electricity in combined cycle plants and natural gas cogeneration plants. According to the Minister for the Ecologic Transition, this exemption cuts the electricity bill paid by final consumers up to 2% (Roca, 2018). However, this exemption does not include coal-fired power plants, which are subject to the special tax on coal.

Electricity used for heating is also taxed, through the special tax on electricity, which is an indirect tax on the consumption of electricity.

There are in place other policy measures that aims to decarbonize the building sector. In December 2019, the Royal Decree Law 732/2019 amended the Building Code of 2006 to introduce renewable energy measures, especially related to energy savings. The royal decree regulates various technical and energy requirements for new buildings and existing buildings that undertake renovations. According to the amendments, the buildings (residential and non-residential) have to use predominantly energy from renewable energy sources to heat water and swimming pools: The minimum renewable energy contribution is 70% of the annual energy demand of the building. In addition, the decree requires non-residential buildings larger than 3.000 m^2 to install a renewable energy generation system for self-consumption or for grid supply. The mandatory installed capacity varies according to the building size (between 30kW and 100 kW). Finally, the primary non-renewable energy consumption of the interiors of buildings cannot be larger than those specified in the decree law.

There are also incentive programs to reduce emissions from the building sector. Specifically, the Royal Decree 235/2013 (Basic procedure for the certification of the energy performance of buildings) states that all new buildings constructed after 31 December 2020 have to be nearly zero-energy buildings. In addition, all new buildings whose construction starts after 31 December 2018 and which are in public ownership shall also be nearly zero-energy buildings.CO_2 emissions from the **transport sector** mostly originate from road transport, but also domestic shipping, pipeline and aviation. The emissions associated with rail transport in electric traction (75% of the energy used, Ministry for the Ecologic Transition) and almost all national air transport are included in the EU ETS (Ministry for the Ecologic Transition and the Demographic Challenge).

As explained above, to protect the competitiveness of the refrigeration industry, Spain decided to gradually increase the tax rate on F-gases from 33 EUR per kilo in 2014 to the full tax rate of 100 EUR per kilo in 2017. In 2018, the coefficient of 0.02 was reduced to 0.015 (Ley 6/2018). According to the World Bank (2019) the Spanish carbon tax rate was originally equal to EUR20/tCO2e, and was reduced to EUR15/tCO2e in 2018 (due to the reduced coefficient introduced by Law 6/2018).

2.2.4.3 Plans for the future evolution of the system

While there are taxes on fossil fuels that function as a carbon tax, there is no explicit nation-wide carbon tax in Spain, based on the carbon content of fossil fuels. However, different authors have explored the possibility of introducing a carbon tax for the entire country. For instance, Buñuel González (2015) explains that a possible carbon tax would need to recognise that half of the CO_2 emissions are already priced through the EU ETS. To avoid overlap, Buñuel González proposes that "emitters subject to the EU ETS are exempted from paying the carbon tax, which is the easiest alternative to reconcile both instruments" (2015, p. 5). Another possible option would be to allow "taxpayers to deduct the amounts paid for the purchase of EU ETS allowances" (Buñuel González, 2015, p. 6). The study forecasts potential revenues of up to 4 billion EUR annually.

Villar (2018) also advocates for a reform of the Spanish environmental taxation system, to include more taxes covering different activities, depending on the pollutant load or quantifiable environmental damage, such as CO_2, NOx emissions, among others.

The National Energy and Climate Plan (NECP, 2020) considers it necessary to reform the current system of the Mechanical Traction Vehicles Tax. The new rates should be based on the emission of pollutants. The idea is to fiscally penalize the owners of vehicles that are more harmful to the environment and vehicles with higher fuel consumption. Such measures could form part of a green tax reform analysed by the Ministry of Finance.

In addition, The National Energy and Climate Plan (NECP, 2020) suggests reforming the Special Tax on Certain Means of Transport since 74% of registered vehicles are not subject to this tax, because they remain below the threshold of 120 gCO_2/km. The goal would be to subject a larger share of vehicles to the tax based on their CO_2 emissions

From the official side, the Ministry for Ecological Transition is working on a Climate Change Law, but it is unclear whether it will include an economy-wide carbon tax. No political party mentioned it in their 2019 election programmes, which makes it unlikely that concrete steps will be taken in 2020 (Drews, van den Bergh and Maestre Andres, 2019).

However, the Union of Technicians of the Ministry of Finance (Gestha, 2019) proposed to implement a tax that includes economic activities and products that in their process or use emit Carbon Dioxide (CO2), Nitrous Oxide (N2O), Methane (CH4), Chlorofluorocarbons (CFC) and Tropospheric Ozone (O3). Gases such as sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are taxed in our country by the F-Gas Tax. Given that the collected revenues are not very significant, they propose to include the F-Tax into the new broader tax. This proposed tax would not include companies that participate in the EU ETS to avoid double taxation.

As stated, there is a considerable sector of the academia and tax experts pushing for a nation-wide carbon tax in Spain. There is also a technical suggestion to create an interrelation between the national carbon price and the EU ETS price. Buñuel González (2015, p. 7) suggests that one option to set national tax rates would be to take the EU ETS price as a benchmark.

2.2.5 France

2.2.5.1 Description of the regime in place

France initially pursued the introduction of a carbon tax in 2000 (extending the *taxe générale sur les activités polluantes*, TGAP to include CO_2) and again in 2009 (introduction of the *contribution climat énergie*, CGE). Both proposals, however, were ruled to be unconstitutional and were thus revoked. In both cases, the constitutional court criticised the numerous exemptions of the tax and ruled that they infringed the principle of equality before tax. The criticism also applied to the exemption for companies covered under the EU ETS. The court argued that many companies received their allowances for free and therefore an exemption from the carbon tax would represent unfair treatment of those companies and households that are subject to the tax (Agora Energiewende 2019, p 4).

In a renewed attempt, the current carbon tax was finally introduced in 2014. The instrument called *contribution climat énergie* (CGE) sets an explicit carbon price, but it is implemented as an increase of existing excise duties on fossil fuels rather than a separate new tax on carbon emissions. This solution allowed policy-makers to exempt certain companies without facing another ruling based on the principle of equality before tax (IC4E 2018).

Stated goal and context

When the carbon tax in France entered into force in 2014, almost two decades of political debate about ecological tax reform had preceded it. From early discussions in the 1990s to a commission chaired by former Prime Minister Michel Rocard dedicated to the subject in 2009 (Ministère de l'écologie, de l'énergie, du développement durable et de la mer, Ministère de l'économie, de l'industrie et de l'emploi 2009) to a 2013 resolution of France’s Parliament (Assemblée Nationale 2013), the stated goals remained broadly similar:

- expand the tax base through higher taxes on natural resources and pollution in line with the polluter-pays-principle,
- provide incentives to people and companies to behave more environmentally-friendly and shift investments accordingly,
- send a long-term signal with a progressive tax rate in line with climate goals.

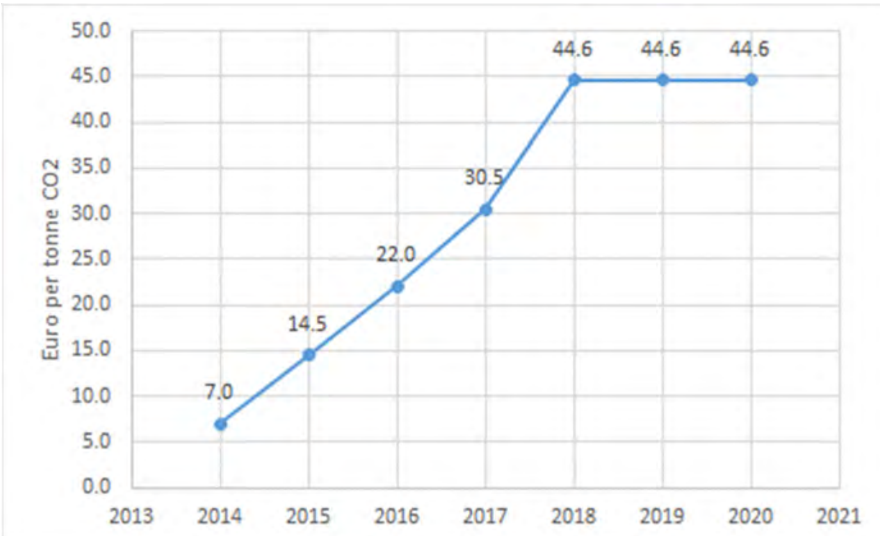
When the carbon tax was first introduced, the French government had just established its climate policy targets in its 2015 low-carbon strategy (*Stratégie nationale bas carbone*), aiming at cutting GHG emissions by 30% by 2030 and by 75% by 2050 (both compared to 1990 levels). The pathway towards these goals is organised in five-year carbon budgets.

The 2050 target has since been strengthened. The French government now aims for carbon neutrality by mid-century. Total GHG emissions in 1990 are to be devised by 6 by 2059, translating to a reduction of -93% (Ministère de la Transition écologique et solidaire 2019, p. 74). In addition, France has targets enshrined in EU law: Under the EU Effort Sharing Regulation, it has the binding obligation to reduce until 2030 its GHG emissions in sectors not covered by the EU ETS by 37% compared to 2005 levels (Regulation (EU) 2018/842).

Tax rate and progression over time

The tax was initially introduced at a rate of 7 Euro per tonne of CO_2 in 2014. The rate increased annually to reach 44.60 Euro/t in 2018 (see Figure 19). Besides motor fuels, the CGE also applies to natural gas, coal and heating oil, with differentiated rates reflecting the different average carbon content of the fuel types. To avoid double-taxing, the carbon tax is not levied on electricity since carbon emissions from power generation already incur a price under the EU ETS.

Figure 19. Increase of the French carbon tax 2014-2020



Source: OECD 2020, p. 50.

The CGE is raised in addition to existing excise duties for different fuel types. It is integrated in the following existing taxes: 1) consumption tax on energy (*taxe intérieure de consummation sure les produits énergétiques*, TICPE) applying to petroleum products, 2) the consumption tax on gas (*tax intérieure de consummation sure le gaz naturel, TICGN*) and 3) the consumption tax on coal (*taxe intérieure de consummation sur le charbon*, TICC).

The significance of the carbon tax relative to excise duties depends on the sector: in road transport, the CGE raised the tax level from 43 ct/litre of diesel in 2013 to 59 ct/litre of diesel in 2018 and from 61 to 68 ct/litre for gasoline (E5). Natural gas used for heating was exempt from excise duties until 2014, thus the current tax level of 8.45 €/MWh is entirely due to the CGE (see Table 4).

Table 4. Increase of energy tax rates for different products in France 2013-2020 (households and companies without exemptions)

	2013	**2014 ***	**2015**	**2016**	**2017**	**2018-20**
Natural gas in households (€/MWh)	Exempt	1.27	2.64	4.34	5.88	8.45
Coal (€/MWh)	1.19	2.29	4.75	7.21	9.99	14.62
Diesel (ct/l)	42.84	42.84	46.82	49.81	53.07	59.40
Petrol E5 (ct/l)	60.69	60.69	62.41	64.12	65.07	68.29

Petrol E10 (ct/l)	60.69	60.69	62.41	62.12	63.07	66.29
Heating oil (ct/l)	5.66	5.66	7.64	9.63	11.89	15.62
Heavy oil (ct/kg)	1.85	2.19	4.53	6.88	9.54	13.95

Table 5. Increase of energy tax rates for different products in France 2013-2020 (households and companies without exemptions)

	2013	**2014***	**2015**	**2016**	**2017**	**2018-20**
Natural gas in households (€/MWh)	Exempt	1.27	2.64	4.34	5.88	8.45
Coal (€/MWh)	1.19	2.29	4.75	7.21	9.99	14.62
Diesel (ct/l)	42.84	42.84	46.82	49.81	53.07	59.40
Petrol E5 (ct/l)	60.69	60.69	62.41	64.12	65.07	68.29
Petrol E10 (ct/l)	60.69	60.69	62.41	62.12	63.07	66.29
Heating oil (ct/l)	5.66	5.66	7.64	9.63	11.89	15.62
Heavy oil (ct/kg)	1.85	2.19	4.53	6.88	9.54	13.95

**After the introduction of the carbon tax on 1 April 2014.*

Source: Ministère de la Transition écologique et solidaire 2020b.

A number of exemptions are in place: For gas consumption, companies covered by the EU ETS are fully exempt from the CGE. Energy-intensive companies threatened by carbon leakage (as defined by EU Decision 2014/746/EU) which are not subject to the EU ETS pay a reduced rate of 0.08 Euro/MWh bringing their total energy tax on gas to 1.60 Euro/MWh. Both types of companies are also fully exempt from the carbon tax on oil and butane (OECD 2020, p. 49).

Moreover, energy tax exemptions and reductions that were in place in France before the carbon tax introduction continue to apply. This includes inter alia exemptions for fossil fuels used as feedstock for example in the chemical industry, fossil fuels used in freight transport companies, agriculture, domestic flights, domestic navigation, taxis and public transport (IC4E 2018, Ministère de la Transition écologique et solidaire 2020b). Finally, specific reductions apply in France's oversea territories.

In addition to exemptions defined at the national level, some activities are privileged due to standards set at EU level in Directive 2003/96/EU on energy taxation. This applies for example to solid biomass used for heating and for fuels used in international air traffic and shipping (IC4E 2018).

The future trajectory of the French carbon tax is currently not fixed. Originally, the Energy transition law of 2015 (*Loi relative à la transition énergétique*) foresaw an increase to 56 Euro/t by 2020 and 100 Euro/t by 2030. The 2030 value is based on the recommendation of a commission chaired by Alain Quinet which in 2009 estimated the carbon price trajectory up to 2050 required to reach EU and French climate policy targets in a cost-effective fashion. The trajectory represents the mitigation costs per tonne of CO_2 over time (Commission présidée par Alain Quinet 2009).

The near-term trajectory for the carbon tax rate is defined in the annual budget. In 2018, the budget included a trajectory up until 2022 when the carbon tax was to reach 86.2 Euro/t. However, after the protests of the "yellow vest" movement erupted in autumn 2018, the French government decided to halt the increase. In the 2019 budget (*Loi de finances 2019*), the carbon tax was frozen on the 2018 level of 44.60 Euro/t for 2019 and 2020 and no future trajectory was included (Ministère de la transition écologique et solidaire 2020b).

Effectiveness

The OECD recently assessed the CGE's environmental, economic and social effects in a detailed microeconomic study (OECD 2020). It is based on data from 8,000 companies that are representative of manufacturing in France. The sample covers the years 2001 to 2016. The analysis shows that in these firms an increase in energy prices of 10% resulted in a 6% reduction of energy use and a CO_2 reduction of 9% on average. Building on this observation, the author estimates that the carbon tax reduced manufacturing CO_2 emissions in 2018 by 5% or 3.6 Mt of CO_2 compared to a reference scenario without the tax.[32] If the French government were to double the current tax rate to 86 Euro/t, the CO_2 reduction would rise to 8.7% or 6.2 Mt of CO_2.

For households, Gloriant (2018) has estimated the CO_2 reduction due to carbon tax on transport fuels and heating oil (excluding natural gas). She used a regression analysis to estimate elasticities ex-ante and also compared France's actual emissions ex-post to a counterfactual baseline informed by emission levels in comparable countries without carbon tax. The results of the ex-ante assessment suggest that in 2017, the carbon tax reduced transport emissions by at least 0.6 to 1.7 Mt CO_2 – a reduction of 0.6 to 1.7% compared to the baseline. Emissions from oil-based heating decreased by by 0.7 Mt CO_2 – a reduction of 2% compared to the baseline. For both activities, the annual reduction would rise to 3 to 5.7 Mt in 2022 if the originally planned tax trajectory were to be implemented. Interestingly, the analysis also suggests that consumers react more strongly to tax-induced price increases than they do when faced with market-induced price hikes. By contrast, the study's ex-post analysis does not yield a significant result. This might be a result of the relatively limited number of data points as the assessment only covers 2014 to 2016 – a time when the carbon tax was still relatively low and its effect on consumer prices were subdued by a sinking oil price.

Based on a detailed assessment of the existing exemptions and reductions for certain sectors, IC4E (2018) criticises that these limit the instrument's overall effectiveness in reducing emissions. The study points in particular to freight transport and off-road use of gasoline (for example in the construction sector) as the largest exemptions with respect to the amount of emissions covered by it and in terms of lost revenue. The exemptions result in approximately 15% of energy use emissions in France facing no carbon price at all (Conseil d'analyse économique 2019, p. 6).

Social effects

Like all consumption taxes, the carbon tax is regressive, i.e. it affects poorer households proportionately higher, as they spend a larger share of their disposable income on energy and related services. The Conseil d'analyse économique, a group of economists advising the French Prime Minister, calculated that the originally planned increase of the CGE's rate from 44.6 Euro/t today to 86.2 Euro/t in 2022 would reduce disposable income of the poorest decile in French society by 0.7 %, while claiming

[32] The data set used in the micoreconomic study comprised 8,000 manufacturing companies, 2,3% of which are subject to the EU ETS and currently enjoy an excemption from the cabon component in energy taxes. Therefore, as the author admits himself, the study somewhat overestimates effect of the carbon tax on total emissions.

only 0.25 % of the richest decile's income. If in addition to the CGE's increase the government were to adapt the tax on diesel to the rate levied on petrol (+7.8 ct/l) as it had planned to do in January 2019, the burden on the poorest decile increases to almost 1% of dispensable income (Conseil d'anlayse économique 2019, p. 3).

However, the analysis also shows that the actual burden on each household does not only depend on income, but also on the equipment the household uses and its location in France – with the first element being more important. In particular, households with oil or gas heatings and diesel cars are more heavily impacted by the reform than households who use electric heating and own petrol cars or no car at all. The paper notes that this heterogeneity within income deciles is much harder to address through redistribution measures than the regressive effect (Conseil d'anlayse économique 2019, p. 3).

Impact on companies and employment

In its detailed microeconomic study, the OECD analysed the impact of the French carbon tax on employment in a representative sample of 8,000 French companies. Its central conclusion is that the tax leads to a reallocation of jobs and production from firms with high energy intensity to energy-efficient firms. While a 10% increase in the price of energy leads to a 2% decrease in employment in the companies under observation, employment levels for industry as a whole remained unchanged. The effect is stronger in energy-intensive branches like metal and plastic production, machinery, mechanical engineering and the food industry (OECD 2019).

The study also finds that large companies react to the carbon tax by innovating more – measurable by the numbers of registered patents – and that all companies invest more in emission reduction technology (OECD 2020, p. 58).

Tax revenues

Public revenue from the CGE is estimated to have amounted to 0.3 billion Euro in 2014, rising to 3.8 billion in 2016, 6.4 billion in 2017 and 9.1 billion in 2018 (IC4E 2018). The Conseil d'analyse économique (2019) estimates that in 2017 households contributed 60% of the total CGE receipts while companies paid the other 40%.

A share of these revenues – 1.7 billion Euro or about a quarter in 2017 – was directed towards a fund that finances renewable energy investments. The rest flows into the general public budget (Ministère de la Transition écologique et solidaire 2017).

However, in each budget the government has included a number of measures aimed at compensating households and companies for the additional financial burden caused by the carbon tax. In 2016, 3 billion Euro were earmarked for an instrument that reduced the tax burden on companies proportional to their salary total (*credit d'impôt pour la compétivité et l'emploi*), while 1 billion Euro helped to reduce the bill for energy refurbishment in private homes through a VAT reduction. In 2018, compensation measures also included 100 m Euro for a grant scheme supporting purchases of energy-efficient cars (*prime à la conversion*) and 81 m Euro for a support scheme helping low-income households with covering their energy bills (*cheque énergie*). In total, the sum of compensatory expenditures was below the revenue generated by the carbon tax in 2017 and 2018 (IC4E 2018).

In reaction to the social protest of the "yellow vest" movements that rallied against the increases in fuel tax and social inequality more widely, the government announced two changes to the existing compensation measures (Perthuis and Faure 2018, p. 3):

- the grant for purchases of more efficient cars was increased for low-income households,
- the chèque énergie increased from 150 Euro/year and household to 200 Euro.

2.2.5.2 Current scope of the system / regime and overlaps

Delineation to the EU ETS

The CGE is clearly delineated from the EU ETS. The system foresees exemptions for companies that are subject to emission trading under the EU ETS so as to avoid double-taxing and the CGE is not levied on electricity consumption, since all power generation is subject to the EU ETS.

Interaction with the White certificate scheme (*certificats d'économie d'énergie*, CEE)

France's white certificate scheme (*certificats d'économie d'énergie*, CEE) is in place since 2006. It obliges energy suppliers to promote energy-efficiency measures amongst their customers (households, local authorities and businesses). They can fulfil this obligation by purchasing certificates from other entities who promote energy efficiency measures. The scheme is open to efficiency measures in all sectors not covered by the EU ETS. However, most measures target residential buildings. In the scheme's 3rd period covering 2016 and 2017, 70% of all credits were generated in residential and commercial buildings, followed by industry (15%), transport (5%). Over the period 2011 to 2017, the five most widely used measures under the scheme were attic and wall insulation, energy management systems in industry, and exchange of boilers in single and multi-family homes (ADEME 2019, p. 13).

In the scheme's 4th period covering 2018-2020, energy suppliers have to promote total energy savings of 1,600 TWh cumac,[33] 400 of which need to be realised in poor households. According to the Energy Transition Ministry, fulfilling this obligation will require energy suppliers to invest approximately 2 billion Euro in supporting poor households over the period (Ministère de la transition écologique 2020a).

Trading of CEE certificates takes place on an online platform called Emmy which is operated by the company EEX (www.emmy.fr). In the first quarter of 2020 the average price on the platform was 7.66 Euro/MWh cumac. CEEs can be banked for two subsequent trading periods.

According to ADEME's evaluation of the CEE scheme, energy suppliers refinance the costs for complying with their obligation by increasing energy prices for households, the tertiary sector and in transport (ADEME 2019, p. 16). The following table provides estimated price increase per type of energy carrier and compares it to the impact of the carbon tax. It shows that the CEE's price impact half the level of the carbon tax impact for natural gas and diesel which it is comparable for gasoline. The CEE also has a small impact on power prices which are not subject to the carbon tax.

Table 6. Price impact of CEE scheme compared to carbon tax impact

	Price increase due to CEE scheme (Feb. 2019)	Price increase due carbon tax (2018-20)
Natural gas	4.00 Euro/MWh	8.45 Euro/MWh
Diesel	5.8 ct/l	16 ct/l
Gasoline	5.8 ct/l	7 ct/l
Electricity	6.70 Euro/MWh	0 Euro/MWh

[33] The unit "cumac" refers to cumulated energy savings over the lifetime of the device, discounted by 4% per year to reflect that energy savings are decreasing over time compared to the baseline.

Overlap with carbon tax: On the face of it, the white certificate scheme has many communalities with the carbon tax. Just as the CGE, it covers all sectors outside the ETS. Yet, in practice the lion's share of the measures addresses residential and to a lesser extent commercial buildings. Just as the carbon tax, the CEE aims at harnessing market forces to generate energy savings at the lowest cost. In practice, costs assessments under the CEE are made by energy suppliers and service providers specialised on generation of CEE credits. Their assessment is likely to include factors such as transaction costs for different measures, available economies of scale or existing customer base which are irrelevant for household decision-making targeted by the carbon tax. Moreover, a key difference between the two instruments is that the CEE scheme directly incentivises investments while the carbon tax mainly affects the use phase and only indirectly affects investments.

Given that energy suppliers are passing on their costs for fulfilling the energy efficiency obligation to their customers, this price premium works as an implicit carbon price signal and therefore overlaps with the carbon price signal from the carbon tax. This should be taken into account when both schemes do indeed get significantly more ambitious and thus more expensive for households.

As the carbon tax is fixed, it is not influenced by whether or not the CEE succeeds in reducing energy consumption, and thereby emissions. In the opposite direction, as the carbon tax makes energy-saving investments slightly more attractive, it could help to (marginally) lower the price of white certificates; yet this interaction has not been quantified.

Finally, the CEE scheme provides particular support to low-income households that often lack the capital to invest in energy-efficient goods, thereby helping to mitigate the regressive effect of the carbon tax. In these respects, the instruments are complimentary.

Unlike the carbon tax, the CEE does overlap with the ETS because power suppliers are subject to the obligation and pass the costs on via their retail prices which also include the price effect of EU ETS certificates. However, both effects are relatively small given that the French power mix is dominated by CO2-free nuclear power and the CEE price tag for electricity consumers is also relatively low (0.7 ct/kWh).

Interactions with sector-specific instruments

In addition, several other measures aimed at curbing GHG emissions exist for specific sectors.

For the **transport** sector, national complementary measures include (see also Meinecke 2019):

<u>A bonus-malus incentive system for vehicles</u>: In this system, higher fees for cars with high emissions are funding bonus payments to consumers who purchase an electric vehicle. Criteria for the bonus and the malus are regularly updated to keep up momentum towards the least-polluting vehicles. Since 2020, only electric cars, electric motorbikes and e-bikes can receive the bonus, hybrid cars are no longer eligible. Any car with CO_2 emission above 110 g/km[2] faces a one-time malus which is due when the car is registered for the first time. The malus rises with the car's emissions, reaching 12,500 Euro for the most polluting cars (ADEME 2020). The scheme delivers a strong and effective incentive to purchase more fuel-efficient cars with low GHG emissions.

<u>A scrapping bonus ('*prime à la conversion*')</u>: The scheme rewards consumers who replace old diesel cars with an electric or hybrid vehicle. In its 2018 climate strategy, the French government set the aim for the conversion premium to reach 1 million beneficiaries within five years and help to grow the electric vehicle fleet to 4.8 million by 2028 (Ministère de la transition écologique et solidaire 2018).

Overlap with carbon tax: Both instruments appear to be complementary to the carbon tax. They address the investment decision for a new vehicle and tackle a key barrier for electric or hybrid vehicle which is the higher purchase cost. They are complemented by the EU fleet standards that address the supply side by forcing automakers to put ever more fuel-efficient cars on the market. The carbon tax, in turn, provides a price signal all through the use phase, thereby giving incentive to also moderate kilometres driven. It can thus help curb the rebound effect, i.e. the risk that a more efficient car would allow its owners to spend the money saved on fuel to drive more kilometres. The carbon tax does not apply to electricity and thus creates a complementary incentive for electric vehicles, as the cost per km does not increase for them. Moreover, helping consumers to invest into fuel-efficient cars reduces the burden of the rising carbon tax, and can thus help to make it more acceptable.

In the **building** sector, complementary measures include:

Zero-rate eco-loans (*éco-prêt à taux zero*): A loan of a maximum of 30,000 EUR helps home owners, occupiers and landlords to finance extensive renovation works that improve energy efficiency (Meinecke 2019).

The Energy Transition Tax Credit (*crédit iumpôt transition energétique*): A deduction from the income tax on a maximum of 8,000 EUR spent on energy refurbishment works supports investments in improving energy efficiency of buildings. As of 2020, it will be reshaped into a lump sum prime that is paid when the energy renovation work is carried out (Meinecke 2019).

The premium for the conversion of oil or gas boilers: A new financial bonus introduced in 2019 supports households who replace their inefficient oil or gas boilers with more environmentally friendly heating systems. It is paid out as a lump sum grant, with low-income households being eligible to higher premiums (Meinecke 2019).

Overlap with carbon tax: All three measures support low-carbon investments and are thus complimentary to the carbon tax. Given that the funding comes from the state budget, no implicit carbon price signal results from them. However, just as the carbon price, these instruments are likely to have a regressive distributive effect. In particular, low-income households are unlikely to profit from zero-rate loans or income tax deductions (Perthuis and Foire 2018, p. 4).

2.2.5.3 Price level / trajectory and relation to the EU ETS price

In France, carbon currently priced at 44.60 Euro/t CO_2 in the sectors not covered by the EU ETS. The rate was supposed to increase to 86.20 Euro/t by 2022 and to 100 Euro/t by 2030. However, since the “yellow vest” protests erupted in 2018 the rate increase has been on hold and the future is very uncertain. The coronavirus crisis is likely to further exacerbate the uncertainty. Given the economic hardship that the shut-down is already causing, the government may face additional pressure to re-evaluate the rate increase.

In 2018 and 2019, experts intensively debated various options for going forward with the carbon pricing scheme. There was a clear consensus that the rate increase should continue – albeit potentially at a slower pace – but that the tax needed to be reformed to be more equitable. All experts recommend returning a larger chunk or all the tax revenue to households, focusing in particular on low-income households (IC4E and Terra Nova 2019, IDDRI 2019, Conseil d’analyse économique 2019, Perthuis and Foire 2018). As one concrete option to support the poor, several studies recommend expanding the *chèque d’énergie* and allow it to cover transport-related expenditures in addition to heating and power bills (Conseil d’analyse économique 2019, Perthuis and Foire 2018). In addition, several experts demand a broadening of the tax base by scrapping existing exemptions for businesses in certain branches. This process should be accompanied by new forms of support so as to avoid negative impacts on competitiveness, while maintaining the carbon price signal (Conseil d'analyse économique 2019, IC4E and Terra Nova 2019, IDDRI 2019).

With the same objective of avoiding distortion, the Conseil d'analyse économique as well as IC4E and Terra Nova also suggest that a floor price in the EU ETS could ensure a closer alignment of the carbon price signal outside and inside the EU ETS. Both studies, however, do not elaborate on how the alignment should work in practice (Conseil d'analyse économique 2019, IC4E and Terra Nova 2019. Terra Nova (2017) had proposed a floor price of 20 to 30 Euro/t for the West European countries and other interested countries in 2017 – in addition to a stricter cap on total emissions.

2.2.6 Summary: Key Insights and Takeaways

The case studies show a vast range of pricing instruments applicable to transport and housing. They range from countries with no or only minimal carbon pricing instruments (Poland, Spain) to Sweden as the other extreme, where a carbon price has been in place for almost three decades, has risen gradually to reach one of the highest levels in the world, and is widely credited as the dominant instrument that has brought about significant emission reductions and supported structural changes in the covered sectors.

- The analysis also shows that the devil is in the detail when it comes to **defining carbon pricing**: For instance, some surveys include Poland and Spain among the countries that have a carbon tax in place – which is technically correct, yet in the case of Spain with a very limited scope, since the Spanish carbon tax only applies to emissions fluorinated gases, and hence covers only about 3% of Spanish GHG emissions. Other countries apply significant taxes and excise duties on fossil fuels – which are functionally equivalent to a carbon tax, but are not pegged to the carbon content of fuels and hence technically do not qualify as carbon taxes.
- The notion of a **single carbon price** applicable across sectors remains popular among economists, but does not appear to be a guiding principle in political reality. In none of the studied cases was there an explicit linkage of the carbon tax levels to the current or expected carbon price in the EU ETS, neither as an explicit mechanism, nor as an implicit link through a political declaration. Rather, the approach appears to be that the carbon price should be as high as it needs to be to have the desired effect. As a result, the carbon prices are significantly higher than the EU ETS price in both France and Sweden. In the case of Germany, while the starting-level carbon price in 2021 (at 25 Euro) will be of a similar magnitude as the EU ETS price, this is rather by coincidence, and the carbon price will soon increase to significantly higher levels.
- Where carbon pricing instruments are in place, they have been introduced as **part of a broader package of policies**, or as part of national strategies geared at achieving the respective climate targets. Carbon pricing instruments tend to play a prominent role in the respective strategies: in political statements, in model-based assessments of different policies, and also in the perception of stakeholders, they are viewed as the **corner stone** of the respective strategies, and credited (or modelled) as the single most important policy instrument.
- Where they exist, carbon prices have found to be effective in reducing emissions:
    - For the case of **France**, an OECD analysis showed that an increase of energy prices of 10% resulted in a 6% reduction of energy use in businesses, and a CO_2 reduction of 9% on average. As a result, the existing carbon tax is estimated to have **reduced manufacturing CO_2 emissions**

in 2018 by 5% or 3.6 Mt compared to a reference scenario without the tax. If the French government were to double the current tax rate to 86 Euro/t, the CO_2 reduction would rise to 8.7% or 6.2 Mt of CO_2. For households, Gloriant (2018) estimated the CO_2 reduction due to carbon tax at **at least 0.6 to 1.7 Mt CO_2 for transport emissions** – a reduction of 0.6 to 1.7% compared to the baseline. Emissions from **oil-based heating decreased by by 0.7 Mt CO_2** – a reduction of 2% compared to the baseline. For both activities, the annual reduction would rise to 3 to 5.7 Mt in 2022 if the originally planned tax trajectory were to be implemented.

- In **Sweden**, the carbon tax is considered as the cornerstone of Swedish climate policy and the **key driver behind Sweden's success in cutting emissions** whilst maintaining economic growth. This applies in particular to observed changes in behavior and investments in the building sector, where greenhouse gas emissions have decreased by 90% since 1990, including through the expansion of district heating and the increased penetration of biofuels and heat pumps. Through these measures, the Swedish tax is credited with reductions of 0.5 to 1.5 million tons annually in the early years of its introduction.
- For **Germany**, as the national carbon price will only be coming into effect in 2021, there is no evaluation of its actual effects. However, modelling that was conducted ex-ante expects a decisive contribution particularly in the area of **freight transport**, where the national carbon price and other measures are expected to favour the **shift from road to rail**. Other modelling estimates the expected emission reduction **contribution of the national carbon price in transport at 6 million tons in 2030** – compared to a total of 8 million tons for all other climate policy measures in the transport sector. In the buildings sector, the national carbon price is assumed to be a key driver for increasing investment into insulation and phasing out oil heating, as well as making electric heating solutions (e.g. heat pumps) more attractive.

• What stands out between the three case studies that involve a carbon price is the **importance of a price signal that is not only strong, but also long-lived**. In the case of Sweden, the fact that the carbon price has existed (and continuously increased) for almost three decades means that it could support the structural transformation of the building sector from fossil to bio-based fuels and electricity. Given the long time horizons of investments into the building stock and the involved path dependencies, it is key that the carbon price signal must provide a long-term orientation for investors.

• In terms of **managing overlap** between the national carbon pricing instruments and the EU ETS with its current scope, countries tend to opt for a solution whereby fuels / emissions that are priced under the EU ETS are exempt from the coverage of the national pricing tool. This is the explicit stated objective e.g. for the design of the German national ETS, which will treat fuels differently depending on whether they are sold to an installation inside or outside the EU ETS, but also provides for the option of a rebate if the prior exemption should not be feasible or workable. One notable exception is Sweden, where CHP plants covered under the EU ETS only benefit from a partial exemption: In addition to their compliance obligations under the EU ETS, they still need to pay 91% of the carbon tax on the fuels they consume.

• In France and Poland, **white certificate schemes** (tradable energy efficiency obligations) are an important part of the respective countries' portfolio of climate and energy policies. As market-based instruments, these systems share some commonalities with a carbon pricing instrument, in that they work through a financial incentive, the level of which depends on the distance-to-target. France was the only case study in this subset that applied a white certificate scheme in addition to carbon pricing. In principle, as market-based approaches, carbon pricing and white certificate schemes should be able to coexist and complement each other, in the sense that some measures rewarded under the white certificate scheme are also rewarded under the carbon pricing system, and vice versa.

- Since carbon pricing works as part of a broader package of measures, there are plenty of other cases of **overlap with other instruments**, including ones that also those work through economic incentives. Examples include the bonus-malus systems for cars (pioneered in France, also applied in Sweden), which provide an extra incentive for more fuel-efficient cars and thus reinforce the incentive effect of the carbon price. Other examples include scrapping boni for old and inefficient equipment – e.g. for old cars, also for oil heating. Again, such measures are commonly applied in the countries investigated. While they could be criticised as inefficient from an economic perspective (arguing that they subsidise solutions which the carbon price should be able to leverage), a more pragmatic line of argument would be that they help mobilise mitigation potentials that are very cost-effective, but which are not addressed through the carbon price due to other market imperfections.
- The Member States that implement a carbon price have dedicated programmes for using their **revenue** – typically to address distributional impacts, to mobilise additional mitigation potentials, or a combination of both. France, following the political controversy sparked by carbon prices in 2018, has placed greater emphasis on addressing the equity implications, both through direct support to affected households, and by supporting energy-saving investments for vulnerable groups. Germany has opted against a general rebate or social assistance solution, but rather intends to use part of the carbon pricing revenue to lower the renewable energy surcharge, and hence the electricity price; the remainder of the revenue will be used to fund climate action programmes and measures across different sectors.

2.3 Experiences gained in Emissions Trading Systems outside the European Economic Area

Since the EU ETS started operating in 2005, the number of ETS around the world has increased steadily. Of these, several have also gained experience with covering transport and buildings. The analysis would focus of four systems / jurisdictions. These include three existing systems: California / Western Climate Initiative, New Zealand and Tokyo – which all have the benefit of having operated long enough to assess their functioning and their impacts, which are well documented, and for which experiences have been evaluated or their performance reviewed. In addition, we suggested TCI as one example of a forthcoming, sufficiently concrete initiative.

2.3.1 California's ETS

2.3.1.1 Summary of the programme

History and targets

California's landmark climate change legislation, the Global Warming Solutions Act (Assembly Bill 32, known as "AB32") was signed into law by then-governor Arnold Schwarzenegger in September 2006, launching the regulatory process that led to creation of the state's ETS. AB32 makes the state's greenhouse gas reduction target of bringing emissions to their 1990 levels by the year 2020 a law rather than a mere goal. It requires the California Air Resources Board (hereafter CARB) to undertake a *scoping plan* assessing whether and how a market-based approach could be used to achieve the target.

After extensive research and public consultation - including trips to Europe to learn about the EU ETS - CARB developed a cap-and-trade programme with a decreasing annual allowance budget set to achieve enough emissions reductions in the sectors it covered that the state's overall emissions by 2020 would be at their 1990 level of roughly 430 million tonnes CO_{2e}.

The California ETS's compliance obligations began in the calendar year 2013 for an initial compliance period of two years (2013 and 2014), followed by compliance periods of three years each from 2015 to the end of 2020. The first compliance period can be compared to the EU ETS's pilot phase from 2005-2007 in that it was a "warm up" to get covered entities familiar with the required procedures including reporting, participating in auctions, transacting allowances in the secondary market and submitting them for compliance.

The major programme component that changed as of 2015 was its **scope of coverage**: the scheme initially covered only stationary sources of greenhouse gases, i.e. electricity and industry sources. As of 2015, covered emissions more than doubled when the cap also applied to fuel distributors. Correspondingly, the annual allowance budget (yearly cap) increased from 162.8 million tonnes in 2013 to 394.5 million tonnes in 2015.

Relevant ETS design elements

Design considerations for **cap-setting** were straightforward in California's case, as the law mandating creation of emission reduction policy required that policy to achieve the 1990 emissions level by 2020, and as the cap covered the large majority of all GHG emissions. Creating the decreasing annual allowance budget in the ETS was therefore a matter of accurate emissions measurement and trend projection. CARB had already required emissions reporting from entities emitting 10,000 tonnes CO2e or more on an annual basis since 2008.[34] The data allowed CARB to develop a cap based on actual measured emissions, as opposed to estimates, and allows for continued monitoring of the state's progress towards its reduction goals. The cap was set through 2020, with the allowance budget in that year being below 350 million tonnes.[35] The ETS cap was developed with the effect of complementary policies in mind, such as California's Low Carbon Fuels Standard (LCFS) and the renewable electricity quota - see section "overlaps and interactions with other policies" below.

After California passed legislation in 2017 authorising extension of the cap-and-trade programme for another decade,[36] regulators continued the steep cap trajectory: the 2030 allowance budget is 200.5 million tonnes, meaning the programme is designed

[34] This requirement was later harmonised with the US Environmental Protection Agency's Greenhouse Gas Reporting Rule. See California Air Resources Board "Regulation for the Mandatory Reporting of Greenhouse Gas Emissions." Available online at http://www.arb.ca.gov/cc/reporting/ghg-rep/regulation/mrr-2012-clean.pdf

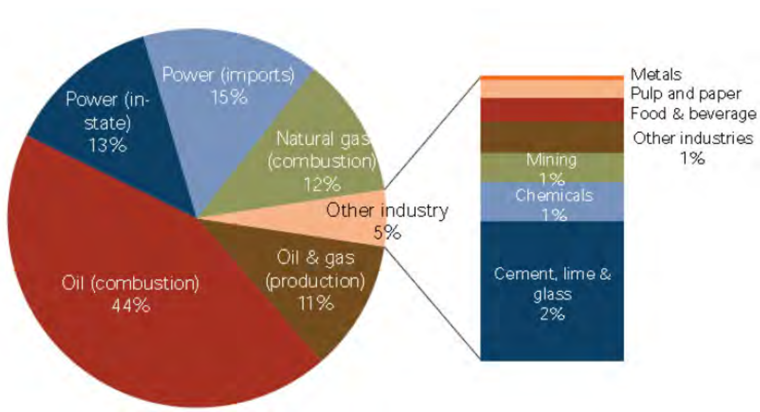
[35] See CARB's GHG inventory and projected emissions data from the time, which has since been archived. The overview of archived projections, available at https://ww2.arb.ca.gov/ghg-bau, features 2020 BAU greenhouse gas emissions projections used in the AB32 Scoping Plan (2008) and for the Cap & Trade Regulation (2010)

[36] Assembly Bill 398, "Global Warming Solutions Act" available online at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB398

to nearly halve emissions from the covered sectors over the 15-year period from 2015-2030.[37]

In contrast to the cap, decisions about which sectors the ETS should cover were not straightforward because California's energy situation differs significantly from that of most regions to which an ETS had previously been applied. Emissions from *imported* power[38] and from transport (the vast majority of fuel combustion in Figure 20) made up a much larger (and, in the latter case, faster growing) portion of the state's greenhouse gas output than in comparable jurisdictions.

Figure 20. California total energy-related emissions in 2009 (Source: Ecologic, based on CARB archived state GHG emissions data by fuel type)



Given this, implementing even the most stringent ETS for the power and industry sectors only would be insufficient to meet the 2020 target. While power and industry combined accounted for roughly 41 percent of the state's emissions, emissions from the transport sector and from residential/commercial fuel use accounted for nearly half of California's GHG output (transport alone for roughly 40 percent by 2014 estimates). With strong projected population growth (more houses and especially more cars and more vehicle miles travelled), emissions from transport and buildings were (and are) precisely those expected to grow most over the course of the ETS compliance periods.

However, the allowance prices regulators foresaw under the ETS were not high enough to significantly impact the price at the pump: direct taxes on fuel provide a much greater price incentive to the consumer to use less fuel.[39] But unlike in Europe,

[37] California Air Resources Board FINAL REGULATION ORDER CALIFORNIA CAP ON GREENHOUSE GAS EMISSIONS AND MARKET-BASED COMPLIANCE MECHANISMS REGULATION, available online at https://ww2.arb.ca.gov/rulemaking/2018/cap-and-trade-ghg-2018

[38] Whereas Europe is largely an "island" in terms of power generation, with transmission bottlenecks containing electricity flows in such a way that power produced in the countries covered by the EU ETS is also consumed in those countries, this is not the case in California. At the time of ETS creation, nearly one-third of power consumed in California was imported from out of state, mostly from coal-fired generators in neighboring Arizona, New Mexico, and Utah - but also in the form of hydropower from water-rich Oregon and Washington to the north. California thus took the unusual (and legally complex) step of covering power demand rather than just supply, meaning power companies are subject to compliance obligations under the state's ETS to the extent that the electricity they generate is consumed in California. This coverage of power imports has been subject to legal challenges since the entry into force of the programme.

[39] It takes a very high carbon price to significantly increase the price of fuel "at the pump," or in a way that impacts consumers noticeably: the ratio for gasoline (petrol) is typically just under one hundred, meaning it would take allowance prices of over $100/tonne CO_2 to raise the cost of transport fuels by only $1/gallon (0.26/litre). (Hafstead and Picciano, 2017)

emissions from fuel combustion are not addressed in a substantial way by other policies: the US features some of the lowest fuel taxes in the developed world (Watson, 2019). Surcharges, levies, or taxes on fuel were at the time of the scoping plan (and are) considered "dead in the water" politically.[40] Including transport emissions in the cap-and-trade programme was thus a way for California policymakers to implement a price signal on fuel consumption without resorting to a fuel tax - even if this only made for a very small fuel price increase and thus minimal expected behavioural change.[41]

The exact **scope of coverage for transport sector emitters** is determined by the fuels for which distributors must purchase allowances covering the embedded carbon content of their emissions. In addition to gasoline (petrol) and diesel these are natural gas, reformulated blendstock for oxygenate blending and distillate fuel oil, and liquefied natural gas. A fuel supplier must account for the embedded carbon under the ETS if it either holds an inventory position of fuel in the bulk transfer/terminal system, or if it imports fuel into California outside the bulk transfer/terminal system (CARB 2014).

The building sector is not specifically targeted to be within the scope of the programme, but it is to the extent that the covered fuels are used for home or commercial heating. This pertains mainly to natural gas and LNG: almost two-thirds of California households use natural gas for home heating (EIA, 2020).

In the Californian ETS, the **point of regulation** is set where the fossil fuel enters commerce in California: the so-called terminal rack where oil and gas are physically transferred. The owners of these facilities (large oil and gas companies) pass the costs of allowances reflecting the embedded CO_2 to the consumer in the form of higher fuel prices. Since the number of terminal racks is limited, the number of covered entities needed is comparatively small: only about 450 businesses representing about 600 individual facilities are compliance entities under California's ETS (PMR and ICAP, 2016, page 35 and CARB 2019). These numbers also reflect the fact that entities covered as part of the transport sector (with the upstream point of regulation at the terminal rack) are *also* covered as stationary sources in the industry sector, to the extent that they operate refineries in the state having direct emissions of the refining process. The latter are covered if their annual emissions exceed 25,000 tonnes/year, just like other industrial facilities. These companies are thus simultaneously transport, building, *and* industry sector emitters. In the case of natural gas suppliers, emissions from natural gas supplied to covered facilities are subtracted from the supplier's total emissions to **avoid double counting**. In Figure 22 under section "performance and effectiveness" below, the total CO_{2e} emissions for the "Supplier of Natural Gas, NGL, or LPG" source category reflect this accounting.

Overlaps and interactions with other policies

Unlike Europe, where the ETS is conceived of as the flagship emission reduction measure, California's ETS is explicitly part of a suite of overlapping sector-specific measures to meet the overall goal of AB32. Regulators at CARB estimated the degree to which each of these complementary initiatives would contribute to the 2020 target

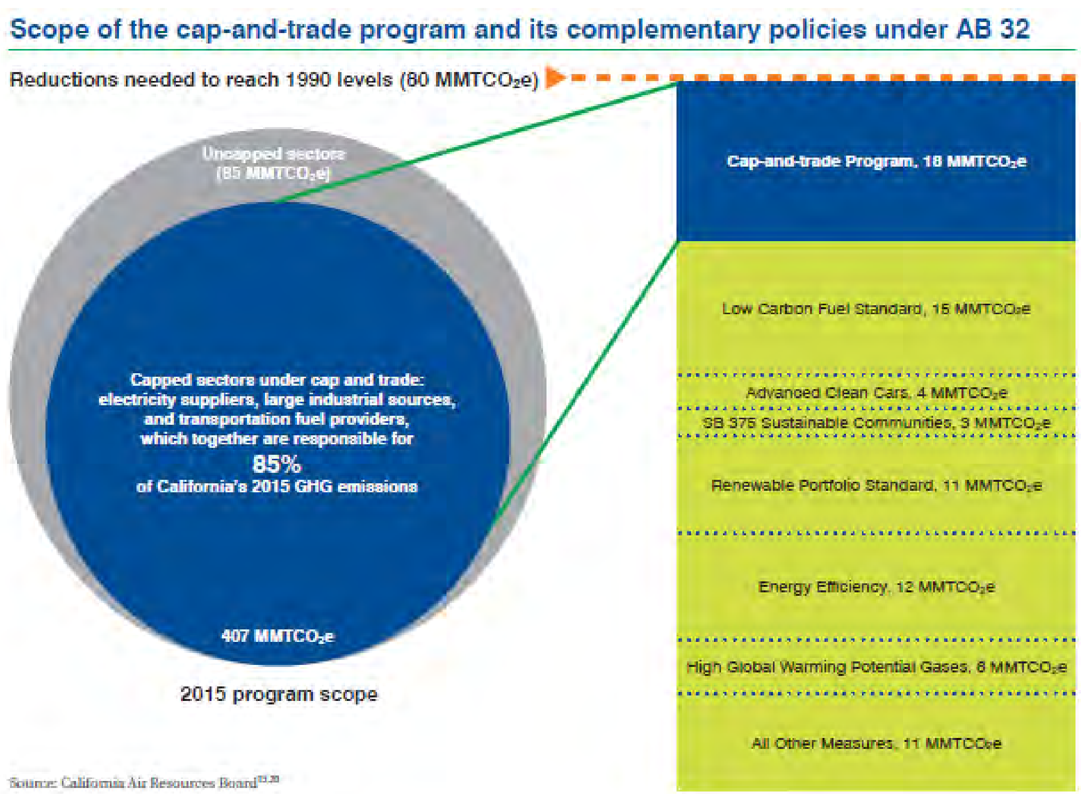
---

[40] See "The American obsession with the price of gasoline." Associated Press: 27 May, 2012 (updated 10 January 2019). Accessed online in March 2020 at https://www.oregonlive.com/business/2012/05/an_american_obessession_with_t.html

[41] Although demand for transport fuel is comparatively inelastic in the US, research indicates that it takes much higher price increases to evoke significant behavioural change: according to a 2017 Energy Survey from University of Michigan, "consumers reported that the price would have to be over $5 per gallon [Euro 1,20 per litre] before they would consider gasoline to be unaffordable, in the sense of having to make significant changes in their travel behavior." (DeCicco and Truelove, 2017). This would require an ETS with allowances prices of $500/tonne or more.

before implementing them, and continue to estimate the extent to which greenhouse gas reductions can be attributed to each based on annual reporting data. The ETS in this context is merely a "backstop," given that the state's low carbon fuels standard (LCFS) and its extremely ambitious renewable energy requirement (RPS) were (and are) expected to account for a large emission reduction in the transport and power sectors, respectively.

Figure 21. Scope of California's cap and trade program



The main overlapping measure in California's transport sector is the **low carbon fuels standard (LCFS)**, a rule enacted by CARB to reduce carbon intensity in transportation fuels as compared to conventional petroleum fuels, and thereby decrease CO2 emissions from vehicles. CARB first approved the measure in 2009, and it was later amended to reflect transport's inclusion in the ETS.

The LCFS is also a market-based mechanism in that it involves tradeable credits. All transportation fuels[42] are assigned a carbon intensity (CI) value based on their lifecycle greenhouse gas emissions. The standard CI value is measured in grams of carbon dioxide equivalent per megajoule (gCO_{2e}/MJ). Each fuel type's CI score corresponds to a "clean fuel benchmark" that CARB has assigned for each year. If the fuel has a CI value lower than the benchmark (i.e. ethanol, biodiesel, and electricity), it generates credits. If the CI value is higher (i.e. conventional gasoline/petrol and diesel), it generates deficits. The benchmark becomes progressively more ambitious, forcing an ever-lower CI value and thus ever cleaner fuels over time.

[42] There are several exemptions, including conventional jet fuel for aviation, fuel used in military applications, fuel used in interstate locomotives, fuel used in ocean-going vessels, as well as propane and CNG used in school buses (CARB 2020)

The LCFS regulates refiners and importers of transport fuels. They can comply with the LCFS by increasing their supply of low-carbon fuels to meet the CI benchmark for their overall fuel sales, or by purchasing surplus credits from other companies. To comply, a covered entity needs to show that it possessed and has retired a number of credits from its credit account that is equal to its compliance obligation. Entities may carry a credit deficit for up to five years, but thereby incur a five percent interest penalty each year (CARB 2020). Alternatively, entities that have not met their compliance obligation may purchase surplus LCFS credits pledged by other companies through the so-called Credit Clearance Market.

The LCFS was intended to be the climate policy responsible for most of the emissions reductions in California's transport sector: regulators projected it to account for 15 Mt/year of emissions reductions from vehicles alone, whereas they foresaw the entire ETS accounting for 18 Mt reductions per year from all its covered sectors (see Figure 22). This continues to be the case under the new more stringent targets through 2030, and the extension of both policies through that year.

Other measures that target emissions from sectors covered by the ETS include California's extensive energy efficiency mandates (buildings, power sector) as well as its zero emission vehicle programme, and investments in high-speed rail. The extent to which these measures have influenced the "pure" carbon market incentive (the price of an allowance in the ETS) is not easily distinguishable in a real-world context. The state's most recent greenhouse gas inventory, described in the following section, provides insights into this question.

2.3.1.2 Performance of the system

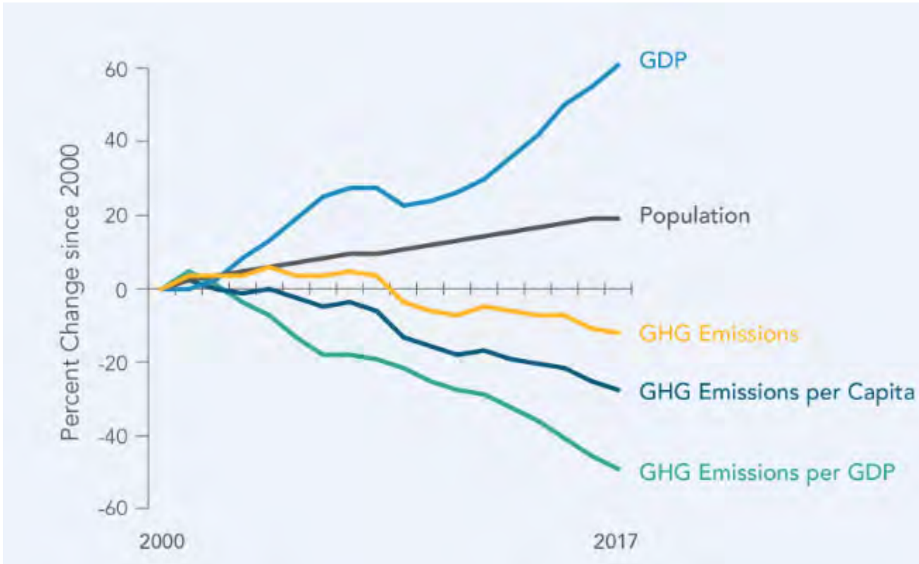
Given that California's ETS was not intended to be the main tool in the state's emission reduction toolbox,[43] its "success" at reducing emissions is not measured vis-à-vis other policies but rather at the economy-wide level. By that metric, the ETS *has* been a success: the most recent greenhouse gas emissions inventory[44] showed that "California has reduced emissions below the 2020 target established by AB 32 by a total of 7 million metric tons of CO_{2e}. The 2018 data supports the conclusion that California remains well below the 2020 emissions target and continues to make progress in decarbonising key sectors of the economy." (CARB 2019). The emission reductions were achieved despite the fact that population and the economy[45] grew since the start of the ETS in 2013, see Figure 22.

Figure 22. Change in California GDP, Population, and GHG Emissions Since 2000

[43] California's Legislative Analyst's Office acknowledges this in a 2017 report saying "the cap serves as a 'backstop' to achieve GHG emissions targets in the covered sectors, regardless of programmatic or economic changes that affect emissions." (LAO 2017).

[44] At the time of writing (March 2020) the most recent inventory report was for emissions in 2018, which were assessed in a report published in November 2019 (CARB 2019).

[45] If it were a country, California would be roughly the world's 5th largest economy as measured by gross state domestic product: in 2018 with a population of 39.5 million, California's GDP surpassed that of the United Kingdom. (Segarra, 2018).

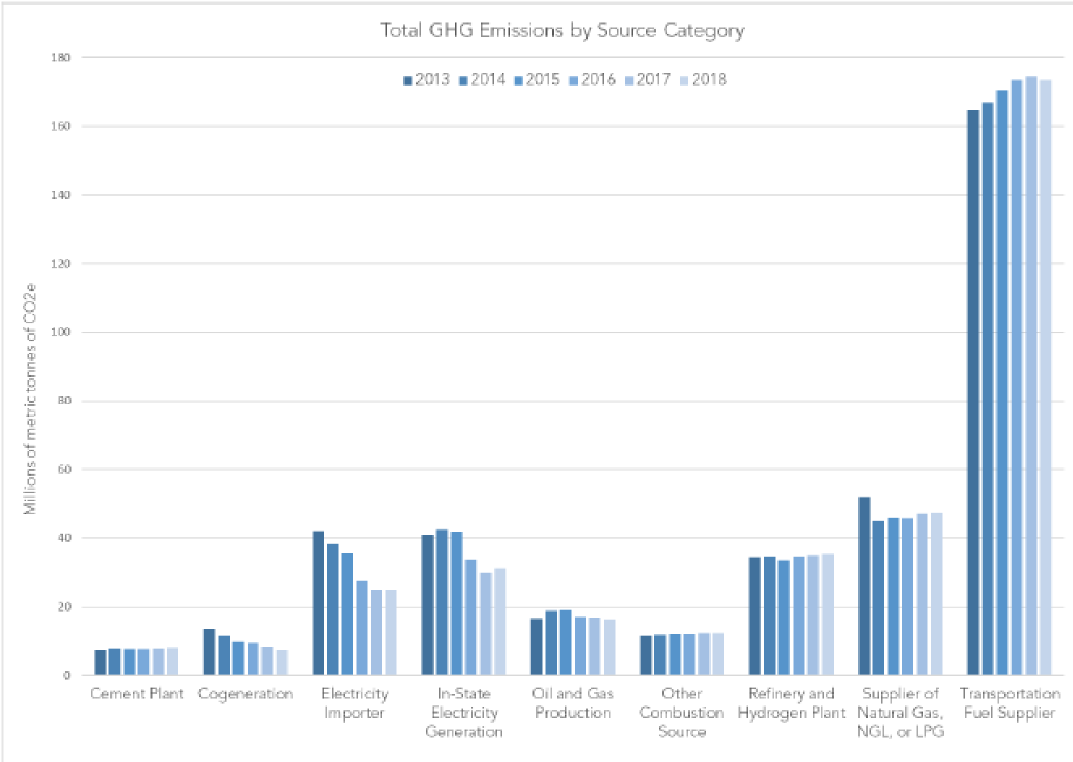


Source: CARB. California Greenhouse Gas Emission Inventory: 2000 – 2017, 2019 edition

Digging into the inventory's breakdown of covered emissions by sector[46] over the first six years of the programme (data for 2019 is not available yet), results are in line with the economic rationale behind a market-based approach: emissions have fallen in the areas with *lowest marginal abatement costs*. Per tonne, abatement can be achieved at lower cost in the power sector (by e.g. switching from coal to gas) than in the transport sector, where longer-term systemic change (like shifts in the modal split from private to public transport) is necessary to achieve the same amount of abatement. Hence the source category in which most reductions have been achieved so far is electricity generation - particularly generation *outside* of California (source category "electricity importer"), which was significantly more carbon intensive than in-state generation in 2013 and started with comparatively lower per-tonne abatement costs.

[46] The reporting requirement applies to entities emitting 10,000 tonnes/year or more, whereas the ETS coverage threshold is 25,000 tonnes, with the breakdown corresponding to actual covered emissions accordingly.

Figure 23. Total GHG emissions by source category, 2013-2018



Source: CARB 2019

This textbook reflection of an ETS's "pure" function is, however, somewhat coincidental in California's case: emissions from the covered source categories are driven by a number of measures other than the ETS. Power sector emissions reductions were largely the result of electricity sellers needing to meet California's stringent renewables quota (the renewable portfolio standard - RPS - of 33 percent by 2020) rather than the allowance price incentive[47] - which ranged between $11 and $20 per tonne over most of this period and were even lower in the early years.

Likewise, the recent plateau and wane in transport sector emissions is also due to California's zero emission vehicle incentives and its standards for new and light-duty vehicles approved in 2004 that require automakers to achieve fleet-wide fuel economy improvements in the model years 2009-2016[48] - as well as the LCFS and other transport sector policies.

In terms of distributional effects, the ETS's allocation design explicitly aims to finance additional transport sector reductions downstream. Transport sector emitters covered

[47] To be in line with the 2020 target, California electricity retail sellers had to serve at least 29 percent of their electric load with RPS-eligible resources by 31 December, 2018. According to the most recent report on compliance by the CPUC, retail sellers either met or exceeded this requirement overall. (CPUC 2019, page 9). The state's legislative analyst's office concludes in a recent report that the RPS is a "substantial driver of emissions reductions" in the power sector, with costs of "about $60 to $70 per ton reduced in energy procurement costs" (LAO 2020), signifying that the RPS drove power sector abatement more than the carbon allowance price.

[48] These standards require fuel economy averages fleetwide for passenger cars and the smallest light trucks of 323 g/mi in 2009 and 205 g/mi in 2016, and for the remaining light trucks of 439 g/mi in 2009 and 332 g/mi in 2016 (US EPA/NIHTSA, 2010, page 17).

upstream (fuel suppliers) are the entities needing the majority of the allowances each year, but they do not receive any allowances for free. As opposed to emitters in the industry sector, which are allocated certain percentages of their compliance obligation depending on their competitiveness and leakage potential, fuel suppliers pay for every allowance they need to meet their compliance obligations. The massive state revenue from selling so many allowances to large oil and gas companies is invested in programmes at the local level, effectively "redistributing" allowance proceeds from corporate entities to public and community projects such as greening urban areas or financing public transport that have a (dispersed) overall emission reduction effect. To enhance these distributional effects, the California legislature required at least one-fourth of the annual proceeds from allowance sales to be spent on projects specifically benefitting disadvantaged communities.[49]

2.3.2 New Zealand ETS

2.3.2.1 Summary description of the system

The New Zealand Emissions Trading System (NZ ETS) has been in operation since 2008. It was intended to be an all sector, all gas system, including transport and buildings. At the time of its launch, all economic sectors were to be phased in over the period 2008-2013, uniquely including the forestry sector as both a source and sink and the agricultural sector (Leining et al. 2016). At the current stage of implementation, agriculture does not yet have surrender obligations under the NZ ETS but, nevertheless, the NZ ETS has the broadest sectoral coverage of any ETS in the world, covering all other sectors to capture 51% of New Zealand's gross emissions (ICAP 2020). In addition to its broad coverage and plans to fully include the agriculture and forestry sectors, the New Zealand ETS is notable for its upstream point of regulation (including for transport fuel and energy, which captures emissions associated with the buildings sector) and close links to international markets.

New Zealand emissions goals

The ETS is New Zealand's central policy to achieve its GHG emissions reduction/ sequestration goals. New Zealand has set increasingly stringent future targets (Ministry for the Environment 2019a). Most ambitious is a net zero target for all emissions excluding biogenic methane by 2050[50], which passed into law in November 2019. As a stepping stone, New Zealand has committed to reduce gross GHG emissions by 30% below 2005 levels for the period 2021-2030. In the shorter term, New Zealand is aiming to reduce gross GHG emissions by 5% relative to 1990 for the period 2013-2020, and is on track to meet this 2020 target (Ministry for the Environment 2019a). Despite the increased ambition, due to a lack of implementing measures, Climate Action Tracker still finds New Zealand's current policies as insufficient to hold warming below 2°C by 2050 (Climate Action Tracker 2020).

New Zealand emissions profile

Figure 24 shows the historic and projected sectoral contributions to New Zealand's total GHG emissions. The figure also shows total emissions both including and excluding Land Use, Land Use Change, and Forestry (LULUCF). The key gives each

[49] California's enacted budget for Fiscal Year 2014-2015, for instance, appropriated $832 million in allowance auction revenue to "programs that improve public health, quality of life and economic opportunity" - legislatively enacted rules for spending auction proceeds required over $200 million in that year to "benefit the state's most disadvantaged and burdened communities." Roughly $630 million in proceeds went towards "clean transportation," including high-speed rail infrastructure. (CARB 2014b).

[50] Biogenic methane (i.e. emissions from agriculture) is to decrease by 24-47% below 2017 levels by 2050.

sector's contribution as a percentage, calculated with 2017 data (Ministry for the Environment 2019a)[51]. The projections assume implementation of existing measures. Note that all sectors other than agriculture are covered by the ETS[52]. Noteworthy is the supply of ETS credits from sequestration, predominantly through plantation forestry (equivalent to 30% of gross emissions in 2017). Decreasing annual sequestration from forestry over the coming decades (due to the changing age structure of NZ forestry) will be offset by emissions reductions from other sectors, seeing New Zealand's net emissions slowly decline.

Transport emissions are shown in the figure separately. Due to the upstream point of regulation, emissions from buildings (heating, cooling, and warm water) are included in the energy sector numbers. In 2017, the transport sector accounted for 20% of New Zealand's gross emissions, 91% of which come from road transport (MBIE 2020a)[53]. Since 1990, transport sector emissions have grown by 81%, they are expected to peak in 2020 then begin to slowly decline (Ministry for the Environment 2019a).

Direct emissions associated with the buildings sector are more difficult to parse, as they are not recorded as a separate sector in New Zealand accounts[54]. Direct emissions arising from the combustion of fossil fuels in buildings account for 2% of New Zealand's gross emissions, which have increased by 4% since 1990 (MBIE 2020a). This does not include any heating or other energy use in buildings that is powered by electricity (which accounts for 69% of household energy use) (Isaacs et al. 2010). It also does not capture emissions arising from burning wood, the predominant form of residential heating after electricity (MacGregor et al. 2018). Similarly for commercial buildings, electricity is overwhelmingly the most common fuel source (MacGregor et al. 2018).

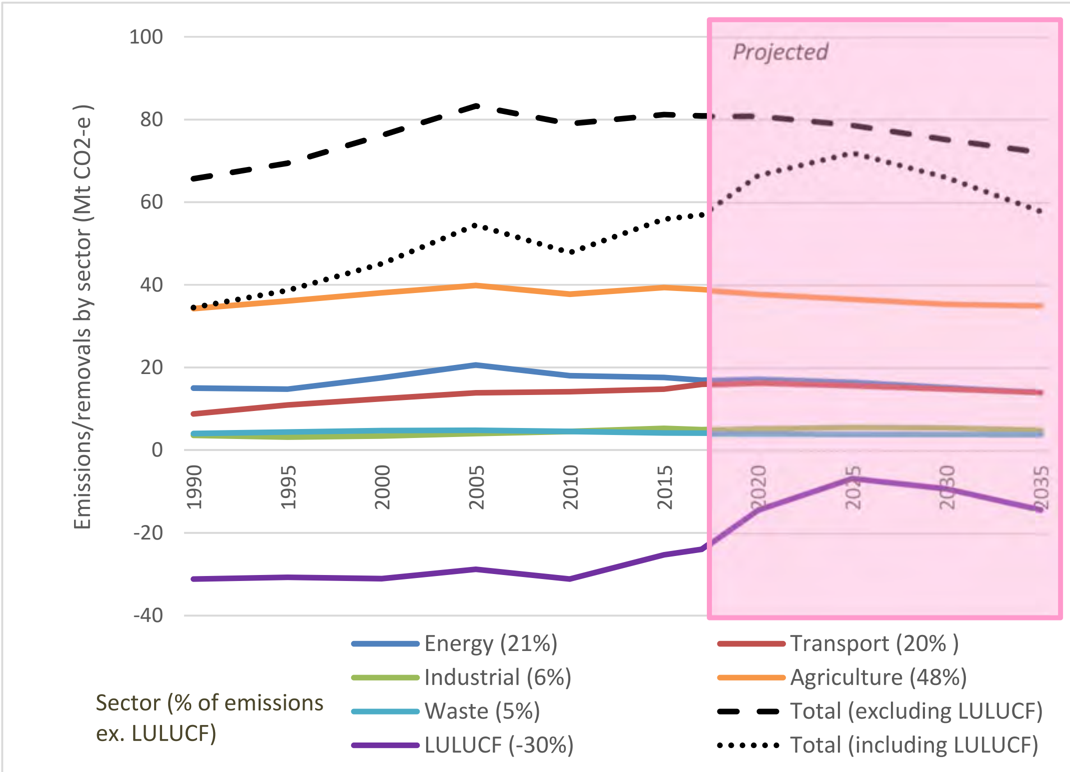
Figure 24. New Zealand emissions by sector, 1990-2035

[51] These numbers are based on New Zealand's Fourth Biennial report to the UNFCCC, calculated using UNFCCC methods.

[52] Agriculture is required to monitor and report emissions but does not have to surrender allowances to cover them; current policy discussions indicate that agricultural emissions will be managed outside of the ETS in the future. Agriculture emissions make up approximately half of New Zealand's GHG emissions, primarily arising from livestock digestion from New Zealand's large cow and sheep stocks.

[53] Transport figures include all emissions arising from domestic transport but exclude international transport emissions (MBIE 2017).

[54] In part, this arises due to New Zealand's use of upstream obligation in the ETS: New Zealand focuses on the upstream source of emissions (e.g. importation of coal), rather than where the emissions arise (e.g. burning of coal for residential heating).



Source: Ministry for the Environment 2019a

ETS Design

The New Zealand Emissions Trading Scheme's design has been determined by the government's objectives for the policy. When it was initially designed, there were two aims: to enable New Zealand to meet its Kyoto Protocol and UNFCCC obligations and to reduce New Zealand's net emissions relative to business as usual (Leining and Kerr 2018). Since its beginning, the balance of this dual ambition has shifted, resulting in design changes to the New Zealand ETS. Over the first decade of its existence, priority was given to enabling New Zealand to meet its international obligations at least-cost (Leining and Kerr 2016). However, following New Zealand's signing up to the Paris Agreement in 2015 and subsequent government evaluations of the ETS (Ministry for the Environment 2016) (New Zealand Productivity Commission 2018), the ETS is currently undergoing significant changes (ICAP 2020). Below, we cover the initial design, reasoning, and expected changes, with a particular focus on the transport and building sector.

Cap and price controls: Up until 2020, there has been no fixed cap on total emissions in the New Zealand Emissions Trading Scheme. Rather, the emissions from the NZ ETS are constrained by the number of emission units in circulation, which are supplied from two sources: first, units generated through sequestration by the forestry sector (in 2017 equal to 30% of gross NZ GHG emissions) and through supply from the New Zealand government (Ministry for the Environment 2019a). The New Zealand government currently supplies emissions units (New Zealand Units – NZUs) through free allocation. Free allocation includes one-off allocations to the forestry and fishing sectors to compensate for ETS impacts on asset values, as well as ongoing output-based allocation for trade-affected industries, who receive free allowances corresponding to 60-90% of their compliance obligation.[55] Output based allocation mainly applies to industry, aiming to prevent carbon leakage. It does not apply to transport or buildings sectors, as these are not trade exposed and providers are assumed to be able to pass on emissions costs to customers. While the NZ ETS was initially designed with no price floor or cap, from 2009 a de facto price cap was in place thanks to a fixed price option (FPO). ETS participants could meet their obligations either by surrendering the requisite number of allowances or by paying the government the FPO fee of $25NZ (14.70EUR[56]) per unit they were liable to surrender[57]. There were no limits on the number of emission that could be covered by the FPO. For the period 2008-2018, all non-forestry sectors had a one-for-two surrender obligation, effectively halving the cost of complying (ICAP 2020). Initially, international Kyoto-compliant units (AAUs, CERs and ERUs) were a third source of supply, yet this provision ended in 2015 when the New Zealand scheme was delinked from international carbon markets(Leining and Kerr 2016).

A series of reviews 2016-2020 identified problems with the NZ ETS, which alongside a change in government have resulted in proposed significant reforms, which are currently under consultation. The primary problems identified were a mismatch between New Zealand's 2030 target and unit supply volumes in the ETS, and significant regulatory uncertainty. Together, these linked issues undermine the credibility of the NZ ETS price signal, increasing uncertainty and costs for participants as well as slowing or decreasing mitigation action (Ministry for the Environment 2017). The New Zealand Productivity Commission's review (2018) further concluded that these issues lead to low and uncertain NZU prices and underinvestment in emission reductions. While proposed reforms are yet to be finalised, they are expected to include the following:

- an overall cap on emissions (calculated in five year bands and derived from a New Zealand-wide "emissions budget" that takes into account unit supply from LULUCF)
- an increase in the unlimited fixed price option to $35NZD (20.59EUR) for the year 2021, after which it is discontinued and replaced with
- a cost containment reserve that will release a limited number of units at a trigger price of $50NZD (29.41EUR)
- auctioning of any remaining allowances up to the cap (with a price floor) (Ministry for the Environment 2019b)

In the initial five year cap, no international units will be accepted - the government has indicated that any future access to international units would have quantitative limits (ICAP 2020). These changes are motivated by an increase in ambition in line with the Paris Agreement and New Zealand's Zero Carbon Act commitment to net zero emissions for non-biogenic methane emissions by 2050 (Ministry for the Environment 2019b).

Point of regulation: The New Zealand Emissions Trading Scheme applies an upstream point of obligation, with some minor exclusions. This was selected to

[55] In 2014, free allocation equated to 15% of total emissions surrendered (Leining and Kerr 2016). However, this would significantly increase if agriculture faced surrender obligations; current proposal for their entry in 2025 would see them awarded 95% free allocation.

[56] All Euro values calculated using 2019 average exchange rate of 1EUR:1.6998NZD (Eurostat: ert_bil)

[57] Note, while these price cap units could not be banked, there is otherwise unlimited banking in the New Zealand system. Foresters and free allocation recipients were able to bank those units and meet their obligations using the fixed price option. This has resulted in significant banking – in June 2018 banked units could have covered 4.5x the amount surrendered in 2017 (Leining and Kerr 2018).

minimise participant transaction costs and government administration costs, and to enable effective monitoring and verification whilst capturing as many emissions as practically possible and passing on effective economic incentives (Leining and Kerr 2018). In 2018, this amounted to a total of 275 mandatory participants as well 2173 voluntary participants, 92% of whom come from the forestry and agriculture sector (Environmental Protection Agency 2019).

The transport sector point of obligation is as high up as possible: at the point that a liquid fossil fuel supplier imports fuel or takes fuel from a refinery (Environmental Protection Agency 2020). This applies to all major liquid fuels that are used domestically, including petrol, diesel, aviation fuel, and light and heavy fuel oil, as well as “any other liquid fossil fuel”, which is listed in the regulation to capture other fuels not listed. To avoid confusion, the regulation explicitly exempts some related products on the grounds that they are infrequently combusted or associated emissions are negligible (e.g. solvents, lubricants). International aviation and marine fuel are also exempt. This high point of obligation means that users of fuel are covered by the emissions trading scheme but are not participants: they face the carbon price signal for the fuel they consume, but do not have to monitor emissions or handle emission allowances. Liquid fossil fuel participants must record the annual amount of fuel purchased or consumed and, using government provided emissions factors, calculate total emissions and retrospectively (i.e. by April 30th of the following year) surrender an equivalent number of units. Upstream participants must also annually report and subtract fuel that they sell that is used for international aviation/marine or sold to voluntary participants (see below), who take over this obligation (Ministry for the Environment 2009b). Biofuels used in the transport sector are not covered by the ETS (Environmental Protection Agency 2020).

An interesting exception to the high point of obligation is that large buyers of liquid fossil fuels and stationary sources can voluntarily opt in to the ETS. In 2018, there were four mandatory participants and five voluntary participants (principally domestic airlines) (Environmental Protection Agency 2019). Downstream actors that opt in take over the emissions obligation from the upstream entity. This creates transaction costs for the upstream entity related to quantifying the downstream entity’s fuel purchases, which are then deducted from their own emissions obligations. The upstream entity is not obliged to accept the shift, and some upstream entities have denied downstream actors from opting in (Kerr and Duscha 2014). This opt-in option arose as some downstream fuel buyers felt that they were paying higher than necessary carbon prices due to upstream point of obligation incompetence (due to limited commodity trading experience relative to downstream actors) or market power (due to network effects or other reasons) (Kerr and Duscha 2014).

Emissions arising from heating commercial and residential buildings are captured by upstream points of obligation in the stationary energy sector[58]. This operates similarly to the liquid fuels sector: any importer or miner of coal or natural gas[59] for domestic use is obliged to report the amounts and types of energy imported/produced, and surrender an according number of units calculated using government-generated emissions factors. *De minimis* exclusions apply, e.g. only importers of more than

[58] If buildings are heated using liquid fossil fuels, this will be captured by the liquid fossil fuels sector i.e. through the same mechanisms as the transport sector. Excluding electricity, the New Zealand Productivity Commission (2018) reports that 42% of emissions from commercial, residential, and domestic heating come from burning liquid fossil fuels, with the balance from solid and gaseous fuels, which are captured by stationary energy ETS participants.

[59] Users of geothermal fluid that produces significant emissions, burners of waste oil or used tyres or waste, and fuel refiners are also included (Environmental Protection Agency 2020)

2,000 tonnes of coal are included. In 2018, there were 82 mandatory stationary energy participants in the ETS (Environmental Protection Agency 2019). Very large users of coal or natural gas (e.g. electricity generators) further down the supply chain can voluntarily opt in and take over upstream obligations;[60] in 2018 there were six voluntary participants (Environmental Protection Agency 2019).

Monitoring, reporting, and verification: The NZ ETS MRV is modelled on New Zealand's tax system and relies on self-assessment (Leining and Kerr 2018). With few exceptions, participants must record relevant activities and report and surrender emissions units annually, in line with the government's GHG inventory reporting schedule. The government generally defines default emissions factors to calculate emissions. However, some stationary energy and liquid fuels participants can apply for a unique emissions factor (UEF) if they can prove that their emissions factor lies significantly below average (i.e. below the default emissions factor)[61]. This reduces administration costs for those who accept the default emissions factor, whilst also fairly allowing changes for higher efficiency fuels and incentivising participants to lower their emissions factors (Leining and Kerr 2018).

To enforce compliance, participants face automatic penalties for failing to surrender required credits, with increasing fines for failing to meet record keeping, reporting, and notification obligations, and criminal charges for providing false information or evasion (Leining and Kerr 2018). There are no requirements for third party verification (except for those with a unique emissions factor) but the regulator annually audits a selection of participants. Leining and Kerr (2018) report that the regulator's annual compliance checks find that the majority of participants understand their obligations and are willing to comply.

Overlap with other policies: The ETS is New Zealand's main policy for reducing emissions, but complementary policies also significantly affect domestic emissions (New Zealand Productivity Commission 2018). Significant policies in the transport sector, include informational schemes on car fuel efficiency and support for low-emissions or electric vehicles, such as more stringent fuel efficiency standards, publicly funded electric vehicle infrastructure, clean car discounts, exemption of electric vehicles from road user fee, and research into green freight (Ministry for the Environment 2019a). Transport emissions are also affected by policies not targeting climate change, especially fuel taxes: at current NZU prices of $25NZD (14.70 EUR) the ETS adds 3% to the pump price of petrol, significantly less than the 50% component of broader fuel taxes, which are earmarked to primarily fund national land transport infrastructure and contribute to accident compensation (MBIE 2020b).

Complementary policies in the buildings sector include insulation and heating grants programmes. The residential programme aims to result in warmer, dryer homes, which as a co-benefit decreases emissions by 8kt CO_2-e annually (equivalent to 0.3% of expected ETS impact) (Ministry for the Environment 2019a).

There is potential for slippage at the margin in the transport sector, as international aviation fuel and marine fuel is exempt. International shipping carriers also carry domestic cargo but, as the majority of their fuel is used for international travel, the fuel that they buy in New Zealand is exempt from the ETS, which could create some

[60] Opt-in is limited to very large users: they must annually purchase at least 250,000t of coal or 2 petajoules of natural gas (Environmental Protection Agency 2020).

[61] To avoid adverse selection (where all participants with low emissions factors apply for UEFs, resulting in the default emissions factor lying below the average emissions factor of the participants applying it, and resulting in the regulator receiving insufficient units to cover the total sector emissions), the default emissions factor is set slightly above average emissions and the threshold for applying for a unique emissions factor is set below average emissions (Ministry for the Environment 2009a).

slippage of emissions (Environmental Protection Agency 2020). Given the difficulty of attributing these international trade emissions solely through the NZ system, New Zealand is working with the IMO on international marine emissions and CORSIA on international aviation emissions (New Zealand Productivity Commission 2018).

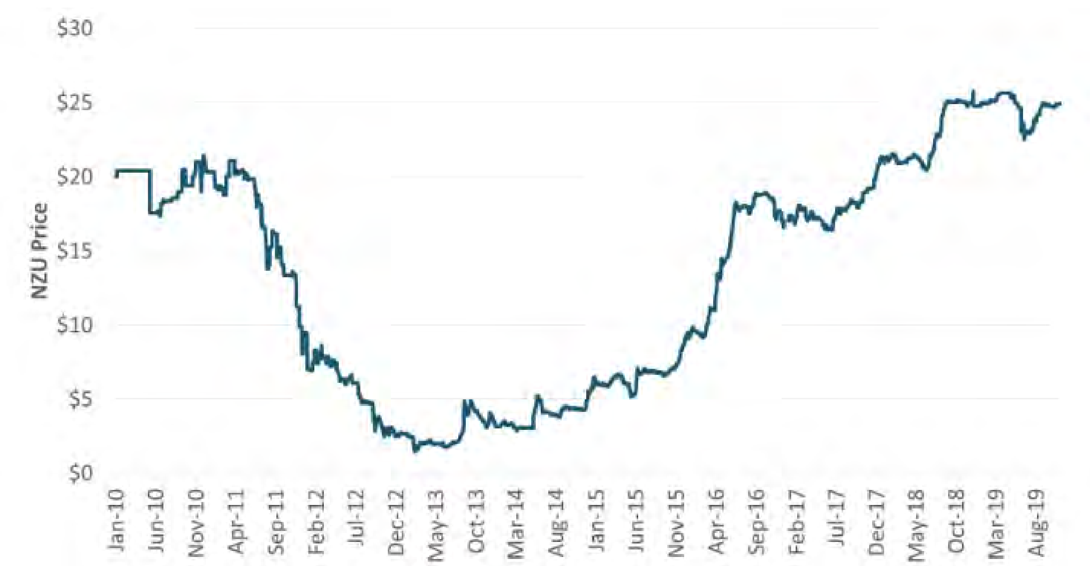
2.3.2.2 Performance of the system

We discuss performance of the NZ ETS in terms of its success in reducing emissions, impacts on competitiveness and overall economic performance, distributional impacts, and administrative aspects, with a focus on transport and buildings. Generally, reviews conclude that because of low prices, the ETS has had minimal impact in terms of reducing emissions, with accordingly small economic performance and distributional impacts (Leining and Kerr 2016).

Price history

A decisive metric in the success of the system is its ability to pass on incentives to participants. In general, the impact of the NZ ETS has been limited due to the low prices faced by participants, especially from 2011-2016, as shown in Figure 25. These low prices occurred because until 2015 the regulator accepted credits issued under the UN Clean Development Mechanism (Certified Emissions Reductions, CER) and Joint Implementation (Emission Reduction Units, ERU) projects, which were very low due to oversupply and questions of environmental integrity (Leining and Kerr 2016). After the NZ ETS was decoupled from international markets, prices remained artificially low due to the government's provision of a $25 NZD (14.70 EUR) price cap and a one-for-two surrender rule (ICAP 2020). Prices have since tracked upwards, with prices at the start of 2020 reaching $29NZD (17.06 EUR) on the back of the proposed NZ ETS reforms announced in late 2019 (Carbon Pulse 2020).

Figure 25. Price of New Zealand Units, 2009-2017



Source: Ministry for the Environment 2019b

Performance impacts

Reviews of the ETS suggest that it has had only a minor impact on domestic emissions. Leining and Kerr (2016) report that the government's own estimates show that all of New Zealand's mitigation measures in the stationary energy and transport sectors combined (including the ETS) had only reduced cumulative 2007-2013 emissions by 681 kt CO_{2e}, equivalent to 0.3 percent against baseline. Indeed, the New

Zealand government's 2016 review of the ETS concluded that "no sector other than forestry made emissions reductions over Kyoto Protocol Commitment Period One (2008–12) that were directly caused by NZ ETS obligation" (Ministry for the Environment 2016). The impact on forestry also appears to have initially been limited to the first years of the scheme, when relatively high prices limited deforestation and potentially induced some afforestation (Leining and Kerr 2016). The government's most recent projections indicate increasing impact, with the NZ ETS expected to have an overall impact of 2,935 (kt CO_{2e}) in 2020, equivalent to a 3.6% reduction on baseline (Ministry for the Environment 2019a); these projections do not consider the proposed reforms to the ETS announced in late 2019.

The New Zealand Productivity Commission (2018) identified that the reasons for the failure to impact emissions lie with low prices that are in turn due to lack of a cap on supply, and high policy uncertainty, for example related to future ambition and future allocation of units. The proposed reforms to the NZ ETS aim to address these issues and increase certainty of future NZ ETS prices so as to induce domestic mitigation (Ministry for the Environment 2019b).

Performance impacts: transport and buildings

In line with the small overall impact of the ETS, impact on emissions from the transport and buildings sectors are likely to have also been small. For transport, the reason is the small price impact of the ETS: at NZU prices of $20NZD (11.75EUR), the New Zealand Productivity Commission review of the ETS (2018) reports that the ETS component of fuel prices are $0.05NZD (0.03EUR) per litre of petrol, or approximately 2.5% of the pump price. Even if NZU prices rose to $100NZD (58.83EUR), this would only increase petrol prices by approximately 10%. Accordingly, the Commission concludes that while higher NZ ETS prices will increase behaviour change, this effect will still be minor and complementary measures will be required to reduce transport emissions, which grew 12% between 2010-2017 (Ministry for the Environment 2019a). With regards to impact on building emissions, the New Zealand Productivity Commission (2018) states that to phase out low efficiency building heating units, high expected future emissions prices are important (at a minimum above $40NZD (23.53EUR). Given the relatively low NZ ETS prices since 2010, and the slow response of the buildings sector due to the long life of investments, no significant impact on emissions is expected.

Impacts on competitiveness, overall economic performance, and distributional impacts

As we are unable to tease out the specific distributional impacts related with building and transport aspects of the ETS, here we summarise overall ETS impacts. Given the relatively low prices, the impact of the policy as a whole on the New Zealand economy has been small. The New Zealand Productivity Commission (2018) reviewed theory and evidence and concluded that the ETS, especially under higher emissions prices, will be regressive. This occurs as low-income households spend a greater proportion of their income on energy, transport, and food, and are less able to invest to reduce emissions. In terms of sectoral distributional impacts, the impact on forest owners and fishers (who faced new obligations or costs under the ETS) were managed through free allocation of allowances: one-off allocations were made to owners of pre-1990 forests to compensate for lost asset values; commercial fishers also received a one-off allocation, to compensate for increased costs associated with the ETS (Leining and Kerr 2016). Ongoing output-based allocation to trade-effected producers is intended to offset competitiveness impacts, as well as minimising leakage. Highly-exposed industries receive output-based free allocation at a rate of 90% of previous year output, while moderately exposed producers receive 60% free allocation[62]. In general, the government intends to manage distributional impacts on the broader economy and society through the benefit and tax system, rather than the ETS (New Zealand Productivity Commission 2018).

Administrative costs

The Ministry for the Environment's 2016 review concluded that the NZ ETS operates effectively and efficiently (Ministry for the Environment 2016). The NZ ETS cost $38.9 million NZD (22.85 million EUR) over the period 2008-2015, with ongoing running costs of $6.4 million NZD (3.77 million EUR). In general, participants reported that the scheme was well-run.

2.3.3 Tokyo Municipal Government

2.3.3.1 Summary description of the system

Since 2010, the Tokyo Municipal Government (TMG) has operated an Emissions Trading System, covering about 10.8 million tons of CO_2 emissions in 2020, or 20% of the municipalities total GHG emissions (Environmental Defense Fund, International Emissions Trading Association, and CDC Climat 2015). At the time of its introduction, it was the first ETS introduced at municipal level, a feature that it now shares with several Chinese pilot ETS. With a population of 13.1 million, the Tokyo Municipality is larger than Belgium, and accounts for more than 10% of Japan's population, as well as close to 20% of Japan's Gross Domestic Product[63] - yet only 5% of Japan's greenhouse gas emissions.

A unique feature, which sets the Tokyo ETS apart from all other ETS, is that it covers both direct emissions (particularly from industrial facilities, but also from district heating and cooling plants, waste processing and water and sewage plants) and indirect emissions, i.e. the consumption of electricity and heat in large commercial, and office buildings. The latter category also includes public buildings, educational and medical facilities. The system does not cover residential buildings. Participation in the system is mandatory for installations / buildings with an annual energy consumption of more than 1.5 million litres of oil equivalent.

For buildings, the system covers both their fuel use, as well as energy consumed in the form of electricity and heat delivered to the buildings. Based on a fixed standard factor for the carbon intensity of the grid, the electricity consumption of the covered entities is converted into their indirect CO_2 emissions, for which entities need to surrender allowances. All in all, the Tokyo ETS initially covered some 1,300 entities. This number has fallen to 1,100 more recently (ICAP 2020), as several installations have fallen below the threshold and since left the system. Among the installations covered by the system, commercial and residential buildings dominate, accounting for 80% of the installations covered by the system (ICAP 2020).

A further unique feature of the Tokyo ETS is that it does not issue credits for the actual emissions, but rather for emission reductions that exceed the reduction target of each installation. In the first commitment period (2010-14), industrial installations were obliged to reduce emissions 6% below the baseline (8% for commercial buildings); in the second commitment period (2015-19), this obligation rose to 15% below the baseline for industry and 17% for commercial buildings. For the third period (2020 – 2024), the targets have increased further to 25 and 27%, respectively (ICAP 2020). The baseline is determined for each installation as the average emissions of

[62] Highly exposed industries are defined as those that emit over 1600t$C0_2$-e/$1million NZD of revenue (USD0.69million); medium exposed are over 800t$C0_2$-e/$1million NZD revenue (ICAP 2020).

[63] https://www.metro.tokyo.lg.jp/ENGLISH/ABOUT/APPENDIX/appendix02.htm

three consecutive years between 2002 and 2007, which each covered entity can select themselves (Environmental Defense Fund, International Emissions Trading Association, and CDC Climat 2015).

If an installation reduced its emissions beyond this target, it could apply for issuance of credits – which could then be sold to other installations who did not meet their target. As a result, there is no pre-defined cap in the Tokyo ETS – instead, the cap is derived from the sum of the covered installations' emissions after reduction targets have been deducted. The total supply of allowances consists mostly of allowances for target overachievement. In addition, there are also three types of offsets – of which only renewable energy certificates play a significant role (Environmental Defense Fund, International Emissions Trading Association, and CDC Climat 2015). Installations that fail to comply with their obligations face a penalty of ¥ 500,000 (approx. 4,200 Euro), and will need to cover 130% of their excess emissions in the following compliance period.

The Tokyo ETS was preceded by several different policy instruments targeting energy consumption and efficiency of buildings. In particular, the mandatory Emission Reporting Programme that had been operating since 2002 can be seen as a precursor of the Tokyo ETS, covering essentially the same installations (Rudolph and Kawakatsu 2012).

The Tokyo ETS is complemented by a suite of companion energy policy measures including monitoring, information sharing and advisory services for the covered entities. Some of these measures have in fact become integrated into the ETS: in their annual reporting, companies have to report not only on their energy consumption and associated emissions, but also on the specific measures that they are taking to reduce emissions in the future. Based on the energy consumption data received from the covered companies, the competent authorities estimate a benchmark for the respective sector, and inform companies how they perform relative to the benchmark (Wakabayashi and Kimura 2018, 1037). Based on the energy efficiency measures which they report, installations can also apply to be classified as top-level performers: those that report the most comprehensive set of measures are rewarded with a less strict emission objective (and hence would have more excess allowances to sell). In addition, the top performers are also listed publicly in official publications, which is believed to be a strong motivator for companies (Brundgage-Moore 2019).

Since the Tokyo ETS only covers the larger installations, the bulk of the small and medium sized facilities fall below the threshold. These account for 60% of total CO_2 emissions in the commercial and industrial sectors (Environmental Defense Fund, International Emissions Trading Association, and CDC Climat 2015, 8). These installations are therefore covered by the Tokyo Carbon Reduction Reporting Programme, under which they are obliged to take specific climate change measures and submit annual emission reports.

In many design aspects, the Tokyo municipality has taken other choices than the existing ETS. Most of these can be explained by its particular situation. With its long-run emission reduction objectives and strategy, the Tokyo municipality has been more ambitious than other provinces and the national government for quite some time. Since discussions on carbon pricing at the national level have led nowhere for years, Tokyo decided to move forward by itself. In this effort, it was followed by the neighbouring province Saitama, which has established a separate ETS which is by now linked to the Tokyo system, but otherwise the model has not been taken up elsewhere.

The Tokyo ETS continues the tradition of regulating and rating the energy consumption of the building sector, as the main driver of Tokyo's emissions. At the same time, Tokyo has only limited jurisdiction over how the power and heat are generated, since most of Tokyo's power is imported from neighbouring provinces. As Tokyo does have jurisdiction over the direct emissions (i.e. the power plants), it instead opted to regulate further downstream, at the level of energy users.

2.3.3.2 Performance of the system

The Tokyo ETS is generally viewed as a great success in reducing emissions. During the first commitment period, all covered installations achieved their targets. In fact, three quarters (76%) even achieved their (more ambitious) second-period targets already in the first period. In 2016, the Tokyo Metropolitan Government announced that, during the first commitment period, the programme had managed to reduce CO_2 emissions from the covered facilities by 25%, or 14 million tonnes, below base-year emissions. This trend continued also in 2017, despite an increase in gross floor space of the covered buildings (ICAP 2020). Other scholars point out that this reduction is calculated in comparison to an inflated baseline, and that the actual reduction is closer to (still significant) 14% below the emissions at the start of the system. The majority of reductions were achieved in commercial buildings, which cut their emissions about twice as much as industrial facilities (Wakabayashi and Kimura 2018, 1041). Other estimates arrive at comparable reductions: Arimura and Abe estimate that the actual emission reduction was at 13.3%, of which approximately half was due to the ETS, and the other half due to increasing electricity prices (Arimura and Abe 2020).

There has, however, been some debate to what extent the reported reductions can be attributed to the ETS. It has been observed that the reductions are largely explained by factors other than the ETS: among them, first and foremost, the 2011 Great East Japan earthquake and tsunami. As a result of the nuclear accident in Fukushima, much of Japan's nuclear power generation capacity was shut down following the earthquake. This resulted in harsh measures to reduce electricity consumption: large electricity consumers were ordered to cut their peak consumption by 15% compared to the previous year. In addition, the economic impacts of the earthquake lowered energy demand, and the use of less efficient generation plants and natural gas increased electricity prices (Arimura and Abe 2020). All these factors leading to a drop in the reported (indirect) emissions. Further drivers were technological advances to use electricity more efficiently, in particular the replacement of dated equipment for heating, ventilation and air conditioning, as well as the market penetration of LED lighting, becoming the new norm and replacing fluorescent lighting (Wakabayashi and Kimura 2018, 1039). In particular for the replacement of outdated heating, ventilation and air conditioning equipment, the uptake of these technologies may have accelerated by the Tokyo ETS – however it has been pointed out that the prices in the system have mostly been too low to stimulate low-carbon investment (Wakabayashi and Kimura 2018, 1037).

The performance of the Tokyo ETS has been less impressive, however, when it comes to creating a liquid and transparent market for trading allowances. Since its inception, trading volumes in the system have remained very low. To this day, there is no central trading venue in the Tokyo ETS (unlike all other ETS in force), instead trading only takes place as bilateral over-the-counter trade between covered entities. One reason for the low trading volumes is evident – 91% all covered entities (over-)achieved their targets through their own efforts, only 9% relied on purchased credits to fulfil their obligations. Hence there was only very little demand, and thus hardly any need to trade.

As there were very and only bilateral few transactions, and since there is no central trading venue, little is known over the prices of allowances. A survey conducted by the Tokyo Metropolitan Government revealed very high prices in the order of ¥ 4,000 to 5,000 per ton of CO_2 (34 – 42 Euro) for credits from installations that had exceeded their targets, and of ¥ 5,000 to 6,000 (42 – 50 Euro) for renewable energy certificates (Environmental Defense Fund, International Emissions Trading Association, and CDC

Climat 2015, 8). Wakabayashi and Timura report that prices were even higher initially at ¥ 10,000 (84 Euro), and have since fallen to 2,000 ¥ / tCO_2 (17 Euro) (Wakabayashi and Kimura 2018, 1036). They estimate that less than 3% of the issued emission reduction credits – about 300,000 in total – were actually traded (Wakabayashi and Kimura 2018, 1035). The authors attribute the low trading volume to the fact that most installations achieved their reduction objective – and that therefor there simply was not a lot of demand in the market. Arimura and Abe use the response of firms to the observed electricity price increase to derive an implicit carbon price: from the observed reactions to the electricity price, they infer econometrically which carbon price signal was necessary to achieve the observed emission reduction, arriving at an implicit price of ¥ 4,688 (approximately 40 Euro), which is indeed in the range of the observed prices (Arimura and Abe 2020).

The fact that the vast majority of installations have achieved their targets without resorting to trade points to limited efficiency of the system. To reduce emissions where it is cheapest to do so, and then to trade these emission reductions, is essential to the logic of cost minimisation through an ETS. If almost all covered entities chose to fulfil their emission targets themselves, without resorting to trade, it suggests that some abatement options were tapped that were higher than necessary, and that cheaper potentials were not addressed.

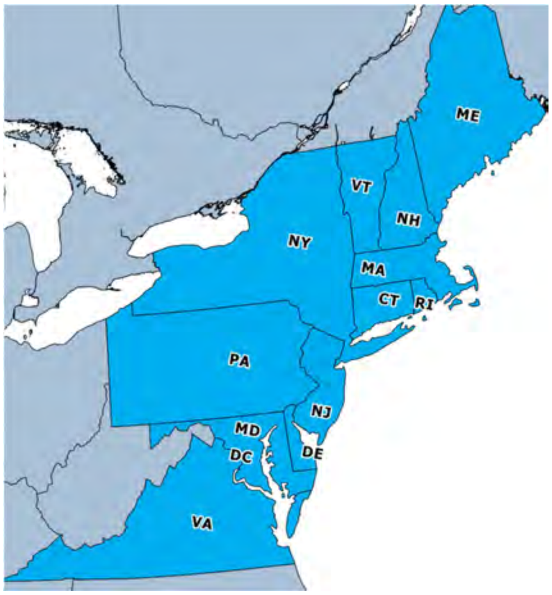
2.3.4 Transport and Climate Initiative (TCI)

2.3.4.1 Summary description of the system

The TCI is not an existing ETS, but rather a group of 13 northeastern and mid-Atlantic jurisdictions in the US that have been working together to reduce transport emissions in their region for the past half-decade. The collaboration has considered several policies designed to cut CO_2 from the transport sector, which makes up over 40 percent of the region's greenhouse gas emissions (TCI, 2019b). In this context, the jurisdictions have explored market-based policies including a so-called "cap-and-invest" programme that incorporates most features of an ETS combined with an upstream point of regulation. If the programme is launched, it will thus constitute an ETS for the transport sector – more specifically, motor vehicles.

The participating jurisdictions are the District of Colombia (Washington DC, which is not a state) and the states Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia. Together, they comprise 72 million people with 52 million registered vehicles and generate US $5.3 trillion in GDP (TCI 2019a). That is roughly one-fifth of the US total for all three metrics.

Figure 26. Jurisdictions in the TCI



Source: TCI 2019a slide 4

Ten of the 13 members (all except Washington DC, Pennsylvania, and Virginia)[64] are also members of the existing Regional Greenhouse Gas Initiative (RGGI), an ETS covering CO_2 emissions from the power sector. RGGI has been in operation since 2009 and is small compared to the EU ETS – in 2017, the generators covered by RGGI emitted only about 75 million tonnes[65] CO_2 (RGGI, Inc., 2019). The TCI cap could cover about three times this amount of emissions (TCI 2019a, slide 4).

The design of RGGI is relevant to the TCI because creators of the latter are explicitly leaving room for it to link with the former in the future – this would make for a joint ETS that covers the power and transport sectors of those states.

There is interest in such a link among existing RGGI market participants, especially among the "speculators" like banks and traders because of the increased arbitrage opportunities across a greater diversity of compliance buyers. Regulators developing the programme have modeled its design elements after those of RGGI (see "ETS design" section below) in preparation for a potential link. However, official documents mention the prospect relatively little (the draft MoU includes a vague reference to "other emissions reduction programs" and specifically says "linking is not immediately contemplated"),[66] as many of the participating jurisdictions face opposition to market mechanisms. Particularly environmental justice groups, wary of so-called pollution

[64] Virginia has adopted a state ETS that will link to RGGI in 2021

[65] RGGI uses US tons rather than metric tonnes - this figure is converted from 82 million tons cited in the monitoring report. In an attempt to remain consistent, references to emissions volume (tonnage) will be metric unless otherwise cited in this report. That means the source documents will not correspond to the tonnage cited here.

[66] Section G. (3) of the MoU reads: "Linking. The TCI Program could link to other emissions reduction programs through mutual agreement to accept each other's emission allowances. Linking is not immediately contemplated, but the TCI Program and Model Rule shall be developed to enable potential linking in the future, if desirable" (TCI 2019b).

hotspots they fear a market will cause in disadvantaged communities, generally oppose what they call "pollution trading" in favour of fixed regulatory mandates.

The effort to gain buy-in from those groups is evident in the entire TCI process, which is run as a collaboration among jurisdictional regulatory agencies and the public. Relevant studies and documents must be developed and considered in public meetings with stakeholder input at every stage, rather than as e.g. a bill in the participating states' legislatures. The most recent iteration of this process involved circulation of a draft Memorandum of Understanding (MoU) that would, if signed by the authorities in the relevant jurisdictions, launch the cap-and-invest programme among those jurisdictions.[67]

That draft MoU and its appendices is what currently constitutes "the TCI", but has not been adopted yet. A public comment period on the draft ended in March 2020, with a final version expected in Q2 2020. If adopted by all jurisdictions in 2021, the TCI could enter into force January 2022 - estimates of reduction trajectories are pegged to that year as the "start date" (TCI, 2019b). The declining emissions cap would be set for ten years through the end of 2031.

TCI emissions goals

The MoU does not set a specific target for emissions from the transport sector, but directs the relevant agencies in the states that end up adopting it to set such a target based on modelling work done so far. That work, summarised in a public webinar, lays out the modelling assumptions for a plausible *reference case* with which to compare policy scenarios of varying ambition. The reference scenario takes into account e.g. increased electric vehicle infrastructure buildout over the coming decade as well as the effect of US federal corporate average fuel economy vehicle emissions standards through 2025. On this basis, it projects on-road vehicle transport emissions in the region to *decrease* by 19 percent during the 2022-2032 time period in the reference case, i.e. without further interventions. The cap would not apply to rail transport.

The modelled policy scenarios represent caps that would require 20, 22, and 25 percent CO_2 reductions, respectively, in the region's transport emissions over the same timeframe. This is only one, three and six percent more ambitious, respectively, than the reference case - but the 19 percent reductions projected in the reference case are already its most "optimistic" end of the spectrum. When sensitivity analysis was applied to the reference case, it revealed high sensitivity to the federal fuel economy standards president Trump is currently dismantling (Phillips and Mitchell, 2020) and to lower oil prices. A scenario in which federal fuel economy standards are rolled back and oil prices remain low thus yields only six percent reductions in transport emissions during 2022-2032, meaning emission reductions of 20, 22, or 25 percent in the 2022-2032 timeframe go well beyond "business as usual."

All scenarios assume the cap is applied to the fossil portion of motor gasoline (petrol) and on-road diesel combusted in vehicles. Covered vehicles include not only light duty cars and trucks, but also commercial light trucks, freight trucks, and buses (TCI 2019a, slide 24).

If adopted, the final MoU would authorise regulators to set the cap - stakeholders generally assume regulators will pick one of the three modelled policy scenarios. In their submissions during the public comment period, environmental groups strongly

[67] The draft MoU stresses that that "Signatory Jurisdictions will work with communities to ensure that the benefits of a cap-and-invest program flow equitably to communities that are underserved by clean transportation alternatives, disproportionately bear the costs of the current transportation system, or suffer disproportionate impacts of vehicular pollution and climate change" (TCI 2019b, page 2).

urged adoption of the most stringent cap scenario (25 percent reduction) (Carbon Pulse, 2020).

Point of regulation: Only the fossil fuel components of motor gasoline (petrol) and on-road diesel fuel destined for final sale or consumption in a TCI jurisdiction would be covered - as in the Californian system, this would occur upon removal from a fuel storage facility or "terminal rack" in the participating jurisdiction. For fuel delivered from another jurisdiction, the point of regulation is at delivery into the participating jurisdiction (TCI 2019b, page 5).

Correspondingly, there would be two types of entities with a compliance obligation: "position holders" or companies that own the affected fuel at the point it is delivered across a terminal rack, and "enterers" or companies that own the affected fuel when it is otherwise delivered from a facility in another jurisdiction for final sale or consumption in a participating jurisdiction. To avoid overlapping compliance obligations, enterers would *not* be required to hold allowances for fuel that a position holder already sells in the TCI region and holds allowances for. Which entity has the burden of proof in the case of such overlap is not specified in the MoU, which merely states that "sufficient documentation must exist to demonstrate that the compliance obligations are being fulfilled by the position holder (on behalf of the Enterer)." (TCI 2019b, page 6).

In all other design elements, the TCI's structure resembles that of RGGI: it envisions three-year compliance periods, requiring jurisdictions to auction (rather than give out for free) all allowances, cost-containment and emissions-containment mechanisms,[68] allowing banking (but not borrowing) of allowances, and the use of offsets.

Monitoring, reporting, and verification: The draft model rule requires an electronic emissions reporting system informed by existing reporting requirements for state fuel suppliers. It suggests the participating jurisdictions use existing platforms for the accompanying allowance tracking system, likely having in mind RGGI's tracking system referred to as COATS.[69] Compliance obligations are to be calculated based on the CO_2 emissions that occur when the covered fuel is combusted, and the draft MoU suggests using standard emission factors for this calculation such as those "developed by the United States Environmental Protection Agency or other similar sources." (TCI 2019b, page 7).

Overlap with other policies: The modeling that establishes the reference case and suggested three cap stringencies not only takes into consideration other policies in the jurisdictions' transport sector, but is explicitly based on those as modeling inputs. Thus the cap that the TCI ultimately applies if and when it enters into force will be inherently calibrated to the effect of other policies. Those effects of other policies include, electric vehicle introduction year estimates, assumptions that the current US federal vehicle emissions standards will continue through at least 2025, phaseout of the current US federal electric vehicle tax credit, estimated regional impact of individual state electric vehicle subsidies, and projections of the effect of RGGI on the region's power prices (with Virginia included as a RGGI member state). (TCI 2019a, slide 17).

---

[68] RGGI's cost containment reserve (CCR) is a pool of allowances that are held in reserve *in addition to* the annual cap and are only made available for sale if emission reduction costs are higher than projected (i.e. allowance prices surpass a predetermined "ceiling" trigger price). The emissions containment reserve (ECR)allows RGGI states to *withhold* allowances from circulation if abatement costs are lower than projected (i.e. allowance prices reach a predetermined "floor" trigger price). These features serve roughly the same purpose as the EU ETS's market stability reserve (MSR).

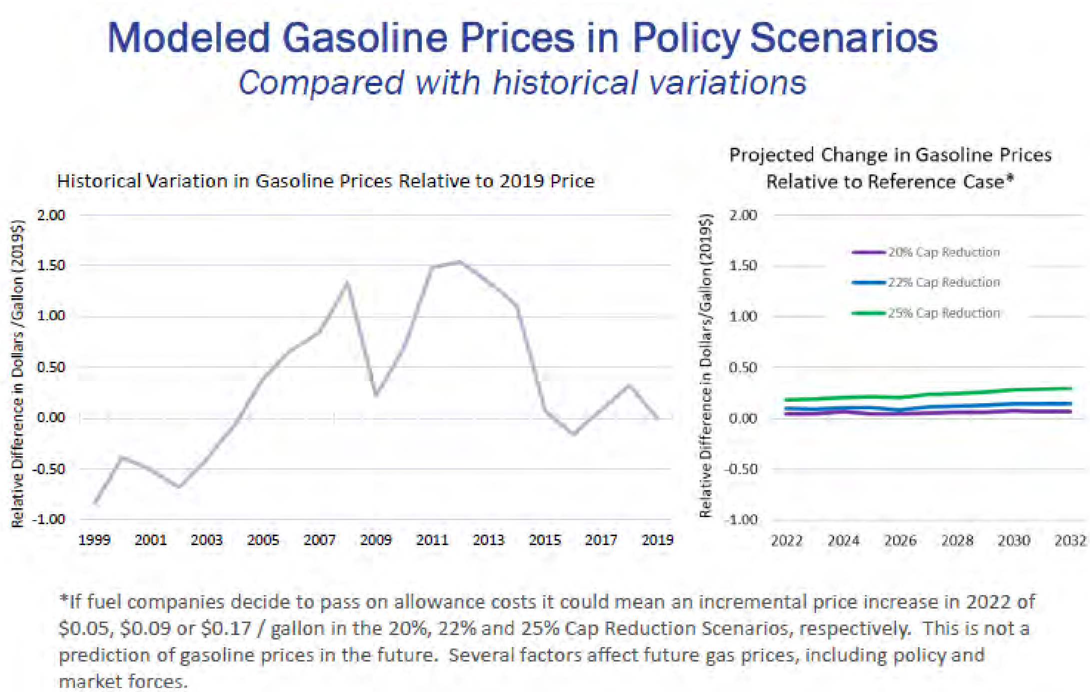
[69] See RGGI COATS website with access to the platform and downloadable reports on market activity as well as compliance: https://www.rggi.org/allowance-tracking/rggi-coats

2.3.4.2 Performance of the system

Since the TCI does not yet exist, its performance cannot be analysed - however, the modelling detailed above produced estimates of the effect of the three cap scenarios on several factors including:

- allowance prices (and resulting auction proceeds)
- gasoline (petrol) prices
- public health benefits in terms of US$ saved from reduction in asthma and other health issues caused by vehicle air pollutants (ancillary benefits not directly related to CO_2 reduction)
- avoided climate impacts in US$.

Figure 27. Modelled TCI scenarios



	No Cap No Investments		20% Cap Reduction with Investments		22% Cap Reduction with Investments		25% Cap Reduction with Investments	
	Reference Case		Policy Case		Policy Case		Policy Case	
	2022	2032	2022	2032	2022	2032	2022	2032
Emissions Total, million metric tons; and percent reduction from 2032 to 2022	254	206 **-19%***	254	202 **-20.5%**	254	199 **-22%**	253	192 **-24%**
Allowance Prices per metric ton (2017$)	*n/a*	*n/a*	$6	$9	$11	$18	$22	$36
Total Proceeds (Billion/ year)	*n/a*	*n/a*	$1.4	$1.8	$2.8	$3.6	$5.6	$6.9
Public Health Benefits, *Prelim.* (Billions of 2017$)	*n/a*	*n/a*	-	$3	-	$6	-	$10
Avoided Climate Impacts (Billions of 2017$)	*n/a*	*n/a*	-	$0.25	-	$0.46	-	$0.89

Overall, the macroeconomic modelling concluded that the higher fuel costs allowance prices would cause are small relative to overall expected economic growth in the business as usual case. In the most stringent cap scenario (25 percent reduction from 2022), allowances would cost $36/tonne (€33/tonne) in 2032, which would increase the price "at the pump" for the average consumer by roughly $0.36/gallon of gasoline (€0.09/liter of petrol).[70] All three scenarios would have "a modest positive impact on GDP, income, and jobs, all of which would be greater than business as usual in 2032 and substantially net positive over the 2022-2040 timeframe."

Those prices, though low compared to projected EUA prices in the EU ETS during this timeframe, are actually higher than those expected in RGGI. The power-sector-only programme has featured allowance prices below €5/tonne throughout most of its existence, with prices only recently exceeding $5/short ton on expectations of a tighter market starting when reforms take effect in 2021. Even going forward in this tighter market, analysts do not expect RGGI allowance prices to reach the trigger price of its Cost Containment reserve (Larsen and Herndon, 2018), which starts at $13/short ton in 2021 and increases by seven percent per year to about $26/short ton in 2031 (~€21/tonne).

The modellers acknowledge that the already impressive reductions their projections show for the reference case (19 percent over 10 years) are very sensitive to US federal fuel standards and oil prices. A major factor contributing to the assumed emissions drop is that the modelled "business as usual" scenario for the northeastern US includes a major increase in electric vehicle use during the 2022-2032 timeframe. The demographics of the northeastern US features higher population density and relatively more urban areas compared to the rest of the country, which correlates with better feasibility of electric vehicle charging infrastructure and with consumer

[70] USD to EUR exchange rate of 7 April 2020 (0.917) from www.xe.com/currency converter

preference for smaller, more fuel efficient cars. The effects of vehicle fuel efficiency standards and state policies to encourage electric vehicle use are therefore likely more impactful on transport sector emissions than they would be in the US as a whole.

2.3.5 Summary: Insights and lessons relevant for the EU ETS

The four systems investigated in this section offer different insights on the point of regulation and their relative advantages and drawbacks:

- The experiences in **New Zealand** and in **California** both show that the use of **upstream obligations** for transport and heating fuels lowers the number of participants, **keeping participant transaction costs and administrative costs low**. Both systems – and also the forthcoming TCI programme on the US East Coast – have placed the point of regulation as high upstream as possible: at the terminal rack where the fuel is produced / imported, rather than the level of fuel traders. As a result, the number of participants remains low, with 450 companies representing 600 installations in the case of California – for an economy that is larger than France or the UK. The NZ experience also documents the relatively low administrative costs, both for the public administration and for the covered entities.
- The examples of NZ and California thus show that upstream regulation is a feasible option where markets **are sufficiently liberalised** to allow cost pass-through. California also shows (albeit in the electricity sector) how smart regulation can combine cost pass through with compensation for rate payers, keeping the price signal intact and yet the burden on private households low. Since both California and New Zealand are essentially hybrids (with upstream coverage in transport as well as downstream in other sectors), neither have experienced problems of low liquidity or too high market power, which could be more problematic in a pure upstream system. Due to its size, this would be much less of a concern for the EU.
- The NZ ETS complements the upstream point of regulation with an interesting derogation, whereby (large) downstream installations can opt into the ETS and assume compliance obligations themselves. This option complicates the implementation of the system and creates additional administrative burdens both for the supplier and the customer, as fuel suppliers need to differentiate between fuels depending on the status of their customers. Yet it offers a recourse if downstream installations object to the way their fuel suppliers factor in the cost of allowances, and fear that they abuse their market position to extract excessive rents. So far, five companies (all domestic airlines) have made use of this opt-in provision. The derogation, however, is not specifically designated for airlines, but is open to all large installations.
- Compares to the upstream systems, the **Tokyo** example shows that also a **stand-alone ETS for buildings generally can work, even if applied at the downstream level**. Despite some weaknesses – such as the low level of liquidity – the system has operated for a decade, and is generally viewed as a success, particularly in terms of reducing emissions. By excluding residential buildings, the Tokyo ETS avoids many distributional implications of including buildings in an ETs.

The experience of all existing systems is that, even if ETS prices rise to relatively high levels, the emissions component of fuel costs will remain small: in the case of the NZ ETS, at current carbon prices the carbon price only adds about 3 cents, or 2.5%, to the pump price; and even for a much more ambitions carbon price of 60 Euro, petrol prices would still increase only by about 10%. The relative impact is somewhat larger in California – since there are no federal taxes on transport fuels, their prices are low to begin with. Still, the effect of the price signal remains limited, which means that additional measures are necessary to drive swift emission reductions.

- This is particularly evident for **California**'s ETS, which is (and was from the beginning) seen as a **"backstop" policy among many sector-specific measures** aiming for a specific overall emission reduction target, and which have been designed in coordination with the ETS.
- It is also evident in the case of the **TCI**, where **policies other than the ETS are expected to deliver most of the anticipated reductions** in the transport sector – whereas a modest carbon price is expected to deliver some addition reduction.
- But also in **New Zealand**, where the ETS supposedly has a more central role among climate policy instruments, there is a **shared understanding that complementary policies are necessary**, and may in fact turn out to be main drivers of change, particularly in the case of transport emissions.
- **Japan** has traditionally been a country with high energy costs, and as a result started from a high base as an economy with already relatively high energy efficiency. Nonetheless, in commercial buildings, **energy costs only account for a low proportion of total costs**, and hence have low priority. Both factors suggest that it takes an **even stronger price signal** to bring about reductions in buildings – and indeed both the observed and the modelled prices were in the order of 40 Euro per ton and above.

Whether the ETS serves as a flagship or as a backstop in the climate policy mix of the respective jurisdictions – one main function of the ETSs in either case has been to provide long-term orientation for owners of cars and buildings, for investors and consumers.

- For **New Zealand**, following a period of drastic design changes it has become clear that the overall impact of the scheme depends on its fundamental ability to generate a price incentive to act, in turn determined by limited supply of credits, i.e. a binding and sufficiently stringent cap. Given the long-term time horizons for transport and building investments, long-term policy certainty is important to drive ETS impact.
- Yet the **Tokyo ETS also shows that effective policy is not only a matter of a high-enough carbon price**: covered entities have to report not only their emissions, but also the mitigation measures taken. They receive feedback on their emission mitigation performance and on the energy efficiency relative to others; in addition, the top-performing entities are publicly credited. These factors that work in support of and in conjunction with the ETS are believed to have enhanced the effectiveness of the system significantly.

The TCI in particular finds itself in a comparable situation to the EU, in the sense that there is already an existing ETS covering some sectors of the economy (in this case RGGI covering power generation). While an expansion of RGGI is not feasible politically, the chosen approach is to set up TCI "linking-ready", i.e. to align key design parameters to facilitate an eventual linking between TCI and RGGI.

3 TASK 2: Data analysis

The data analysis described in this section starts from a precise overview of the energy consumption mix currently observed in the two sectors: road transport and buildings. It then focuses on current emissions outside the EU-ETS and the corresponding abatement potentials in the sectors, before assessing how these sectors may react to uniform price signals both in terms of energy consumption and resulting emissions. Such analysis is crucial to build the basis of the general architecture of an integration of road transport and buildings into the EU-ETS.

The section is divided into six main questions:

- Questions 2.1.a to question 2.1.d provide insights on the current energy consumption mix, supply chain, corresponding emissions from fossil fuels and abatement possibilities in road transport and buildings; and
- Question 2.2.1 and question 2.2.2 analyse the sensitivity of fuel demand and emissions to price variations, before evaluating the likely impact of a uniform carbon price on fossil fuel use and related emissions.

3.1 Question 2.1a: Analysis of energy use in road transport and buildings

This question aims at assessing the current use of energy in the road transport and buildings sectors. To this end, Enerdata's *Odyssee*[71] database has been used as the main source of data and has been complemented to some extent with additional data derived from Enerdata's *Global Energy and CO_2 Database*[72]. Those two databases provide historical figures up to 2017 in these two sectors, and for some time series up to 2018.[73]

All emission figures in this section correspond to CO_2 emissions from fuel combustion (other greenhouse gases are not covered). Also, CO_2 emissions from both the Odyssee and the Global Energy and CO_2 databases are derived from energy balances, using IPCC emission factors. The resulting values may slightly differ from the emission inventory data (and therefore other sections of this report); however, this approach allows to consider more recent data (up to 2018).

The data analysis has allowed to derive figures, and perform the corresponding assessment, at a fairly granular level of detail, as summarized in Table 7 below.

[71] https://www.enerdata.net/solutions/database-odyssee.html

[72] https://www.enerdata.net/research/energy-market-data-co2-emissions-database.html

[73] Additional data sources have been analysed for this task, such as the EU Building Stock Observatory (EU BSO), and Eurostat. However, the EU BSO is based on data from the Odyssee database and hence does not provide complementary or more up-to-date figures. Odyssee (project financed by the European Commission) and Eurostat should provide comparable figures at the EU level. The choice of Odyssee has been motivated by the additional features it provides, such as the link to the MURE database, the existing Odyssee analysis tools available, the underlying network of national experts and the additional time series available compared to Eurostat on the drivers for energy consumption.

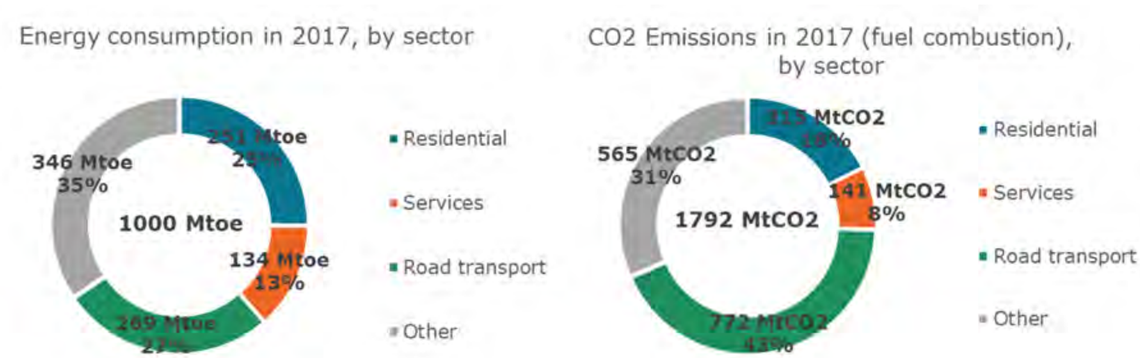
Table 7. Description of sectors, sub-sectors, fuels and uses covered in the road transport and buildings data analysis

Sectors	**Sub-sectors**	**Fuels**	**Uses**
Buildings	Residential	Coal Oil products Natural gas Heat Wood Electricity	Space heating Water heating Cooking Lighting Air cooling Electrical appliances
	Commercial		
Road transport	Cars and motorcycles	Gasoline Diesel LPG Natural gas Biofuels (biodiesel and bioethanol)	
	Buses		
	Trucks and light-duty vehicles		

Source: Own representation, based on Odyssee (Enerdata)

At the EU-27 level, as of 2017, the two sectors account for 65% of total energy consumption and a similar share of total CO_2 emissions (69%). However, the buildings sector alone consumes 38% of the EU total final energy and accounts for 26% of total emissions, whereas road transport, which consumes 27% of the EU total final energy, is the main emitting sector in Europe, responsible for 43% of the CO_2 emissions.

Figure 28. Total final energy consumption and CO_2 emissions in the EU-27



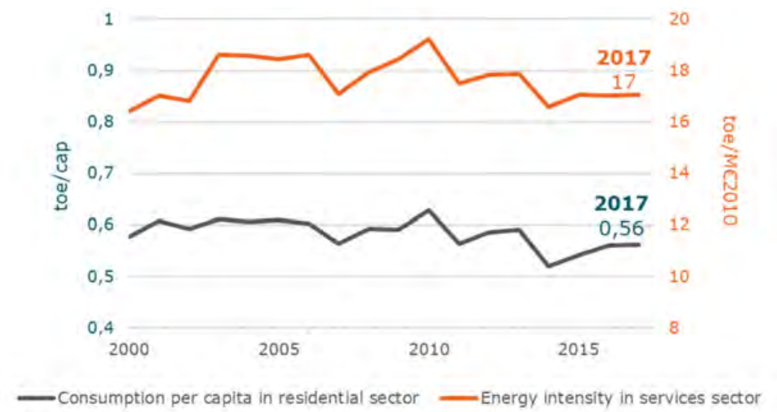
Source: Enerdata Odyssee and Global Energy & CO_2 Database

The assessment made under this question is detailed for the two sectors, while each is discussed first at the EU-27 level (current situation and the corresponding trends since 2000), before performing a brief comparison between Member States.

3.1.1 Buildings

In the buildings sector, total energy consumption reached 385 Mtoe in 2017, with residential buildings representing 65% and commercial buildings 35%. The sector emitted a total of 455 $MtCO_2$ of CO_2 emissions in 2017 (69% from residential buildings, 31% from commercial buildings).

Figure 29. Evolution of per capita energy consumption (residential buildings) and energy intensity (commercial buildings) in the EU-27



Source: Enerdata Odyssee and Global Energy & CO_2 Database

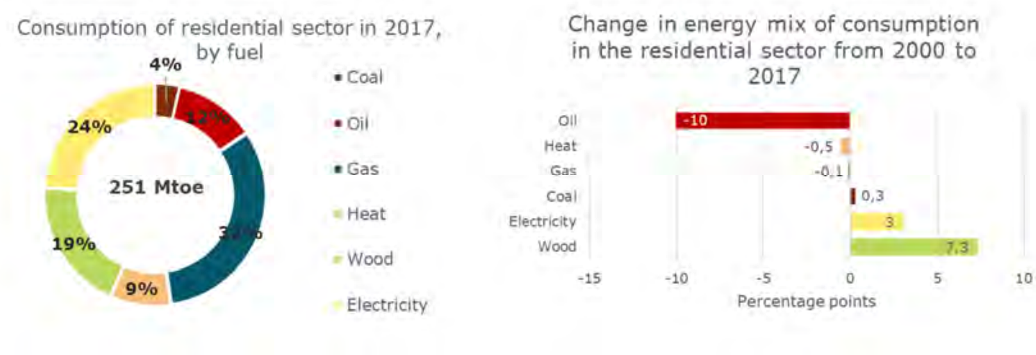
To understand the recent evolution of the buildings sector and how residential and commercial buildings compare, Figure 29 illustrates the changes observed in per capita consumption (residential sector) and energy intensity (commercial sector).

In the residential sector, consumption per capita reached 0.56 toe/cap in 2017, while in average since 2000, it decreased by an average 0.15%/a. Commercial buildings have decreased their energy intensity by an average 0.23%/a over the period (despite a peak in 2010) to reach 17 toe/M€$_{2010}$ in 2017. This improvement in both sub-sectors can also be observed in the corresponding CO_2 emissions, as these have decreased by an average 0.93%/a between 2000 and 2017 in the EU-27.

3.1.1.1 Residential buildings

Looking more closely into the residential sector, energy consumption has overall kept very stable since 2000, increasing by only 0.07%/a until 2017. It relies mainly on natural gas (32% in 2017), followed by electricity (24%) and wood (19%). Since 2000, the most drastic changes have applied to oil products consumption, with a decrease of 10 percentage points in the energy mix over the period, and to wood (+7.3 percentage points). The electrification process appears here as marginal, with only a +3 percentage points increase in the energy mix between 2000 and 2017.

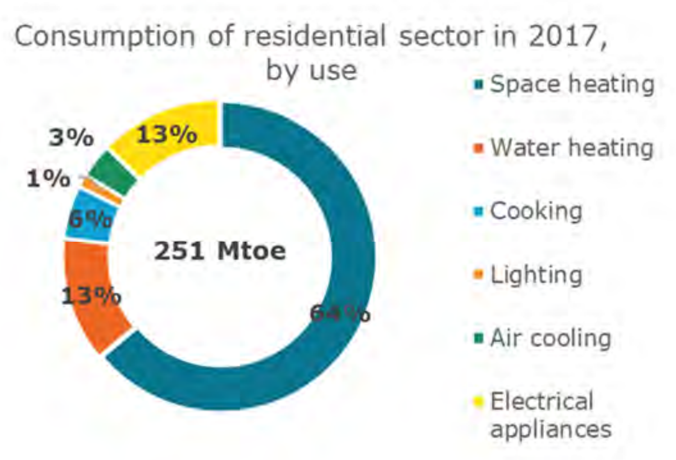
Figure 30. Energy consumption of the residential sector by fuel and 2000-2017 change by energy type (EU-27)



Source: Enerdata Odyssee and Global Energy & CO_2 Database

Figure 31 illustrates the role of the different end-use in the residential sectors. As of 2017, space heating represents by far the main energy consuming end-use (64%). However, this share is on a decreasing trend since 2000 (70%, and 67% in 2010), mostly in favour of the use of electrical appliances (13% in 2017 vs 10% in 2000). Beyond space heating, the second two major uses in residential buildings are electrical appliances and water heating (13% each).

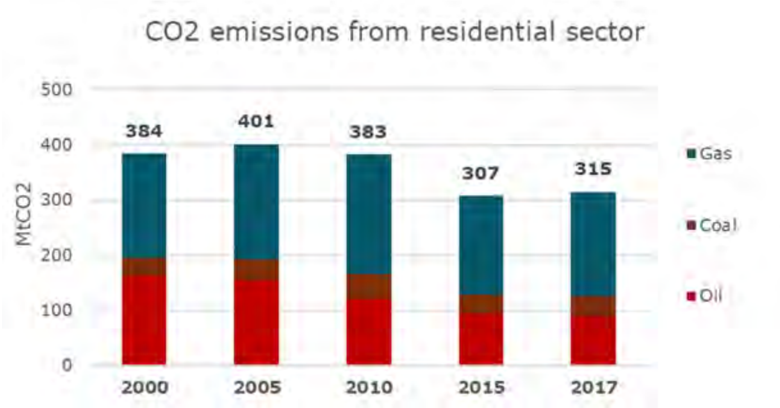
Figure 31. Energy consumption of the residential sector in the EU-27, by end-use



Source: Enerdata Odyssee and Global Energy & CO_2 Database

CO_2 emissions from the residential sector are on a decreasing trend since 2000 (1.2%/a on average). They reached 315 $MtCO_2$ in 2017 (see Figure 32), with natural gas accounting for the most part of emissions (60%), followed by oil products (29%) and coal (11%).

Figure 32. Evolution of CO_2 emissions of the residential sector, EU-27

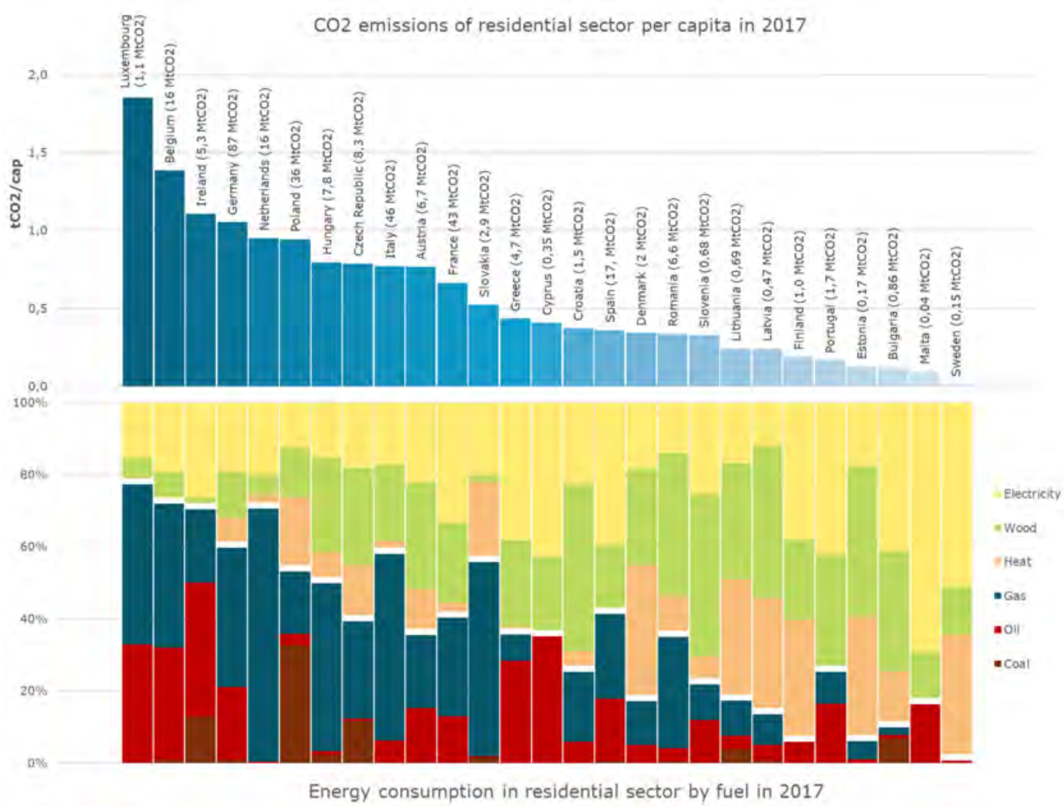


Source: Enerdata Odyssee and Global Energy & CO_2 Database

Figure 33 shows the Member State breakdown of CO_2 emissions (upper part), where Member States are sorted in the descending order of their CO_2 emissions per capita. The lower part of the graph displays the corresponding energy consumption mix for each Member State, with dark colours used for fossil fuels.

As examples of large contributors to CO_2 emissions, Luxembourg, Belgium, Iceland and Germany show significant per capita emissions (1-1.8 tCO_2/cap), along with relatively high shares of fossil fuels in energy consumption (between 60% and 80%). Countries with a significant share of coal in energy consumption, like Poland and the Czech Republic), also appear in the upper range of per capita CO_2 emissions. Conversely, the right side of the figure illustrates the example of countries where fossil fuels are not dominating the energy consumption mix of the residential sector (like Sweden, Bulgaria, Portugal, Finland). In these countries, the use of electricity and biomass is significantly higher, explaining the low levels of per capita emissions (0-0.2 tCO_2/cap) and related absolute levels of CO_2 emissions (below 2 $MtCO_2$ for each of those countries).

Figure 33. CO_2 emissions and share of fuels in energy consumption in the residential sector, by Member State



Source: Enerdata Odyssee and Global Energy & CO_2 Database

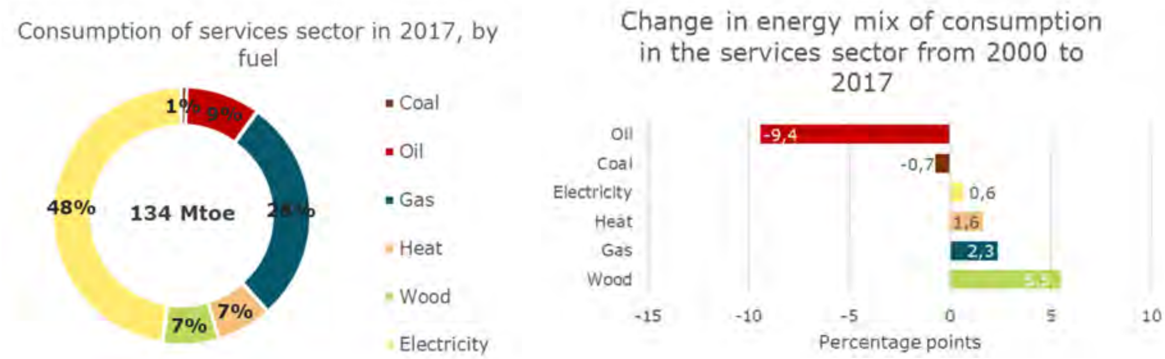
To conclude, the residential sector is currently responsible for 309 $MtCO_2$ emissions at the EU-27 level. These emissions are on a decreasing trend since the early 2000s, due to both a slowly decreasing trend of energy consumption and a progressive decarbonation of energy consumption, in particular a decline of oil in favour of biomass).

3.1.1.2 Commercial buildings

The commercial sector accounts for about one third of buildings' energy consumption and CO_2 emissions.

Its energy mix is dominated by electricity, representing about half of the sector's energy consumption (48% in 2017), as described in Figure 34, and whose share in the energy mix is quite stable since 2000. As observed in the residential sector, gas consumption represents a large part of the energy consumption in the commercial sector (28% in 2017). Overall, the total energy consumption of commercial buildings increased by an average 1.7%/a from 2000 to reach 134 Mtoe in 2017. Over this timeframe, the energy mix has experienced changes: the share of oil products consumption has declined sharply (-9.4 percentage points in the energy mix), in favour of wood (+5.5 percentage points) and natural gas (+2.3 percentage points).

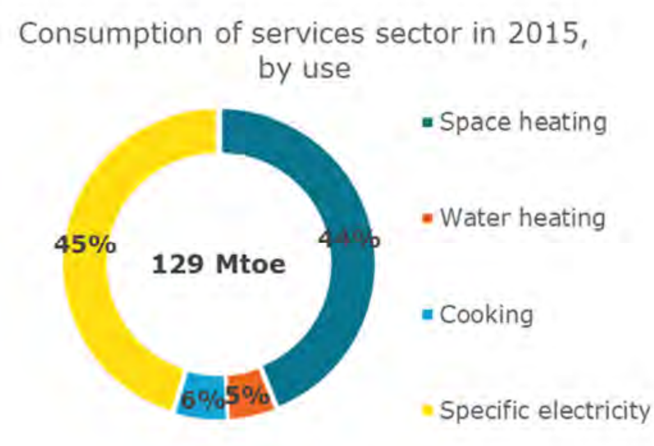
Figure 34. Energy consumption of the commercial sector by fuel and 2000-2017 change by energy type (EU-27)



Source: Enerdata Odyssee and Global Energy & CO_2 Database

Figure 35 shows that the two main end-uses in the commercial buildings sector are specific electricity (45%, in 2015) and space heating (44%). Specific electricity, which includes air cooling, lighting and electrical appliances, has grown significantly between 2005 and 2015, by an average +2.5%/a share in the sector's total energy consumption, notably at the expense of space heating (on average -1.5%/a over the same period).

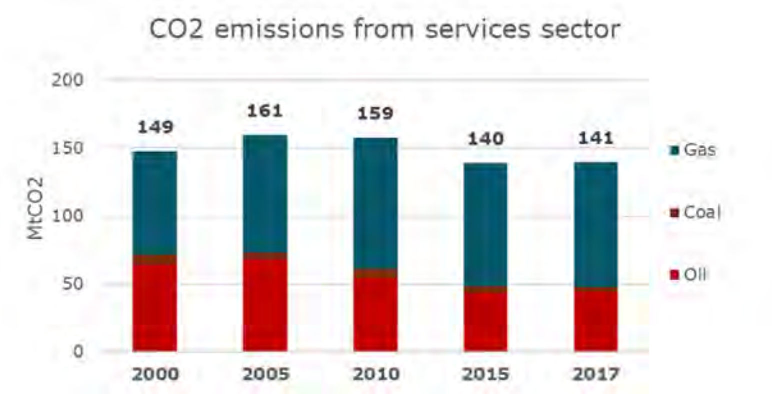
Figure 35. Energy consumption of the commercial sector in the EU-27, by end-use



Source: Enerdata Odyssee and Global Energy & CO_2 Database

CO_2 emissions from energy consumption in the commercial sector amounted to 141 $MtCO_2$ (excluding electricity) in 2017 in the EU-27. On average, emissions have declined by 1.1%/a from 2005 to 2017, as illustrated in Figure 36. Consumption of natural gas is the main source of CO_2 emissions in the commercial sector: in 2017, it accounted for 66% of total CO_2 emissions. Despite their relatively low share in the energy mix, oil products were responsible of 32% of total CO_2 emissions. Given the low consumption of coal in commercial buildings (1% in 2017), related emissions accounted to only 2% of the sector's total emissions in 2017.

Figure 36. Evolution of CO_2 emissions of the commercial sector, EU-27



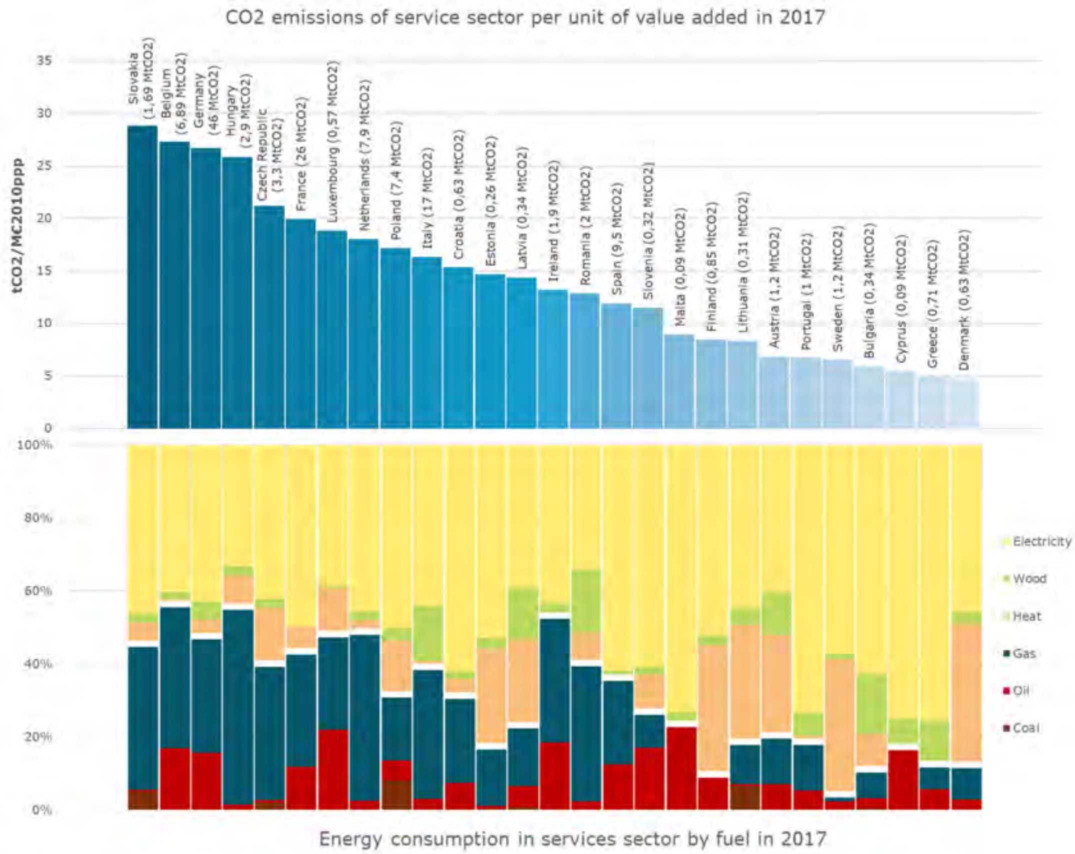
Source: Enerdata Odyssee and Global Energy & CO_2 Database

Figure 37 compares CO_2 emissions per unit of value added and the corresponding energy mix of the EU-27 Member States in the commercial sector. The share of fossil fuels across Member States, which is generally dominated by natural gas consumption, varies between 4% (Sweden) to 56% (Belgium, Hungary). Electricity corresponds to a large share of energy consumption in numerous countries, from 33% in Hungary to 75% in Cyprus and Greece.

Although the German commercial buildings sector is the most emitting one in the EU-27 (46 $MtCO_2$ in 2017) with the highest carbon factor (1.6 tCO_2/toe), emissions generated by unit of value added account for 26.7 $tCO_2/M€_{2010}$ppp; on this indicator, Germany ranks third, overtaken by Slovakia (28.8 $tCO_2/M€_{2010}$ppp; Slovakia fossil fuel consumption per unit of value added is the highest in Europe with 11 toe/$M€_{2010}$ppp) and Belgium (27.3 $tCO_2/M€_{2010}$ppp).

Finally, energy consumption in the commercial buildings sector is dominated by electricity, but the shares of wood and natural gas in the energy mix continue to grow. CO_2 emissions from commercial buildings are slowly decreasing, mostly due to the reduction of the fossil fuels share in the sector’s energy mix.

Figure 37. CO_2 emissions and share of fuels in energy consumption in the commercial sector, by Member State



Source: Enerdata Odyssee and Global Energy & CO_2 Database

Overall, in the European buildings sector, the residential sector accounts for about two thirds of energy consumption and CO_2 emissions, while natural gas consumption is the main source of CO_2 emissions (62% of the buildings sector in 2017), followed by oil products (29%) and coal (9%). CO_2 emissions have been declining over recent years in the EU-27 due to a less fossil-oriented energy consumption mix and despite a slow increase in the sector's energy consumption.

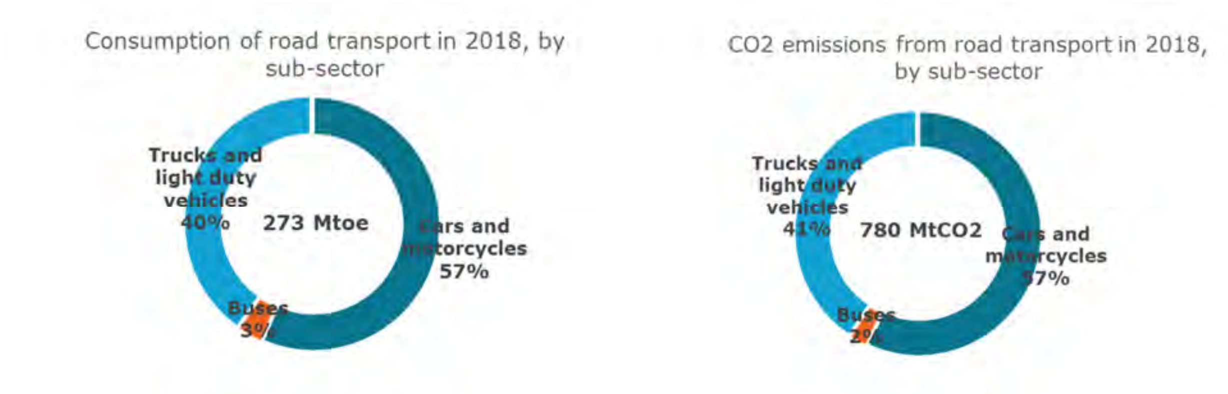
3.1.2 Road transport

Road transport is a significant sector in terms of energy consumption and CO_2 emissions, which is currently not included in the EU ETS.

In 2018, the total energy consumption of road transport reached 273 Mtoe at the EU-27 level (Figure 38), increasing by an average 0.65%/a since 2000. Cars and motorcycles represented 57% of total consumption, while trucks and light duty vehicles accounted for 40%, and buses for the 3% remainder.

The European road transport sector's CO_2 emissions reached 780 $MtCO_2$ in 2018, having increased (slightly slower than energy consumption) at an average 0.39%/a since 2000.

Figure 38. Energy consumption and CO_2 emissions of the road transport sector in the EU-27, by mode



Source: Enerdata Odyssee and Global Energy & CO_2 Database

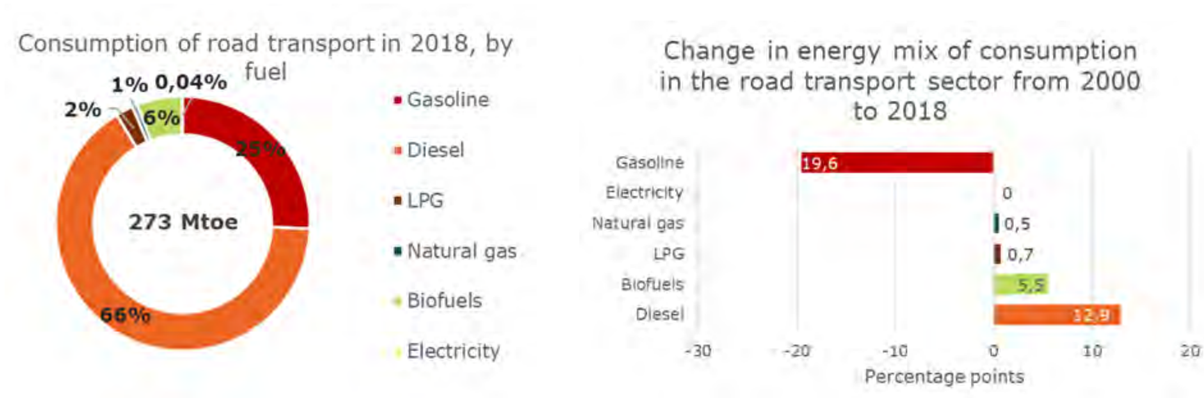
As of 2018, diesel is the main fuel consumed in road transport (66% of the total), significantly over gasoline (25%), while biofuels account for around 6%, LPG 2% and natural 1% (see Figure 39). Electricity consumption remains very low as of 2018.

Diesel is used in all road transport segments, with a market share varying form 49% in cars and motorcycles, to 81% for buses and 93% for truck and light duty vehicles. Conversely, gasoline is for the most part only consumed in cars and motorcycles, with a 41% market share in this sub-sector.

Since 2000, gasoline has seen its market share dropping by almost 20 percentage points, mainly in favour of diesel (+13 pp) and biofuels (+5.5 pp). When considering only cars and motorcycles, the share of gasoline decreased from 72% to 41% over 2000-2018, whereas that of diesel surged from 25% to 49%.

On the other hand, consumption from buses is progressively shifting from diesel consumption, with its share dropping from 98% in 2000 to 81% in 2018 in favour of blended biofuels and alternative fuels such as LPG and natural gas.

Figure 39. Energy consumption of the road transport sector by fuel and 2000-2018 change by fuel type (EU-27)

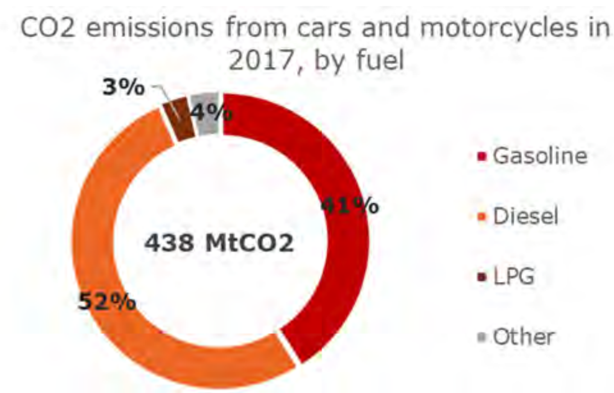


Source: Enerdata Odyssee and Global Energy & CO_2 Database

Diesel is responsible for the bulk of the road transport CO_2 emissions (72%). As of 2017, it accounts for nearly all emissions from buses (99%) and trucks and light-duty vehicles

(97%), and over half of emissions from cars and motorcycles (52%, see Figure 40). Gasoline is responsible for 41% of the cars and motorcycles emissions, while LPG accounts for half of the remainder.

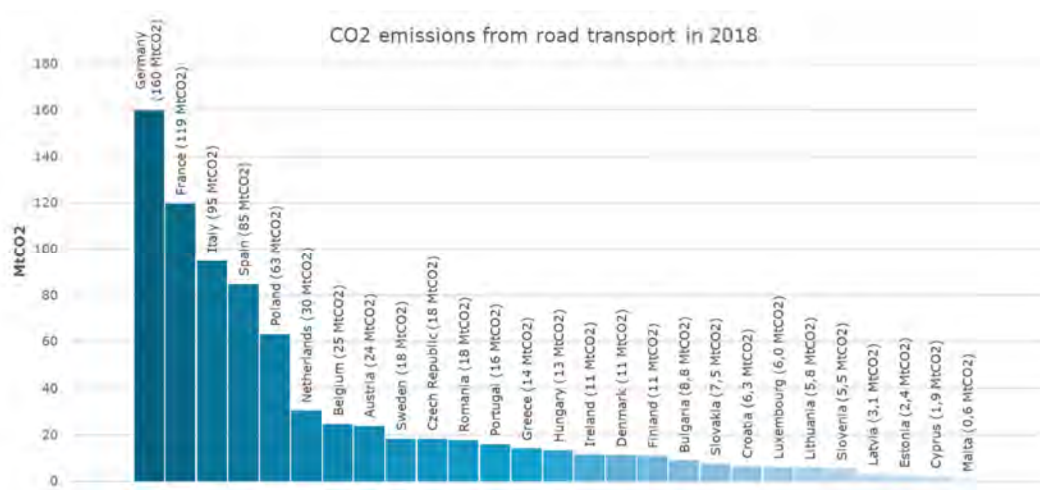
Figure 40. CO_2 emissions from cars and motorcycles in the EU-27, by fuel



Source: Enerdata Odyssee and Global Energy & CO_2 Database

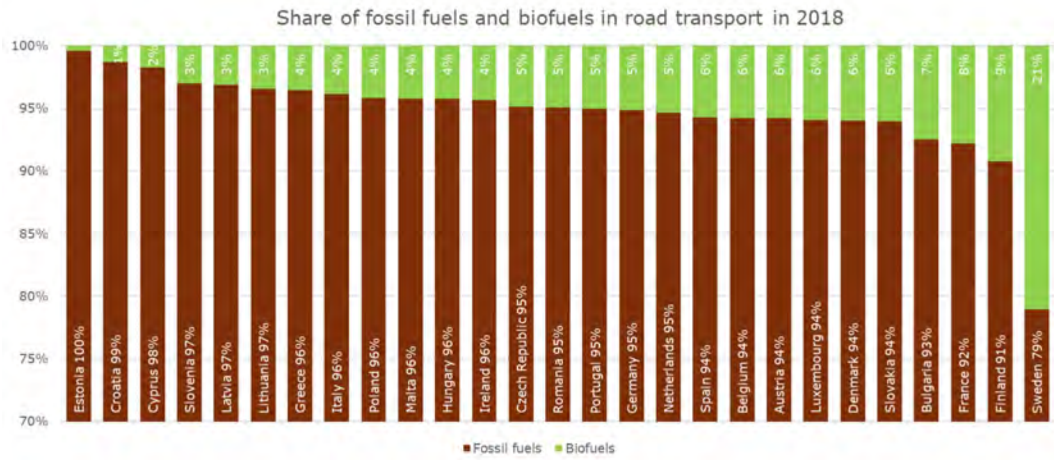
Figure 41 compares the CO_2 emissions from road transport in 2018 across EU-27 Member States, with Germany (160 $MtCO_2$), France (119 $MtCO_2$) and Italy (95 $MtCO_2$) as the most emitting countries in this sector. As stated, biofuels represent 6% of the road transport total consumption at the EU-level, which represents most of the low-carbon fuels consumed (since electricity consumption is still currently very low). Most Member States have a share of biofuels between 4% and 6%, as shown in Figure 42. Six Member States present a share of 3% or less, while 4 Member States record over 7% of biofuels, including Sweden with more than 20%.

Figure 41. CO_2 emissions from road transport sector, by Member State



Source: Enerdata Odyssee and Global Energy & CO_2 Database

Figure 42. Share of fuels in energy consumption in the road transport sector, by Member State



Source: Enerdata Odyssee and Global Energy & CO_2 Database

To sum up, road transport is a crucial sector in terms of energy consumption and CO_2 emissions at the EU level. Energy use and associated CO_2 emissions of this sector have both been increasing over the past two decades. Passenger transportation accounts for 60% of total energy consumption, while freight represents 40%. In terms of fuels, diesel is the main energy consumed (66%, with substantially increasing share since 2000), before gasoline (25%). Biofuels are the main low-carbon fuels used as of today; they represent 6% of road transport's final energy consumption. However, their deployment seems strongly depending on the Member State considered.

3.1.3 Conclusion

The data analysis made under this question has shown that the two sectors – buildings and road transport – account together for two thirds of the EU-27 final energy consumption and almost 70% of CO_2 emissions.

Between the two, road transport appears as a crucial sector: it is the most emitting one (43% of the EU-27 total CO_2 emissions) and its emissions are increasing (+0.4%/a in average since 2000). Within this sector, the main contributing modes of transport are cars and motorcycles, while the main contributing fuel is diesel.

The buildings sector also appears as a key sector with one fourth of total CO_2 emissions in Europe. Residential buildings are responsible for 69% of these emissions, and natural gas consumption is the main source. Emissions from buildings have been declining recently through a slow decarbonation of the sector's energy mix, despite a slight increase in total energy consumption.

3.2 Question 2.1b: Supply chain in road transport and buildings

The delivery of energy to final consumers in the buildings and road transport sectors requires long chains of sequenced activities covering production, import, refining, storage, blending, distribution, retail channels and customer delivery. The supply chains for the different fuels used in buildings and road transport sectors will differ.

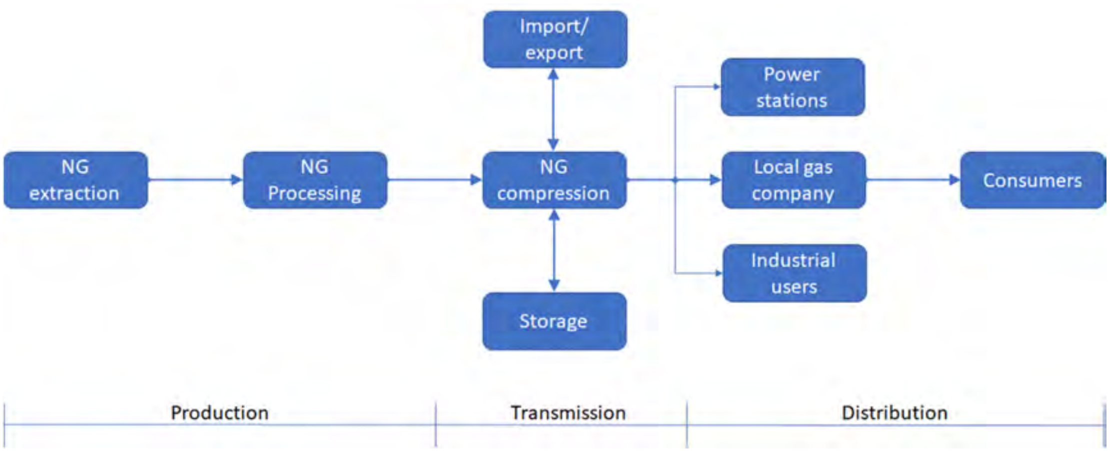
Parts of the fossil fuel supply chain are already covered by the EU ETS, such as qualifying offshore oil and gas exploration and production, storage, and refining installations. In order to prevent overlap, and ensure precision while minimising the administrative burden/ cost, developing a clear and integrated picture of the supply chain is key to understanding the most effective positioning of the regulated entity responsible for monitoring, reporting and verification (MRV) of emissions for the buildings and road transport sectors. The following sections present the supply chains for each fuel type, with a profile of each component of the supply chain, including its function, and an estimate of the number of organisations (by Member State, if available) involved in delivering it.

- Natural gas (Section 3.2.1)
- Solid fuel (coal) (Section 3.2.2)
- Oil (Section 3.2.3)

3.2.1 Natural gas supply chain

Figure 43 presents an overview of the natural gas supply chain – from the extraction of natural gas to its distribution to the built environment (residential and tertiary consumers).

Figure 43. Natural gas supply chain



Source: ICF

The supply chain comprises of three key components: Production, Transmission and Distribution, which are summarised in Table 8 and detailed in the following sections.

Table 8. Estimate of the number of organisations in the natural gas supply chain

STAGE		NO. OF ENTITIES[74]	SOURCE
Production	Extraction/ import	433	Eurostat 2019
	Processing	56	GlobalData (2019)
Transmission	Transmission system operators	58	ENTSOG Transmission Capacity Map 2019
Distribution	Local gas companies	2329	Eurostat 2019

3.2.1.1 Production

The first phase in the supply chain consists of the exploration and production (E&P) of natural gas. Natural gas produced at the well-head (especially in association with

[74] Excluding UK

crude oil) contains varying amounts of natural gas liquids ("NGLs"). Natural gas processing plants remove the NGLs from the natural gas stream, enabling the natural gas to meet transmission pipeline and commercial quality specifications. The output, known as pipeline quality natural gas, has a high methane composition (on the order of 95%), and no moisture.

Companies involved in the exploration and production of natural gas are either organisations completely or majority owned by national governments, or international companies of different sizes, such as majors (very large companies which invest and deliver globally at all stages of upstream, midstream and downstream processes); and exploration companies (focused on high risk exploration, who ‘farm out’ part of their equity for drilling and project development).

In 2017, Europe had 433 E&P companies[75] by national production or bring natural gas into the country by import (Table 9). Nearly 50% are in Italy (16%), Austria (11%), Poland (11%) and Hungary (9%).

Table 9. Total number of companies that either produce natural gas by national production or bring natural gas into the country by import in 2017

MEMBER STATE	NO. OF E&P ORGANISATIONS
Belgium	23
Bulgaria	4
Czechia	24
Denmark	No data
Germany	26
Estonia	1
Ireland	11
Greece	6
Spain	32
France	29
Croatia	9
Italy	70
Latvia	6
Lithuania	5
Luxembourg	5
Hungary	40
Netherlands	No data
Austria	48
Poland	48

[75] This estimate overlaps with the crude oil E&P enterprises listed in Section 3.2.3, since natural gas in the form of associated gas is produced with crude oil.

MEMBER STATE	NO. OF E&P ORGANISATIONS
Portugal	9
Romania	18
Slovenia	9
Slovakia	9
Finland	1
Sweden	No data
Total	**433**

Source: Eurostat, 2019

In 2019, there were approximately 56 gas processing facilities with a capacity of 28,320 million cubic feet per day (Table 10)[76]. The Netherlands accounts for over 85% of Europe's total gas processing capacity, with 50 active plants. Most of the country's gas processing plants are in the Groningen province, close to the Groningen gas field, which is one of the largest natural gas fields in the world.

Table 10. Gas processing plants in Europe in 2019

MEMBER STATE	NO. OF GAS PROCESSING PLANTS
Netherlands	50
Germany	3
Denmark	3
Total	**56**

Source: GlobalData, 2019

3.2.1.2 Transmission

The EU natural gas transmission network is characterised by inter-Member State (MS) or intra-Member State pipelines. Inter-MS pipelines are long distance, high-capacity pipelines that transmit natural gas into and across Europe. To ensure that the natural gas maintains its high pressure through the pipelines, it undergoes compression through compressor stations, which are usually placed at 100 to 200 km intervals along the pipeline. The natural gas enters the compressor station, where it is compressed by either a turbine, electric motor or reciprocating engine.

Intra-MS high pressure pipelines link the entry terminal of natural gas producers (domestic and imports) to local distribution networks markets, or directly to power stations and other large industrial users, as well as the inter-MS pipeline system. Imported natural gas comes through pipelines and to a lesser extent by ship (liquefied natural gas (LNG)). Gas storage fields are also connected to the transmission pipeline network.

In 2019, there were 58 transmission system operators (TSO) transporting natural gas across Europe (Table 11)[77], with close to 30% (16 TSOs) in Germany.

[76] Excluding UK

[77] Ibid

Table 11. Transmission system operators in Europe in 2019

MEMBER STATE	NO. OF TRANSMISSION SYSTEM OPERATORS
AT	5
BE	1
BG	1
CH	2
CZ	2
DE	16
DK	2
EE	1
ES	2
FI	1
FR	2
GR	2
HR	1
HU	2
IR	1
IT	3
LT	1
LU	1
LV	1
NL	2
PL	2
PT	1
RO	1
RS	1
SI	1
SK	3
Total	**58**

Source: entsog, 2019

3.2.1.3 Distribution

Distribution is the final supply chain step in delivering natural gas to customers. While some large industrial, commercial, and electric generation customers receive natural gas directly from high capacity interstate and intrastate pipelines, most other consumers (in the residential and tertiary sectors) receive natural gas from local gas (or distribution) companies. These organisations are regulated utilities involved in the delivery of natural gas to consumers within a specific geographic area.

Local gas companies transport natural gas from delivery points located on inter-MS and intra-MS pipelines to households and businesses through medium- and low-pressure distribution pipeline networks. **In 2017, there were over 2,300 local distribution companies** in Europe comprising municipal companies, local governments and private companies (Table 12). Germany and Italy, who are the largest consumers of natural gas in Europe, account for over 60% of this total (1,415 companies).

Table 12. Number of retailers selling natural gas to final customers

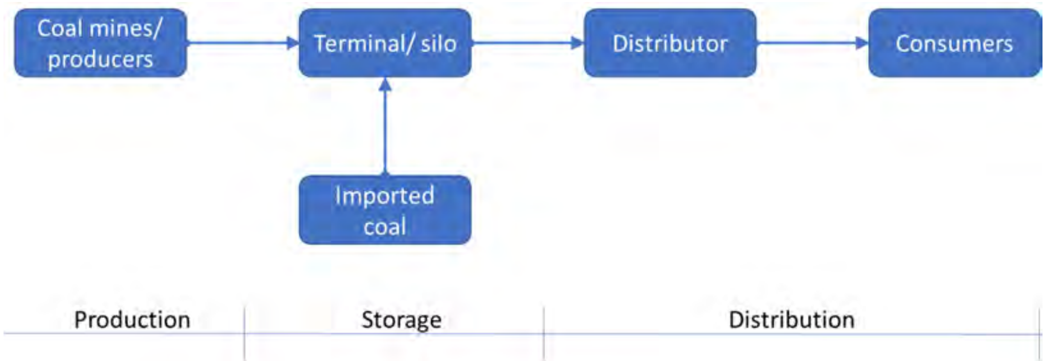
MEMBER STATE	NO. OF LOCAL DISTRIBUTION COMPANIES
Belgium	41
Bulgaria	21
Czechia	110
Denmark	15
Germany	995
Estonia	24
Ireland	9
Greece	39
Spain	71
France	74
Croatia	46
Italy	420
Latvia	6
Lithuania	4
Luxembourg	8
Hungary	28
Netherlands	48
Austria	65
Poland	114
Portugal	25
Romania	86
Slovenia	28
Slovakia	28
Finland	24
Sweden	No data
Total	**2,329**

Source: Eurostat, 2019

3.2.2 Solid fuel supply chain

Solid fuel products are primarily winter heating fuels, such as lignite, hard coal, as well as wood products, such as logs and kindling. Charcoal products are mainly summer fuels used for cooking. Figure 44 presents an overview of the coal supply chain – from the extraction of coal to its distribution to the built environment (residential and tertiary consumers).

Figure 44. Solid fuel (coal) supply chain



Source: ICF

The following details the three key operational components of the coal supply chain: Production, Storage and Distribution, which are summarised in Table 13.

Table 13. Estimate of the number of organisations in the coal supply chain.

STAGE		NO. OF ENTITIES[78]	SOURCE
Production	Coal mines	118	JRC 2018
	Coal producers	198	Eurostat 2020
Storage	Coal terminals	28	JRC 2018
	Importers of coal	500	Estimate (Kompass; Eurostat 2019)
Distribution	Coal distributors	3000	Estimate (Europages - solid fuel distributors)

3.2.2.1 Production

In Europe there were **118 coal mines operating in 2015** (Table 14), with the majority in Poland, Spain, Germany and Bulgaria. Since 2015, while Germany remains the biggest producer of lignite in the world, it had closed all its hard coal mines by 2018.

Table 14. Estimate of the number Mines operating in Europe in 2015

MEMBER STATE	NO. OF COAL MINES
Bulgaria	12

[78] Excluding UK

MEMBER STATE	NO. OF COAL MINES
Czechia	9
Germany	12
Greece	9
Spain	26
Italy	1
Hungary	2
Poland	35
Romania	7
Slovenia	1
Slovakia	4
Total	**118**

Source: JRC, 2018

Coal is mined by two methods: surface or 'opencast' mining or underground or 'deep' mining. Lignite (or brown coal) is typically extracted from opencast mining, while hard coal is produced from underground mines. In Europe, there were **nearly 200 companies mining coal in 2018**, with Poland and Spain accounting for over 60% of total coal mining enterprises (Table 15). Both also, primarily produce hard coal, which is the predominant coal type produced in Europe (65%; 129 enterprises).

Table 15. Number of coal (hard and lignite/brown coal) mining enterprises in 2018

MEMBER STATE	NO. OF COAL MINING COMPANIES
Belgium	0
Bulgaria	21
Czechia	11
Denmark	0
Germany	8
Estonia	No data
Ireland	No data
Greece	10
Spain	64
France	0
Croatia	0
Italy	No data
Cyprus	0
Latvia	0
Lithuania	0

MEMBER STATE	NO. OF COAL MINING COMPANIES
Luxembourg	0
Hungary	10
Malta	0
Netherlands	0
Austria	0
Poland	56
Portugal	0
Romania	17
Slovenia	1
Slovakia	No data
Finland	0
Sweden	0
Iceland	0
Total	**198**

Source: Eurostat, 2019

3.2.2.2 Storage

Lignite is unsuitable for long-distance transportation and is primarily consumed at local power stations. Hard coal is traded world-wide. The transportation mechanism is dependent on the market and the associated distance that it needs to travel. For short distance, coal is transported by conveyor or truck. Trains and barges are used for longer distances within domestic markets. For longer distances, coal is shipped by sea to reach its market. Coal storage facilities are important components in the coal supply chain, and typically take the form of silos, stockpiles and storage domes of varying sizes at production and distribution points. Exact numbers of these storage facilities are unknown.

Europe imports most of its coal from Russia, Colombia, the USA, Australia, South Africa, Indonesia and Canada.[79] Data on the number of **companies importing coal** is limited, but likely on the order of **several hundred**.[80]

Coal terminals, located in seaports and inland waterways, play a major role in coal transportation. From these sites, coal is delivered by rail to its consumers. Companies operating coal terminals in these ports are generally multipurpose dry bulk operators handling (loading and unloading), storing and transhipping a wide range of bulk freight, such as iron ore, petroleum coke, agricultural commodities, etc. **In Europe, there are 28 coal terminals**, operating in 9 Member States (Table 16).

[79] https://ec.europa.eu/energy/data-analysis/energy-statistical-pocketbook_en?redir=1

[80] A high-level estimate assuming a linear correlation between EU enterprises and associated production levels, with EU coal imports indicates that over 600 enterprises are involved in importing coal to the EU. Alternately, the business-to-business portal, Kompass, lists over 320 coal importers.

Table 16. Coal terminals in the EU

MEMBER STATE	NO. OF COAL TERMINALS
Belgium	1
Croatia	1
Denmark	1
Germany	15
France	2
Italy	2
Netherlands	2
Poland	3
Romania	1
Total	**28**

Source: JRC, 2018

3.2.2.3 Distribution

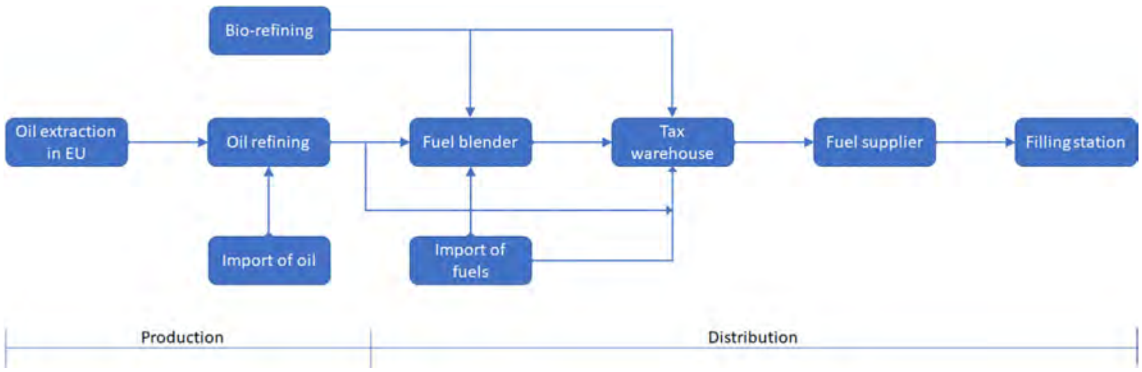
Suppliers of solid fuel and charcoal products to national retailers, source the coal-based products from producers, importers, wholesalers and/or (if vertically integrated) from their own manufacturing lines of business. They package the goods and sell them to national (including petrol stations, supermarkets, garden centres) or local retailers for re-sale to consumers. The exact number of coal distributors in Europe is uncertain, as most distributors operate on a regional rather than national basis, using their own or independent transport. Available information indicates that there are **at least 3,000 distributors** operating in Europe.[81]

3.2.3 Oil supply chain

After crude oil is extracted from the ground, it is sent to a refinery where different parts of the crude oil are separated into useable petroleum products. For the road transport sector and built environment, pertinent petroleum products include gasoline, diesel fuel and heating oil. Figure 45 presents an overview of the oil supply chain – from the extraction of crude oil to its distribution as fuels for the transport sector (gasoline, diesel, biofuel), and built environment (heating oil).

[81] There are 2,894 solid fuel distributors listed on Europages, a business-to-business platform. This includes 1,172 and 1,128 distributors in Germany and Italy, respectively. For the UK, which is not included in this total, Europages lists 499 distributors, which aligns with a value of 500 cited by *Decision of the Competition and Markets Authority, Supply of solid fuel and charcoal products; Case 50366-1, 28-Mar-18*. Nonetheless, the numbers listed for both Poland and Spain are significantly less (71 and 122, respectively), which, considering they are two of the largest coal consumers in Europe, indicates that the information source is likely incomplete, and that the total represents a lower bound.

Figure 45. Oil supply chain



Source: ICF

The following sections and Table 17 summarise the key operational components of the oil supply chain.

Table 17. Estimate of the number of organisations in the oil supply chain.

STAGE		NO. OF ENTITIES*	SOURCE
Production	Oil extraction in EU	247	Eurostat 2019
	Oil refining	87	Concawe 2019
	Biorefineries	213	Bio-Based Industries Consortium 2017
	Oil importers	40	Estimate (Transport and Environment 2016)
Distribution	Fuel blender	500-2000	CE Delft 2014
	Fuel importers	100-1000	Estimate (Transport and Environment 2016)
	Tax warehouses	7000	Europages B2B marketplace (see Tax warehouse_2)
	Fuel supplier	10,000	ECFD 2020
	Filling station	107,545	FuelsEurope (2018)

3.2.3.1 Production

The first step in the oil supply chain is the extraction of crude oil from either land or sea. Oil production includes drilling, extraction, and recovery of oil from underground reservoirs. There are approximately **247 national and international (integrated and exploration-focused) companies** involved in the exploration and production (E&P) of crude oil (and associated gas) **in Europe in 2017** (Table 18).[82] In terms of quantity, over 65% of the enterprises are in France (17%), Netherlands (17%), Poland (21%) and Romania (12%).

[82] This estimate overlaps with the gas E&P companies listed in Section 3.2.1 for associated natural gas produced with crude oil.

Table 18. Total number of enterprises involved in the extraction of crude oil and natural gas in 2017

MEMBER STATE	NO. OF EXPLORATION AND PRODUCTION ORGANISATIONS
Belgium	0
Bulgaria	No data
Czechia	5
Denmark	12
Germany	4
Estonia	2
Ireland	No data
Greece	No data
Spain	19
France	42
Croatia	3
Italy	8
Cyprus	0
Latvia	2
Lithuania	5
Luxembourg	0
Hungary	15
Malta	0
Netherlands	41
Austria	2
Poland	52
Portugal	0
Romania	30
Slovenia	3
Slovakia	No data
Finland	0
Sweden	2
Iceland	0
Total	**247**

Source: Eurostat, 2019

Crude oil imports account for a substantial quantity of European consumption. In 2017, 86.7% of oil and petroleum products were imported from outside Europe. Table 19 indicates that 21 companies account for 93% of total imports of crude oil into Europe in 2016. The remaining imports, 7%, are from numerous companies that import small (less than 1%) shares; as such, the total number of **organisations importing crude oil in 2016 is at least 40**, but likely greater.

Table 19. Companies importing crude oil to the EU

OIL COMPANY HQ	OIL COMPANY	SHARE OF IMPORTS
Russia	Rosneft	20%
	Lukoil	12%
	Gazprom	4%
USA	Exxon	6%
	Chevron	5%
Norway	Statoil	11%
Saudi Arabia	Saudi Aramco	8%
Libya	LNOC	6%
Algeria	Sonatrach	4%
Netherlands	Shell	3%
Mexico	PEMEX	2%
Nigeria	NNOC	2%
Brazil	Petrobras	2%
Khazahkstan	KazMunayGas	1%
France	Total	1%
Columbia	Ecopetrol	1%
Italy	ENI	1%
Kuwait	QB	1%
UK	BP	1%
Malaysia	Petronas	0%
Tunisia	Agip Tunisia	0%
N/A	Others	7%

Source: Transport and Environment, 2016

After short-term storage, the crude oil is delivered through gathering pipelines to refineries, which transforms it intro various oil products, such as gasoline, diesel oil, jet fuel, heating oil, and manufacturing feedstocks. Europe had **87 active refineries in 2017**, with a total capacity of 13.6 million barrels per day (Table 20).

Table 20. Number of refineries in Europe in 2017

MEMBER STATE	NO. OF REFINERIES
DENMARK	
- Refineries	2
- Percentage of EU Total	2.20%
SWEDEN	
- Refineries	5
- Percentage of EU Total	5.60%
FINLAND	
- Refineries	2
- Percentage of EU Total	2.20%
IRELAND	
- Refineries	1
- Percentage of EU Total	1.10%
BELGIUM	
- Refineries	4
- Percentage of EU Total	4.40%
NETHERLANDS	
- Refineries	6
- Percentage of EU Total	6.70%
GERMANY	
- Refineries	14
- Percentage of EU Total	15.60%
AUSTRIA	
- Refineries	1
- Percentage of EU Total	1.10%
FRANCE	
- Refineries	8
- Percentage of EU Total	8.90%
SPAIN	
- Refineries	11
- Percentage of EU Total	12.20%
PORTUGAL	
- Refineries	2
- Percentage of EU Total	2.20%

MEMBER STATE	**NO. OF REFINERIES**
ITALY	
- Refineries	11
- Percentage of EU Total	12.20%
GREECE	
- Refineries	4
- Percentage of EU Total	4.40%
CZECH REPUBLIC	
- Refineries	2
- Percentage of EU Total	2.20%
HUNGARY	
- Refineries	1
- Percentage of EU Total	1.10%
POLAND	
- Refineries	4
- Percentage of EU Total	4.40%
SLOVAKIA	
- Refineries	1
- Percentage of EU Total	1.10%
LITHUANIA	
- Refineries	1
- Percentage of EU Total	1.10%
BULGARIA	
- Refineries	1
- Percentage of EU Total	1.10%
ROMANIA	
- Refineries	4
- Percentage of EU Total	4.40%
CROATIA	
- Refineries	2
- Percentage of EU Total	2.20%
Europe total	**87**

Source: Concawe, 2020)

Biorefineries convert biomass into fuels and value-added chemicals. **In 2017, Europe had 213 biorefineries** (sugar-/starch-based, Oil-/fat-based, wood-based, lignocellulose-based, and biowaste-based) across 17 Member States (Table 21).

Table 21. Biorefineries in Europe in 2017

MEMBER STATE	NO. OF BIOREFINERIES	% SHARE
Austria	4	2%
Belgium	9	4%
Bulgaria	2	1%
Czech Republic	3	1%
Denmark	3	1%
Finland	17	8%
France	32	15%
Germany	62	29%
Hungary	5	2%
Ireland	1	0%
Italy	31	14%
Netherlands	11	5%
Poland	3	0.5%
Portugal	1	1%
Slovenia	2	0%
Spain	14	1%
Sweden	13	7%
Total	**213**	

Source: Bio-Based Industries Consortium, 2018

3.2.3.2 Distribution

The fuel leaving the refineries is either transported directly via fuel distributors to consumers, or to terminals, which are generally located close to transportation hubs. After entering the terminal, compounds (such as ethanol and additives) are blended (by different processes, such as batch blending in tanks and by onboard blending into marine vessels) with the refined products, before the fuel is transported for sale. There is limited data available on the number of **fuel blenders in the EU**, but it is likely within the range of **500 to 2000**.[83]

The import of refined fuel and products (such as LPG and heating oil) is shared among a larger group of companies when compared to crude oil imports. As such, 30

[83] Emissions trading for transport and the built environment. Analysis of the options to include transport and the built environment in the EU ETS; CE Delft (2014)

companies account for over 70% of the total share of imports (Table 22). With the remaining firms all having a less than 1% share of the market, the total number of **fuel importers** is likely to be within a range of **100 to 1000**.[84]

Table 22. Companies importing refined petroleum products to the EU

OIL COMPANY HQ	OIL COMPANY	SHARE OF IMPORTS
Russia	Rosneft	14%
	Gazprom	7%
	Lukoil	7%
	Bashneft	4%
	Russneft	2%
USA	Exxon	4%
	Valero	2%
	Marathon	1%
	Philips	1%
	Motiva	1%
	Chevron	1%
	Tesoro	1%
Algeria	Sonatrach	5%
Norway	Statoil	4%
India	IOC	3%
Kuwait	QB	3%
Nigeria	NNOC	2%
UAE	Vitol	4%
Saudi Arabia	Saudi Aramco	1%
Brazil	Petrobras	1%
Kazakhstan	KazMunayGas	1%
Ukraine	Ukrtanafta	1%
Qatar	Qatar Petroleum	1%
UK	BP	1%
Israel	Bazan	1%
Netherlands	Shell	1%
Egypt	EGPC	1%
Turkey	Tupras	1%

[84] For example, in 2003, Germany had 75 refined fuel (including LPG) importers (Emissioshandel Im Verkehr: Ansatze Fur Einen Moglichen Up-Stream-Handel Im Verkehr (2005))

OIL COMPANY HQ	OIL COMPANY	SHARE OF IMPORTS
Venezuela	PDVSA	1%
France	Total	0%
N/A	Others	26%

Source: Transport and Environment, 2016

Most refined oil products (transport fuels, heating oil) pass through a tax warehouse. A tax warehouse[85] is a term for a premise approved under legislation of the Member State in which the premises are located for the production, processing, holding, receipt or despatch of excise goods under duty suspension arrangements.[86] This system has been implemented to support trade between entities and Member States by suspending tax payment while goods are moved between tax warehouses in the EU, or to a place for export outside the EU. However, the tax suspension procedure ends once the goods have departed the tax warehouse without them being moved under duty suspension; i.e., when the goods (i.e., transport fuels or heating oil) are released from the tax warehouse into the local market for use, taxes are payable. Since tax warehouses are storage premises, where excise goods are held, processed or repackaged, they can be owned by entities along the oil supply chain, including refineries and fuel suppliers.

The exact number of tax warehouses and their location is uncertain; however, each Member State maintains a data bank with information on authorised warehouse keepers, registered economic operators and tax warehouses in the Community. CE Delft (2014) estimated the number of tax warehouse keepers for oil products to be in the range of 5,000 to 10,000 across the EU.[87,88] This is also corroborated through estimates calculated through business-to-business portals, where **over 7,000 bonded[89] warehouses** are listed for service across Europe.[90]

Fuel suppliers (or distributors) have extensive infrastructure for storing and moving fuels (e.g., red and white diesel, biodiesel, heating oil) and lubricants to consumers across Member States. Supplies are obtained from various sources, including refineries, and storage depots (e.g., blending terminals, tax warehouses). Their operational territory ranges from local/regional to national, depending on the number of depots and size of tanker fleet. For example, in the Republic of Ireland the largest fuel distributor had 190 tankers in 2019, while the tenth largest distributor had 17

[85] Also called excise warehouses or customs and excise warehouses.

[86] Under EU Directive 2008/118, Article 4(11), and regulation 3(1) of the Excise Goods (Holding, Movement and Duty Point) Regulations 2010).

[87] A Member State survey identified: Germany = 500-100; Portugal = 436; Denmark = 10; Netherlands = 105; Sweden = 265; Austria = 79; and Ireland = 192 (CE Delft, 2014)

[88] 223 authorized warehouse keepers by the Swedish Tax Authority in 2012. *Transaction Costs of Upstream Versus Downstream Pricing of CO2 Emissions*, J. Coria & J. Jaraitė, Environmental and Resource Economics volume 72, pages 965–1001(2019)

[89] A custom-controlled warehouse where goods are kept for processing (until the customs duty is paid) before delivery. These warehouses can be government-owned or privately owned by large enterprises.

[90] Europages (B2B marketplace). Accessed March 2020. Note: A bonded warehouse is authorized by customs authorities for the storage of goods on which payment of duties is deferred until the goods are removed for domestic consumption.

tankers.[91] Tanker capacity ranges from full 36,000-litre delivery to filling stations to 205-litre barrels delivered to individual consumers.

There are **over 10,000 liquid fuel distributors** delivering fuel, heating oil and LPG to consumers across Europe. Although this includes major oil companies and energy producers, the majority are small and medium-sized enterprises.[92,93]

The final step in the supply chain for road transport fuels are the filling stations, which deliver the fuels to consumers. In Europe, there are over **107,000 filling stations**, with the majority (greater than 50%) located in France, Germany, Italy and Spain (Table 23).

Table 23. Number of petrol stations in Europe

MEMBER STATE	NO. OF FILLING STATIONS
Austria	2,699
Belgium	2,096
Bulgaria	3,200
Croatia	N/A
Cyprus	305
Czechia	3,991
Denmark	2,034
Estonia	514
Finland	1,848
France	11,068
Germany	14,459
Greece	6,100
Hungary	2,068
Ireland	1,789
Italy	20,800
Latvia	610
Lithuania	822
Luxembourg	234
Malta	78
Netherlands	4,142

[91] Top fuel oil distributors. UK mainland, Northern Ireland and the Republic of Ireland. https://fueloilnews.co.uk/top-fuel-oil-distributors/

[92] European Confederation of Fuel Distributors represents over 10,000 distributors of liquid fuels in Europe. Union Pétrolière Européenne Indépendante (UPEI) estimates 12,500 SME heating oil distributors across Europe, including UK. Eurofuel quotes 10,000 distributors across 10 Member States (AT, BE, CH, DE, FI, FR, IE, IT, LU, and UK). As such, at least 10,000 distributors are assumed, excluding the UK.

[93] There is no information on the number of distributors at Member State level.

MEMBER STATE	NO. OF FILLING STATIONS
Poland	7,765
Portugal	3,114
Romania	2,100
Slovakia	962
Slovenia	553
Spain	11,609
Sweden	2,585
Total	**107,545**

Source: FuelsEurope, 2018

3.3 Question 2.1c: Current emissions outside the EU-ETS

This question aims at assessing the distribution of road transport and building sector CO_2 emissions by fuel type which are not covered by the EU-ETS. Therefore, these include emissions resulting from fossil fuels and exclude electricity, district heating, and biomass emissions. In order to carry out this analysis, CO_2 emission data from the latest available national GHG inventories[94] as well energy consumption data from the complete Eurostat energy balances[95] are used. This analysis is carried out at the EU-27 level and for each Member State at the national level.

Table 24 explains the sectoral aggregation applied to buildings and road transport in this analysis. For each sub-sector emissions are analysed by utilising the sectoral codes provided in the 2006 IPPC guidelines for national GHG inventories[96] and the fossil fuels analysed. For buildings, each of these fossil fuel groupings includes CO_2 emission from several fossil fuels reported in the Eurostat energy balances. Moreover, since less types of fossil fuels are used for road transport purposes, the analysis reviews 6 fuel sources which mostly fall under the oil and petroleum products fuel grouping.

---

[94] European Environment Agency, 2020, National emissions reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism, Available at: https://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-unfccc-and-to-the-eu-greenhouse-gas-monitoring-mechanism-15#tab-european-data

[95] Complete energy balances, Eurostat, nrg_bal_c, accessed on 3 April 2020

[96] Gómez et al, 2006, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*; Volume 2: Energy; Chapter 2 – Stationary Combustion.

Waldron et al, 2006, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*; Volume 2: Energy; Chapter 3 – Mobile Combustion.

Table 24. Description of sectors, sub-sectors, and fuels covered in the analysis

Sectors	Sub-sectors	Emission sector codes	Fuels
Buildings	Residential	1.A.4.b Residential	Solid fossil fuels Manufactured gases Peat and peat products Oil and petroleum product Natural gas Non-renewable waste
	Commercial	1.A.4.a Commercial/Institutional	
Road transport	Cars	1.A.3.b.i Cars	Natural gas Liquefied petroleum gases Motor gasoline (excl. bio) Other kerosene Gas oil and diesel oil (excl. bio) White spirit and SBP industrial spirits
	Light-duty vehicles	1.A.3.b.ii Light duty trucks	
	Heavy-duty vehicles and buses	1.A.3.b.iii Heavy duty trucks and buses	
	Motorcycles	1.A.3.b.iv Motorcycles	

Source: Own representation, based on Eurostat energy balances and EEA GHG inventories

The GHG inventories report total CO_2 emissions per emission sector code. In order to disaggregate these total emissions by fuel type, Eurostat energy balances are used to estimate the emissions resulting from the final energy consumption of fuels in each sub-sector. These bottom-up estimates are carried out by applying each fuel's default (Tier 1) CO_2 emission factors reported by Gómez et al (2006) and Waldron et al (2006) in the 2006 IPCC Guidelines for National GHG Inventories[97]. Although the authors suggest using country-specific (Tier 2 and Tier 3) emission factors, this is beyond the scope of this analysis. Therefore, the limitation of this analysis is that the CO_2 emission factors (Tier 1) applied to energy consumption data may vary from the emission factors applied by Member State authorities when they prepared their 2017 GHG inventories. To ensure that the CO_2 emissions reported in this analysis are consistent with the national GHG inventories, the relative shares of each fuel's CO_2 emissions in each sub-sector are applied to national GHG inventory totals.

Moreover, for each Member State, this analysis presents the share of 2017 non-ETS CO_2 emission emitted by buildings and road transport as a proportion of 2017 total Effort Sharing Regulation (ESR) emission[98] [99].These shares are quantified for each fuel type. The total ESR CO_2 emissions also feature in the analysis related to Question 4.1.

[97] ibid.

[98] European Environment Agency, 2019, Greenhouse gas emissions under the Effort Sharing Decision (ESD), Available at: https://www.eea.europa.eu/data-and-maps/data/esd-2

[99] The figures reported by the European Environment Agency are for all GHGs (CO_2 equivalent). Therefore, the denominator used to estimate shares in this analysis includes all GHGs. Having said that, non-CO_2 GHGs emissions are typically very small in comparsion.

3.3.1 Buildings

In 2017, in the buildings sector, EU-27 fossil fuel CO_2 emission amounted to 466 $MtCO_2$. This is split into 325 Mt of CO_2 emissions from residential buildings (70%) and 141 Mt of CO_2 emissions form commercial buildings (30%) %) (see also section 2.1.1.2).[100]

Following a review of Eurostat energy balances data, the buildings analysis focused on 19 individual fuels which were aggregated into five fuel groupings as depicted in Table 25. The 19 fuels were selected based on whether each fuel features in buildings' final energy consumption in at least one Member State. As noted above, electricity and district heating final energy consumption is not included in this analysis as associated emissions are almost fully covered by the EU-ETS. These emissions are covered in the analysis related to Question 1.1. Although district heating emissions are not included in this analysis, the GHG inventories includes all emissions in buildings, including emissions resulting from central heating and water heating from fossil fuel sources.

[100] European Environment Agency, 2020, National emissions reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism, Available at: https://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-unfccc-and-to-the-eu-greenhouse-gas-monitoring-mechanism-15#tab-european-data

Table 25. Relevant Building Sector Fuels

Fossil Fuel Groupings	Fossil Fuels
Solid fossil fuels	Anthracite
	Other bituminous coal
	Sub-bituminous coal
	Lignite
	Coke oven coke
	Patent fuel
	Brown coal briquettes
Manufactured gases	Gas works gas
Peat and peat products	Peat and peat products
Natural gas	Natural gas
Oil and petroleum products	Liquefied petroleum gases
	Motor gasoline (excluding biofuel portion)
	Other kerosene
	Gas oil and diesel oil (excluding biofuel portion)
	Fuel oil
	White spirit and special boiling point industrial spirits
	Petroleum coke
Non-renewable waste	Industrial waste (non-renewable)
	Non-renewable municipal waste

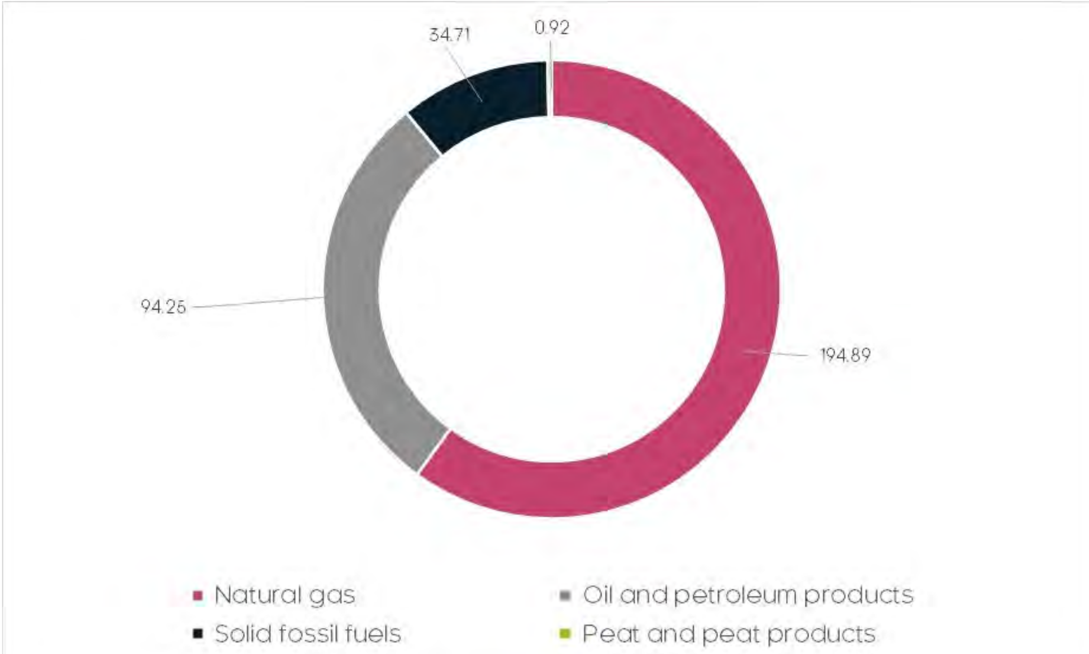
Source: Eurostat energy balances

As explained above, Tier 1 CO_2 emission factors are applied to each fossil fuel's energy consumption data for each Member State. Since Member States are encouraged to apply country-specific factors, some discrepancies are present when compared to the EEA GHG inventory totals. At the EU-27 level, total bottom-up emissions are close to GHG inventory totals. Total residential building emissions are -3% lower than the EU-27 GHG inventory total and commercial building emissions are -1% lower than the EU-27 GHG inventory total. Finally, total road transport emission are -1% lower than the EU-27 GHG inventory total. However, at Member State level, the range of variations is wider. The Member State differences are provided in Appendix A for transparency. Having said that, the relative shares for each fuel's emissions were applied to EEA GHG inventory total for reporting consistency.

3.3.1.1 Residential buildings

At the EU-27 level, non-ETS 2017 residential building CO_2 emission amounted to 325 $MtCO_2$. As depicted in Figure 46, most of these emissions resulted from the combustion of **natural gas** (195 $MtCO_2$) followed by the combustion of **oil and petroleum products** (94 $MtCO_2$) and of **solid fossil fuels** (35 $MtCO_2$). The majority of oil and petroleum products CO_2 emissions resulted from **gas oil and diesel oil (excluding biofuels)** (79%) followed by **liquified petroleum gases (LPG)** (16%). Moreover, most solid fossil fuel CO_2 emissions resulted from **other bituminous coal** (80%) followed by **lignite** emissions (9%). Residential building emissions resulting from peat and peat products (1 $MtCO_2$), manufactured gases (0.004 $MtCO_2$), and non-renewable waste (0.00004 $MtCO_2$) are negligible at the EU-27 level.

Figure 46. EU-27 Residential buildings non-ETS CO_2 emissions by fuel in 2017 ($MtCO_2$)



Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

Table 26 shows the volume of 2017 CO_2 emitted in each Member State per fossil fuel grouping based on the relative shares presented in Figure 47. As described above, these relative shares were applied to the GHG inventory totals in Table 26 for consistency. For **natural gas,** non-ETS fossil fuel emissions are highest in Germany, Italy and France. These are followed by **oil and petroleum products** in each case. However, in the case of Poland, most non-ETS residential emissions are of **solid fossil fuel** combustion due to a heavy reliance on coal-fired boilers[101].

Table 26. Residential buildings non-ETS CO_2 emissions by fuel and Member State in 2017 ($MtCO_2$)

$MtCO_2$	Solid fossil fuels	Manuf. gases	Peat	Oil products	Natural gas	Non-renewable waste	Total
EU-27	34.7	0.0	0.9	94.3	194.9	0.0	324.8
Germany	2.1	-	-	36.6	53.1	-	91.8
Italy	-	-	-	6.1	41.6	-	47.8
France	0.2	-	-	17.1	29.2	-	46.4
Poland	25.7	-	-	1.6	8.4	-	35.7
Spain	0.4	-	-	8.9	7.5	-	16.8
Netherlands	0.0	-	-	0.1	16.4	-	16.5
Belgium	0.3	-	-	7.3	7.4	0.0	14.9

[101] Buildings Performance Institute Europe, 2016, Financing building energy performance improvement in Poland; Status report.

$MtCO_2$	Solid fossil fuels	Manuf. gases	Peat	Oil products	Natural gas	Non-renewable waste	Total
Czech Republic	3.7	-	-	0.1	5.0	-	8.8
Hungary	0.6	-	-	0.2	7.1	-	7.9
Austria	0.1	-	-	3.2	3.5	-	6.8
Romania	0.1	-	-	0.8	5.6	-	6.5
Ireland	0.5	-	0.8	3.0	1.3	-	5.6
Greece	0.0	-	-	3.8	0.8	-	4.7
Slovakia	0.2	-	-	0.0	2.9	-	3.1
Denmark	-	-	-	0.6	1.3	-	1.9
Portugal	-	-	-	1.1	0.6	-	1.7
Croatia	0.0	-	-	0.4	1.1	-	1.6
Finland	-	-	0.0	1.1	0.1	-	1.2
Luxembourg	0.0	-	-	0.5	0.6	-	1.1
Bulgaria	0.61	-	-	0.06	0.16	-	0.83
Lithuania	0.17	-	0.07	0.15	0.36	-	0.75
Slovenia	0.00	-	-	0.40	0.28	-	0.68
Sweden	-	0.00	-	0.54	0.07	-	0.62
Latvia	0.04	-	-	0.16	0.26	-	0.46
Cyprus	-	-	-	0.36	-	-	0.36
Estonia	0.01	-	-	0.03	0.14	-	0.18
Malta	-	-	-	0.04	-	-	0.04

Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

Table 27 shows the residential buildings non-ETS CO_2 emissions presented in Table 26 as a percentage of each Member States' total ESR emissions. Although Germany emits the most, Belgium has the higher proportion of residential building emissions (21.1%). This is followed by Germany (19.7%) Hungary (18.4%), and Italy (17.7%). At the EU-27 level, 14.4% of total ESR emissions are due to non-ETS CO_2 emissions in residential buildings.

Table 27. Residential buildings non-ETS CO_2 emissions by fuel and Member State in 2017 (% of total MS ESR emissions)

% of total ESR CO_2 emissions	Solid fossil fuels	Manuf. gases	Peat	Oil products	Natural gas	Non-renewable waste	Total
Belgium	0.4%	-	-	10.3%	10.4%	0.00%	21.1%
Germany	0.5%	-	-	7.8%	11.4%	-	19.7%
Hungary	1.4%	-	-	0.5%	16.5%	-	18.4%
Italy	-	-	-	2.3%	15.4%	-	17.7%

% of total ESR CO_2 emissions	Solid fossil fuels	Manuf. gases	Peat	Oil products	Natural gas	Non-renewable waste	Total
Poland	12.1%	-	-	0.8%	4.0%	-	16.9%
Netherlands	0.0%	-	-	0.1%	16.0%	-	16.1%
Slovakia	0.7%	-	-	0.1%	13.7%	-	14.6%
EU-27	**1.5%**	**0.00%**	**0.04%**	**4.2%**	**8.7%**	**0.00%**	**14.4%**
Czech Republic	5.9%	-	-	0.2%	8.0%	-	14.0%
Austria	0.2%	-	-	6.3%	6.8%	-	13.3%
France	0.0%	-	-	4.8%	8.3%	-	13.2%
Ireland	1.2%	-	1.89%	6.7%	3.0%	-	12.8%
Luxembourg	0.0%	-	-	5.5%	7.1%	-	12.6%
Greece	0.0%	-	-	8.4%	1.9%	-	10.3%
Croatia	0.1%	-	-	2.5%	6.8%	-	9.4%
Romania	0.2%	-	-	1.0%	7.5%	-	8.7%
Cyprus	-	-	-	8.4%	-	-	8.4%
Spain	0.2%	-	-	4.4%	3.7%	-	8.3%
Slovenia	0.0%	-	-	3.7%	2.6%	-	6.2%
Denmark	-	-	-	1.8%	4.0%	-	5.8%
Lithuania	1.2%	-	0.49%	1.1%	2.6%	-	5.3%
Latvia	0.4%	-	-	1.7%	2.9%	-	5.0%
Portugal	-	-	-	2.8%	1.5%	-	4.3%
Finland	-	-	0.05%	3.7%	0.2%	-	4.0%
Bulgaria	2.3%	-	-	0.2%	0.6%	-	3.1%
Malta	-	-	-	3.1%	-	-	3.1%
Estonia	0.1%	-	-	0.5%	2.3%	-	2.9%
Sweden	-	0.01%	-	1.7%	0.2%	-	1.9%

Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

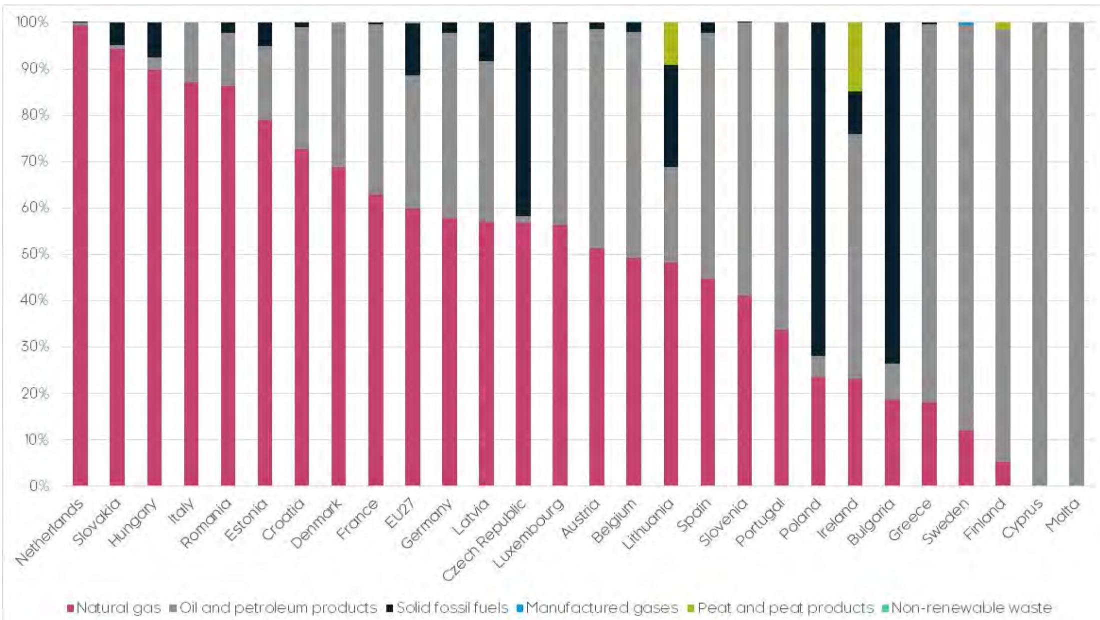
Figure 47 provides estimates of the relative share of non-ETS residential building emissions by fuel type. **Natural gas** is the dominant source of non-ETS CO_2 emissions at the EU-27 level. In fact, residential buildings in the Netherlands and Slovakia almost exclusively emit CO_2 from **natural gas** sources.

On the other hand, Member States like Malta and Cyprus almost exclusively emit non-ETS CO_2 from **oil and petroleum product** sources, the second most relied on fossil fuel at the EU-27 level. Although **gas oil and diesel oil (excl. biofuels)** emissions make up most oil and petroleum CO_2 emissions at the EU-27 level, twelve Member

States have a heavier reliance on **LPG**[102]. Moreover, Irish residential building oil and petroleum product emissions are mostly due to the consumption of **other kerosene** whereas Swedish emissions are mostly due to the consumption of **motor gasoline (excl. biofuels)**.

Finally, Polish and Bulgarian residential buildings mostly consume **solid fossil fuel energy**. These Member States heavily rely on **other bituminous coal**. The Czech Republic also has a relatively large portion of solid fossil fuel emissions due to the consumption of **lignite**.

Figure 47. Share of non-ETS CO_2 emissions by fuel in the residential buildings sector, by Member State in 2017



Source : CE estimates, based on Eurostat energy balances

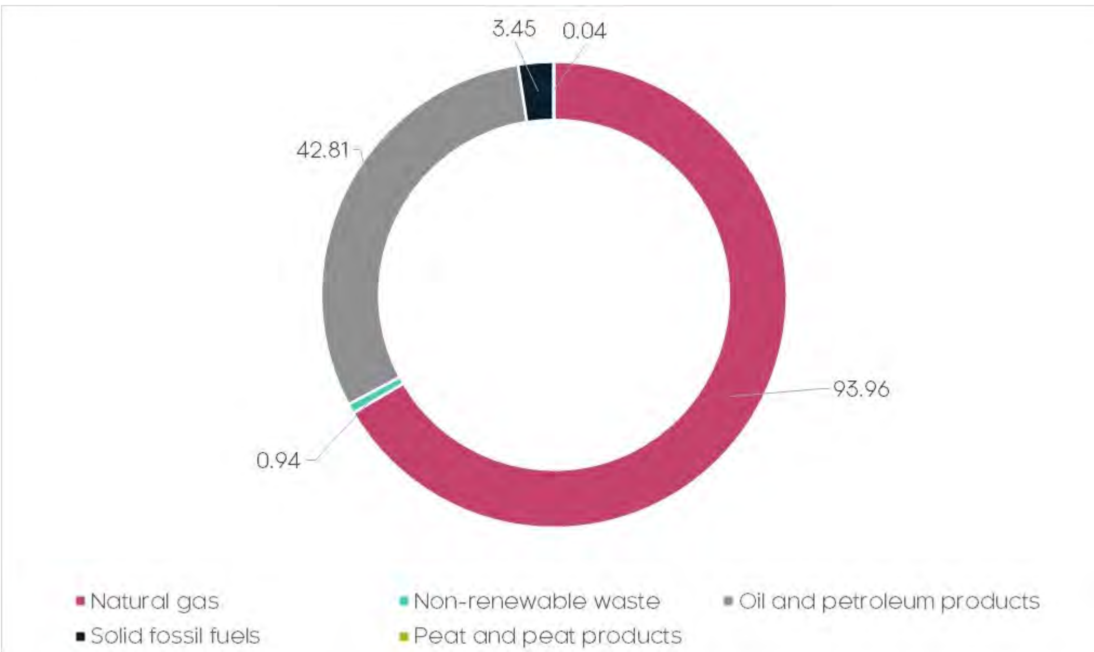
[102] Bulgaria, Czechia, Estonia, Hungary, Italy, Lithuania, Malta, the Netherlands, Poland, Portugal, Romania, and Slovakia.

3.3.1.2 Commercial buildings

At the EU-27 level, non-ETS 2017 commercial building CO_2 emission amounted to 141 $MtCO_2$. Like in the case of residential building emissions, Figure 48 shows that most commercial building emissions resulted from the combustion of **natural gas** (94 $MtCO_2$) followed by the combustion of **oil and petroleum products** (43 $MtCO_2$), and **solid fossil fuels** (3 $MtCO_2$). At the EU-27 level, non-renewable waste (1 $MtCO_2$), peat and peat products (0.04 $MtCO_2$) and manufactured gases emissions (0.004 $MtCO_2$) are negligible.

Similarly to residential buildings, most oil and petroleum products CO_2 emissions resulted from **gas oil and diesel oil (excl. biofuels)** (87%) followed by **LPG** (10%). Moreover, most solid fossil fuel CO_2 emissions resulted from **other bituminous coal** (87%) followed by **lignite** emissions (5%).

Figure 48. EU-27 Commercial buildings non-ETS CO_2 emissions by fuel in 2017 (MTCO2)



Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

Based on the relative shares presented in Figure 49, Table 28 breaks down national level commercial buildings non-ETS CO_2 emissions by fuel type.

Table 28. Commercial buildings non-ETS CO_2 emissions by fuel and Member State in 2017 (MT CO_2)

$MtCO_2$	Solid fossil fuels	Manuf. Gases	Peat	Oil products	Natural gas	Non-renewable waste	Total
EU-27	3.4	0.0	0.0	42.8	94.0	0.9	141.2
Germany	0.1	-	-	18.6	19.4	-	38.1
France	0.2	-	-	9.0	19.0	0.4	28.6
Italy	-	-	-	2.0	21.2	-	23.2

$MtCO_2$	Solid fossil fuels	Manuf. Gases	Peat	Oil products	Natural gas	Non-renewable waste	Total
Spain	-	-	-	3.9	6.7	0.0	10.6
Netherlands	0.0	-	-	0.5	7.0	0.1	7.6
Poland	2.6	-	-	1.3	3.4	0.0	7.3
Belgium	-	-	-	1.9	3.4	0.2	5.5
Hungary	0.0	-	-	0.1	2.9	0.0	3.1
Czech Republic	0.1	-	-	0.1	2.6	0.1	3.0
Romania	-	-	-	0.3	1.9	0.0	2.2
Ireland	-	-	-	0.8	1.2	-	2.0
Slovakia	0.3	-	-	0.0	1.3	0.0	1.6
Austria	-	-	-	0.5	0.7	-	1.2
Portugal	-	-	-	0.5	0.7	-	1.2
Finland	-	-	0.0	0.9	0.1	-	1.0
Sweden	-	0.00	-	0.59	0.15	-	0.75
Denmark	-	-	-	0.19	0.50	0.03	0.72
Greece	-	-	-	0.36	0.36	-	0.71
Croatia	0.00	-	-	0.18	0.45	-	0.63
Luxembourg	-	-	-	0.36	0.22	-	0.58
Latvia	0.02	-	0.00	0.12	0.26	-	0.39
Slovenia	-	-	-	0.23	0.13	-	0.36
Bulgaria	0.02	-	-	0.10	0.22	-	0.34
Lithuania	0.13	-	0.03	0.01	0.16	-	0.33
Malta	-	-	-	0.16	-	-	0.16
Estonia	-	-	-	0.03	0.06	-	0.10
Cyprus	-	-	-	0.09	-	-	0.09

Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

Table 29 shows the commercial buildings non-ETS CO_2 emissions presented in Table 28 as a percentage of each Member States' total ESR emissions. In this case, Malta has the higher proportion of commercial building non-ETS emissions (11.2%). This is followed by Italy (8.6%%) Germany (8.2%), and France (8.1%). At the EU-27 level, only 6.3% of total ESR emissions are caused by commercial buildings' non-ETS CO_2 emissions.

Table 29. Commercial buildings non-ETS CO_2 emissions by fuel and Member State in 2017 (% of total MS ESR emissions)

% of total ESR CO_2 emissions	Solid fossil fuels	Manuf. gases	Peat	Oil products	Natural gas	Non-renewable waste	Total
Malta	-	-	-	11.2%	-	-	11.2%
Italy	-	-	-	0.8%	7.8%	-	8.6%
Germany	0.01%	-	-	4.0%	4.2%	-	8.2%
France	0.05%	-	-	2.5%	5.4%	0.11%	8.1%
Belgium	-	-	-	2.7%	4.8%	0.22%	7.7%
Slovakia	1.28%	-	-	0.1%	6.0%	0.17%	7.5%
Netherlands	0.01%	-	-	0.5%	6.9%	0.11%	7.5%
Hungary	0.02%	-	-	0.2%	6.8%	0.05%	7.1%
Luxembourg	-	-	-	4.1%	2.5%	-	6.6%
EU-27	**0.15%**	**0.00%**	**0.00%**	**1.9%**	**4.2%**	**0.04%**	**6.3%**
Spain	-	-	-	1.9%	3.3%	0.01%	5.3%
Czech Republic	0.20%	-	-	0.1%	4.2%	0.22%	4.8%
Ireland	-	-	-	1.8%	2.6%	-	4.5%
Latvia	0.17%	-	0.01%	1.3%	2.8%	-	4.3%
Croatia	0.00%	-	-	1.1%	2.7%	-	3.8%
Poland	1.24%	-	-	0.6%	1.6%	0.01%	3.5%
Finland	-	-	0.04%	3.1%	0.3%	-	3.4%
Slovenia	-	-	-	2.1%	1.2%	-	3.3%
Portugal	-	-	-	1.2%	1.7%	-	2.9%
Romania	-	-	-	0.3%	2.5%	0.02%	2.9%
Lithuania	0.92%	-	0.21%	0.1%	1.1%	-	2.3%
Sweden	-	0.01%	-	1.8%	0.5%	-	2.3%
Austria	-	-	-	1.0%	1.3%	-	2.3%
Denmark	-	-	-	0.6%	1.5%	0.09%	2.2%
Cyprus	-	-	-	2.1%	-	-	2.1%
Greece	-	-	-	0.8%	0.8%	-	1.6%
Estonia	-	-	-	0.5%	1.0%	-	1.6%
Bulgaria	0.06%	-	-	0.4%	0.8%	-	1.3%

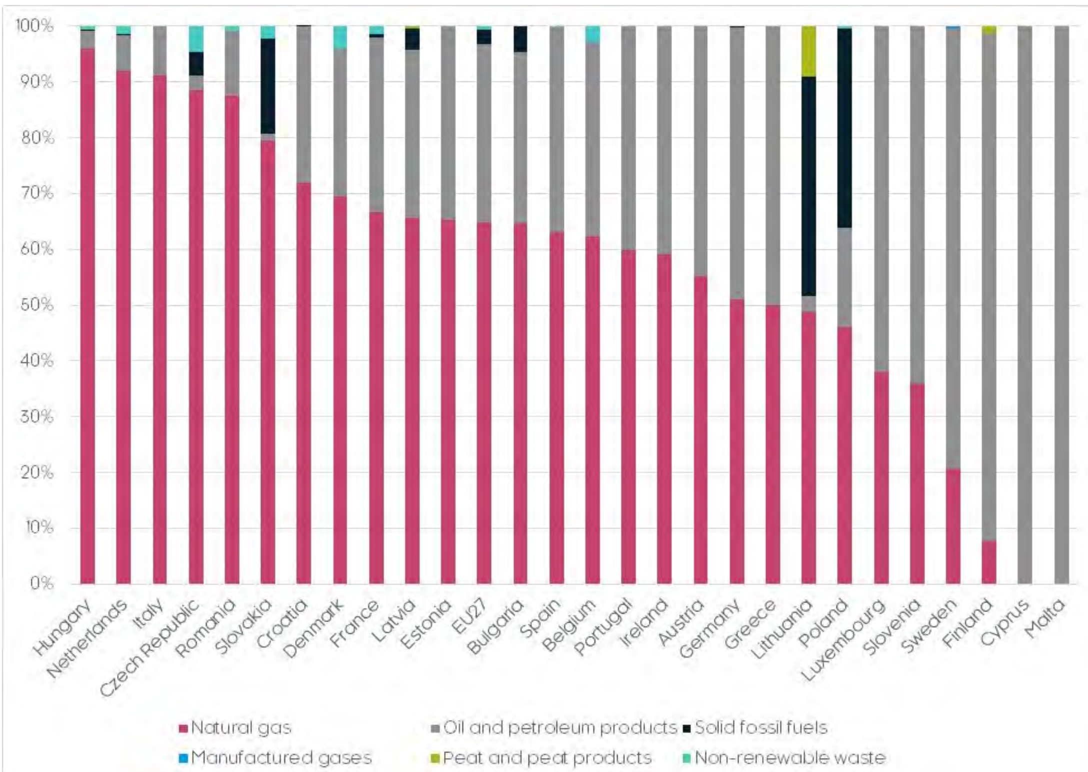
Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

Figure 49 provides estimates of the relative share of non-ETS commercial emissions by fuel type. Following the approach taken to analyse residential building emissions, this figure identifies which Member States have the highest reliance on **natural gas**. The figure shows that Hungarian and Dutch commercial buildings almost exclusively emit non-ETS CO_2 from **natural gas** sources.

On the other hand, commercial buildings in Malta and Cyprus almost exclusively emit non-ETS CO_2 from **oil and petroleum product** sources. **Gas oil and diesel oil (excl. biofuels)** emissions make up most oil and petroleum CO_2 emissions in 24 out of 27 Member States. However, **LPG** make up most Italian and Portuguese oil and petroleum product emissions. Having said that, seven other Member States' **LPG** emissions make up more than 25% of their commercial buildings' non-ETS oil and petroleum product CO_2 emissions[103]. Moreover, the bulk of oil and petroleum product emissions in Romania are due to the consumption of **motor gasoline (excl. biofuels)** and Sweden's commercial buildings emit more than 25% of oil emissions from **motor gasoline**.

Although no Member States have registered a majority of commercial building non-ETS CO_2 emissions from **solid fossil fuels** in 2017, Lithuania and Poland have a relatively large portion of these emissions due to the consumption of **other bituminous coal**.

Figure 49. Share of non-ETS CO_2 emissions by fuel in the commercial buildings sector, by Member State in 2017



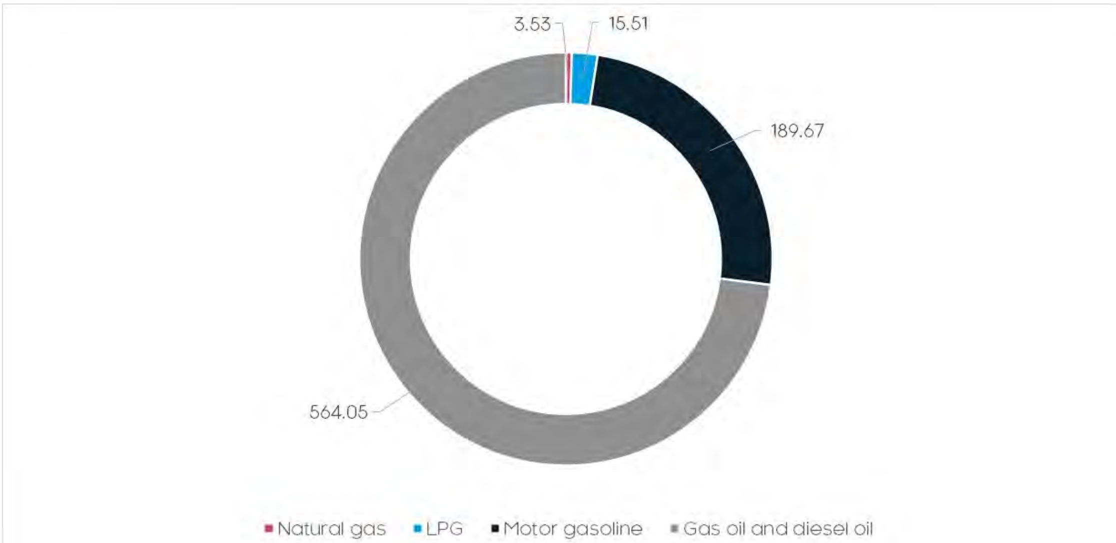
Source: CE estimates, based on Eurostat energy balances

[103] Cyprus, Greece, Hungary, Lithuania, Netherlands, Romania, and Slovakia.

3.3.2 Road transport

At the EU-27 level, non-ETS 2017 road transport building CO_2 emission amounted to 773 $MtCO_2$. Figure 50 shows that, in 2017, the majority of road transport emissions resulted from the combustion of **gas oil and diesel oil (excl. biofuels)** (564 $MtCO_2$) followed by the combustion of **motor gasoline (excl. biofuels)** (190 $MtCO_2$). At the EU-27 level, **LPG** is the third most consumed fossil fuel in road transport (16 $MtCO_2$) followed by **natural gas** (4 $MtCO_2$). Although the Eurostat energy balances reports some combustion of **white spirits**[104] and **kerosene**[105] in road transport, the amount of resulting CO_2 emissions is negligible.

Figure 50. EU-27 Road transport non-ETS CO_2 emissions by fuel in 2017 ($MtCO_2$)



Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

Based on the relative shares presented in Figure 51, Table 30 shows that at the national level. **Diesel (excl. biofuels)** emissions make up the majority of non-ETS emissions. This is followed by **motor gasoline (excl. biofuels)** as the second largest source of road transport non-ETS CO_2 emissions. This holds true for all Member States except Greece and Cyprus, where emissions from **motor gasoline (excl. biofuels)** dominate road transport non-ETS CO_2 emissions.

Table 30. Road transport non-ETS CO_2 emissions by fuel and Member State in 2017 ($MtCO_2$)

$MtCO_2$	Natural gas	LPG	Motor gasoline	Kerosene	Gas oil and diesel oil	White spirit and SPB ind. spirits	Total

[104] 0.045 MT CO_2 in Austria.

[105] 0.00001 MT CO_2 in Romania.

EU-27	3.5	15.5	189.7	0.0	564.0	0.04	772.8
Germany	0.34	1.0	50.7	-	108.1	-	160.1
France	0.21	0.2	21.5	-	104.1	-	126.0
Italy	1.98	4.8	21.4	-	63.2	-	91.4
Spain	0.27	0.2	14.1	-	67.1	-	81.6
Poland	0.03	5.4	12.4	-	43.4	-	61.1
Netherlands	0.14	0.4	11.6	-	17.5	-	29.7
Belgium	0.02	0.2	4.2	-	20.5	-	24.9
Austria	0.04	0.0	4.4	-	18.8	0.04	23.2
Czech Republic	0.13	0.3	4.6	-	13.1	-	18.1
Romania	-	0.2	3.9	0.00	12.9	-	17.1
Portugal	0.03	0.1	3.2	-	12.9	-	16.2
Sweden	0.04	-	6.0	-	9.3	-	15.3
Greece	0.03	0.7	7.2	-	6.6	-	14.5
Hungary	0.02	0.1	4.0	-	8.6	-	12.7
Denmark	0.02	-	4.2	-	7.8	-	12.0
Ireland	0.00	0.00	2.6	-	8.8	-	11.4
Finland	0.01	-	3.7	-	7.0	-	10.7
Bulgaria	0.18	1.3	1.5	-	5.9	-	8.8
Slovakia	-	-	1.7	-	5.4	-	7.2
Croatia	0.01	0.2	1.6	-	4.6	-	6.3
Luxembourg	-	0.00	0.9	-	4.7	-	5.6
Lithuania	0.02	0.3	0.6	-	4.5	-	5.4
Slovenia	0.01	0.04	1.2	-	4.2	-	5.4
Latvia	-	0.2	0.6	-	2.4	-	3.1
Estonia	0.01	0.02	0.8	-	1.5	-	2.3
Cyprus	-	-	1.1	-	0.9	-	2.1
Malta	-	0.00	0.23	-	0.33	-	0.56

Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

Table 31 shows the road transport non-ETS CO_2 emissions displayed in Table 30 as a proportion of each Member States' total ESR emissions. In 2017, Luxembourg's non-ETS road transport CO_2 emissions made up 63.8% of the country's total ESR emissions. This was followed by Slovenia (49.9%), Cyprus (48.6%), and Sweden (47.2%). At the EU-27 level, non-ETS road transport CO_2 emissions accounted for 34.3% of all 2017 ESR emissions.

Table 31. Road Transport non-ETS CO_2 emissions by fuel and Member State in 2017 (% of total MS ESR missions)

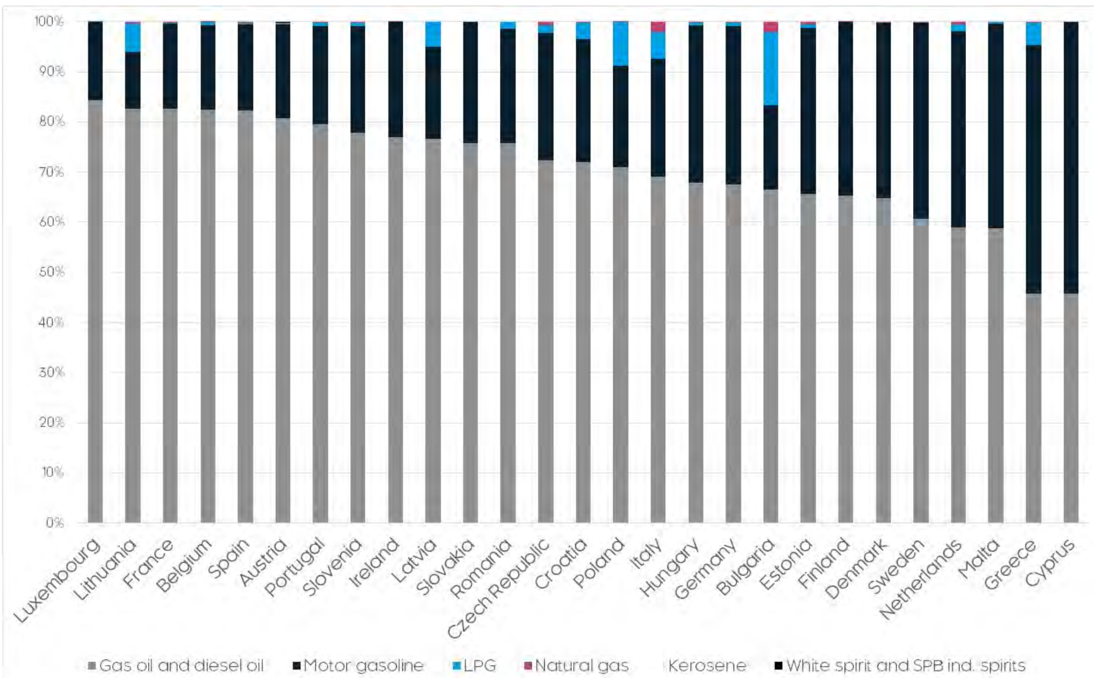
% of total ESR CO_2 emissions	Natural gas	LPG	Motor gasoline	Kerosene	Gas oil and diesel oil	White spirit and SPB ind. spirits	Total
Luxembourg	-	0.02%	9.9%	-	53.9%	-	63.8%
Slovenia	0.07%	0.35%	10.7%	-	38.8%	-	49.9%
Cyprus	-	-	26.4%	-	22.2%	-	48.6%
Sweden	0.13%	-	18.4%	-	28.7%	-	47.2%
Austria	0.08%	0.06%	8.4%	-	36.4%	0.09%	45.0%
Spain	0.13%	0.08%	7.0%	-	33.4%	-	40.6%
Portugal	0.09%	0.27%	7.9%	-	32.0%	-	40.2%
Malta	-	0.13%	16.0%	-	23.0%	-	39.0%
Lithuania	0.13%	2.17%	4.4%	-	31.9%	-	38.5%
Croatia	0.06%	1.25%	9.3%	-	27.4%	-	38.0%
Estonia	0.18%	0.31%	12.4%	-	24.6%	-	37.5%
Denmark	0.05%	-	12.9%	-	23.8%	-	36.8%
France	0.06%	0.05%	6.1%	-	29.5%	-	35.7%
Finland	0.04%	-	12.3%	-	23.3%	-	35.6%
Belgium	0.03%	0.22%	5.9%	-	28.9%	-	35.1%
EU-27	**0.16%**	**0.69%**	**8.4%**	**0.00%**	**25.0%**	**0.00%**	**34.3%**
Germany	0.07%	0.21%	10.9%	-	23.2%	-	34.3%
Italy	0.73%	1.78%	7.9%	-	23.4%	-	33.8%
Slovakia	-	-	8.2%	-	25.5%	-	33.7%
Latvia	-	1.69%	6.1%	-	25.6%	-	33.4%
Bulgaria	0.68%	4.86%	5.6%	-	22.2%	-	33.3%
Greece	0.07%	1.45%	15.8%	-	14.6%	-	32.0%
Hungary	0.05%	0.16%	9.3%	-	20.0%	-	29.4%
Netherlands	0.13%	0.42%	11.3%	-	17.1%	-	29.0%
Czech Republic	0.21%	0.42%	7.4%	-	21.0%	-	29.0%
Poland	0.01%	2.54%	5.9%	-	20.5%	-	28.9%
Ireland	0.00%	0.01%	5.9%	-	20.0%	-	25.9%
Romania	-	0.32%	5.2%	0.00%	17.1%	-	22.6%

Source: CE estimates, based on Eurostat energy balances and EEA GHG inventories

Figure 51 depicts estimates of the relative share of non-ETS road transport emissions by fuel type. Since **diesel** is the most consumed fossil-fuel at the EU-27 level, the figure identifies which Member States have the highest reliance on **diesel**. In fact, road non-ETS transport emissions in Luxembourg and Lithuania mostly result from the combustion of **diesel** fuels. As explained above, road transport in Greece and Cyprus is more reliant on **motor gasoline**. However, **diesel** still accounts for almost half of these Member States non-ETS CO_2 emissions.

Together, **LPG** and **natural gas** emissions amount to approximately 20 MtCO_2 at the EU-27 level. In 2017, 21 Member States utilised **natural gas** and 22 Member States utilised **LPG** for road transport purposes. However, **LPG** emissions in Ireland (5%), Greece (5%), Lithuania (6%) and Bulgaria (15%) account for 5% or more of their total road transport non-ETS CO_2 emissions. Moreover, **natural gas** road transport emissions show the highest national shares in Bulgaria (2%) and Italy (2%).

Figure 51. Share of non-ETS CO_2 emissions by fuel in the road transport sector, by Member State in 2017



Source: CE estimates, based on Eurostat energy balances

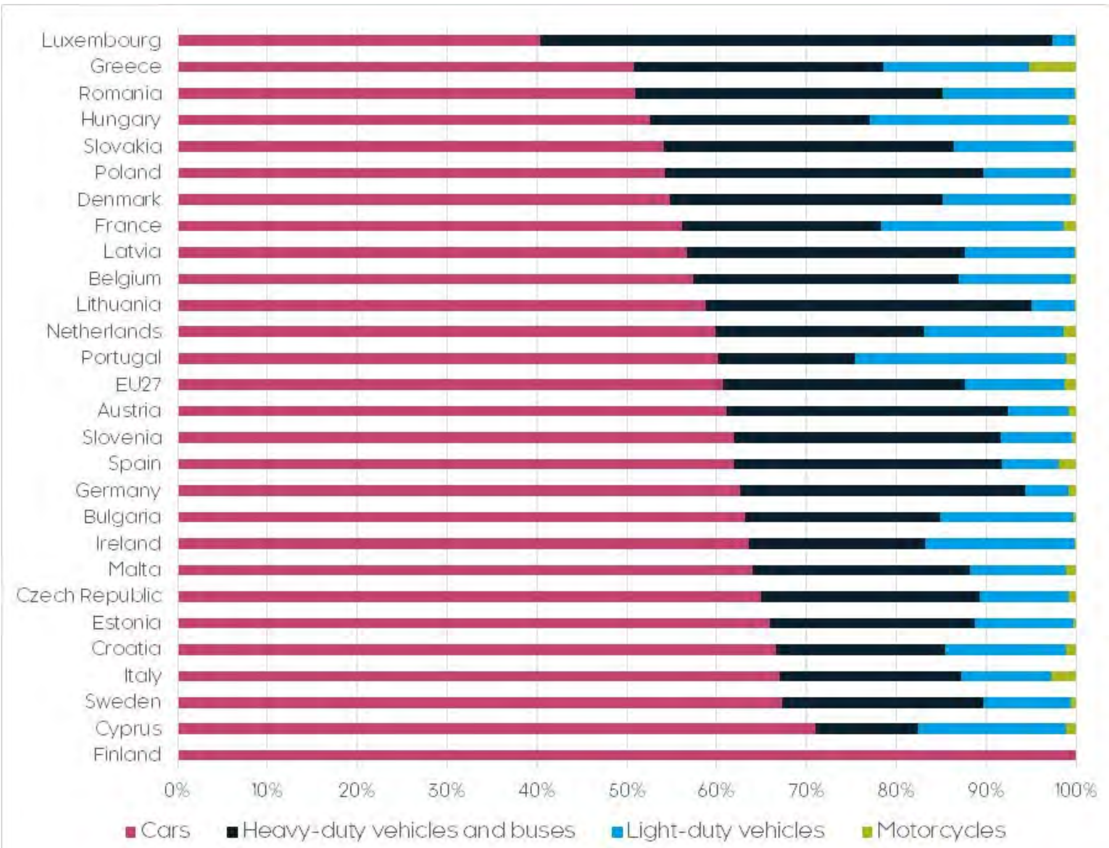
Since Eurostat energy balances data does not split the final energy consumption of road transport by vehicle category, this analysis could only disaggregate total road transport non-ETS emissions by fuel type. Having said that, EEA GHG inventories split total road transport CO_2 emissions by vehicle type and this data is presented in Figure 52. The analysis carried out in question 2.1a shows that diesel is the predominant source of fuel used in **heavy-duty vehicles and buses** while motor gasoline is mostly used by **private passenger cars** (which also consume diesel) and **motorcycles**. Question 2.1a also finds that, over time, buses have increased their use of **LPG** and **natural** gas as a fuel source but still predominantly consume **diesel**.

Figure 52 shows that most road transport non-ETS CO_2 emissions are a result of **private passenger** car usage. In fact, at the EU-27 level, passenger cars account for 61% of all non-ETS CO_2 emissions. Out of all Member States, only Luxembourg registered the highest emissions from **heavy-duty vehicles and buses** rather than cars. The Member States with the highest proportion of emissions coming from **light-duty vehicles** are

Portugal (24%), Hungary (22%), France (20%), and Ireland (17%). Finally, Greece (5%), Italy (3%), and Spain (2%) have the highest proportion of emissions from the combustion of fuel in **motorcycles**.

In the case of Finland, the EEA road transport data is all packaged under (1.A.3.b.i - Cars), making it is impossible to determine the relative share of emissions resulting from other transport categories. Moreover, Cyprus, Germany, and Romania register a small amount of road transport CO_2 emissions under the Other Road Transport category (1.A.3.b.v). However, these emissions amount to a very small percentage of total road transport emissions and were not plotted in Figure 52.

Figure 52. Share of non-ETS CO_2 emissions by vehicle type in the road transport sector, by Member State in 2017



Source: CE estimates, based on EEA GHG inventories

3.3.3 Conclusion

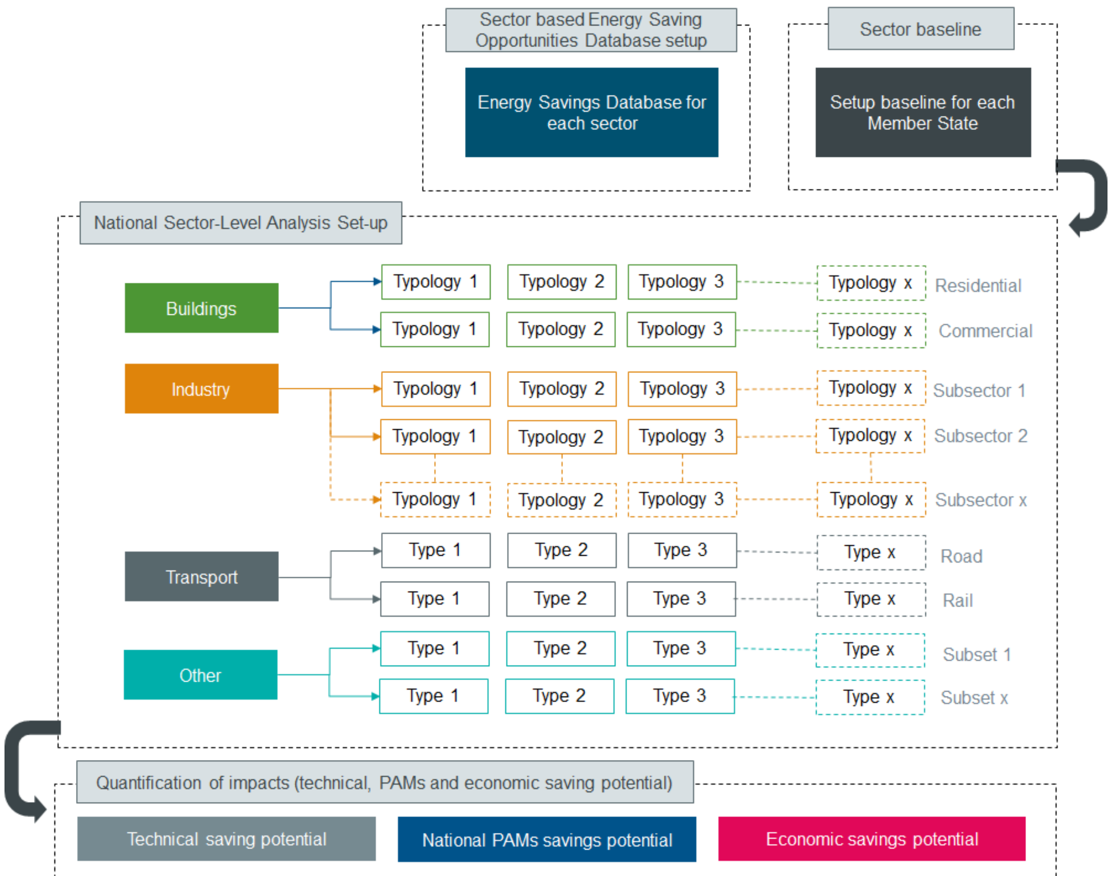
In conclusion, question 2.1c reviews non-ETS CO_2 buildings and road transport emissions in each EU-27 Member State in 2017. The analysis found that, at the EU-27 level, the majority of building emissions are a result of fossil fuels used in residential buildings (70%) and the majority of road transport emissions are a result of fossil fuel combustion by private passenger cars (61%).

In the case of buildings, most EU-27 emissions result from **natural gas**, followed by **oil and petroleum products**. In terms of oil products, both residential and commercial buildings mostly consume **gas oil and diesel oil**, followed by **LPG**. Some Member States have a building sector which is also heavily reliant on **solid fossil fuels**. In the case of road transport, most EU-27 emissions result from **diesel** combustion, followed by **motor gasoline**.

3.4 Question 2.1d: Abatement potentials, costs and barriers

The aim of this question is to quantify the abatement potential in the buildings and transport sectors, and the associated investment costs required to achieve their potential. The analysis was conducted using ICF's Energy Efficiency Potential Model (EEPM), Figure 53.

Figure 53. An effective bottom-up energy accounting framework to support the quantification of investment cost, and abatement potential for end-use sectors



Source: ICF Consulting

The accounting framework used to describe the building and transport sectors in Member States, defines:

- The subsector / subset of each sector within the scope of the study (i.e., residential, commercial buildings, road transport)
- The typology of the building (e.g., single-family homes, multi-family homes, health, education etc.), or the categories of road transportation mode (e.g. Private cars, light commercial vehicles (LCV) and heavy-duty vehicles (HGV))
- The energy use category for each of the typology (e.g., space heating, space cooling, lighting, hot water heating etc.)

- The actual energy end-use equipment in the buildings sector (e.g., boilers, air heaters, heat pumps, insulation, CFL, chillers, make up air units etc.), and the technology type for each mode of road transportation (e.g. average vehicle energy efficiency for EU, average efficiency tyres).

3.4.1 Sector-specific baselines

The baseline energy projection is the starting point for the analysis and provides a projection of future energy use in the Member States, against which the abatement potentials are calculated. The baseline energy consumption in the buildings and road transport sectors was defined by the EUCO3232.5 scenario, with the uptake of energy efficiency measures aligned to account for those already included within the EUCO3232.5 baseline. Assumptions regarding the apportionment of the EUCO3232.5 sectoral baselines (residential, commercial and transport) into building typology and transport mode, as well as the energy end-use consumption profiles for each typology was determined using Member State data, and when this was not available, EU representative data.

3.4.2 Profile of Energy Saving Opportunities

Energy saving measures are applied to the end-use equipment or technology, which enables the quantification of the investment cost and abatement potential. Each measure contains a specific profile of detailed parameters, including lifetime, capital/ operating costs, abatement potential, energy use type, technology readiness level, market penetration rate and trend. The model analysis includes some fuel switching measures, such as air source heat pumps, and solar heating; however, broader fuel switching analysis due to carbon taxation is presented in Task 2.2.2.

The incremental cost of ESOs has been amended in line with the maturity of technologies and the uptake of Nearly Zero Energy Buildings (NZEB) post 2021 according to EU guidelines that all new buildings will be NZEB by 2020 (2016/1318). Technology costs are also modelled to reduce over time due to learning as manufacturers gain design and production experience, and as parts along the supply chain decrease in price.

For the residential and commercial sectors (including public buildings), over 150 energy saving measures, including possible measure permutations[106] for each category of energy saving measure have been assessed. For the road transport sector, abatement measures range from vehicle engine efficiency improvements, smart mobility, to alternate fuels (e.g., zero emission vehicles, biofuels and natural gas).

3.4.3 Quantification of abatement potentials

The abatement potential is estimated by assuming that measures are implemented when they become technically feasible. For many measures, this will be almost immediately; however, for others, such as emerging technologies, these are implemented when the currently installed equipment has reached its end of life. Since the EUCO3232.5 baseline scenario already accounts for energy savings due to implementation of policies and measures through 2030, the calculated energy savings were discounted to prevent double counting of the results. The marginal cost of abatement is estimated using the total cost to implement the measure, energy savings during the measure lifetime, CO_2 abatement, and a discount rate of 8%[107]. Investment

[106] ICF's list of building energy saving measures contains granular technical options for each category of measure. For example, insulation includes ceiling, wall, crawlspace, slab options, while lighting efficiency is characterised by interior and exterior LED options.

[107] See section 3.6.1

costs are from the perspective of the energy end-user and look at the full capital cost of implementing the measure. Fuel price projections used to quantify energy savings are based on Enerdata's Global Energy and CO_2 Database[108], which contains data based on various sources, including Eurostat (for electricity and gas). See section 3.5 for additional details. CO_2 abatement is calculated by multiplying energy savings by fuel-specific emission factors from 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

3.4.3.1 Buildings sector

Residential sector

The abatement ($MtCO_2$) and energy savings (mtoe) potential in the residential sector in 2030, in the EU27 is presented in Table 32 and Table 33, respectively, at different carbon prices (€0/tCO_2, €30/tCO_2, €50/tCO_2, €90/tCO_2 and €150/tCO_2). The results show that in 2030, 15% of the baseline (25.2 $MtCO_2$) can still be cost effectively abated from an end user (i.e., building owner) perspective, without a carbon price being applied. As the carbon price is increased from €30/tCO_2 to €150/tCO_2, the abatement potential increases from 16% (26.3 $MTCO_2$) to 20% (33.3 $MtCO_2$), against the EUCO3232.5 baseline emission for 2030, as additional, more costly measures become economically viable for implementation.

Table 32. Marginal abatement potential ($MTCO_2$) for residential buildings within EU27 in 2030

2030	EMISSIONS ($MTC0_2$)	ABATEMENT POTENTIAL (MTCO2)	% ABATEMENT POTENTIAL
EUCO 3232.5 Baseline	169.5		
Carbon Price 0 (EUR/tC02)		25.2	15%
Carbon Price 30 (EUR/tC02)		26.3	16%
Carbon Price 50 (EUR/tC02)		26.7	16%
Carbon Price 90 (EUR/tC02)		32.4	19%
Carbon Price 150 (EUR/tC02)		33.3	20%

Source: ICF Consulting

Table 33. Marginal energy savings (mtoe) for residential buildings sector within EU27 in 2030

2030	ENERGY CONSUMPTION (MTOE)	ENERGY SAVINGS POTENTIAL (MTOE)	% SAVINGS POTENTIAL
EUCO 3232.5 Baseline	192.4		

[108] https://www.enerdata.net/research/energy-market-data-co2-emissions-database.html

2030	ENERGY CONSUMPTION (MTOE)	ENERGY SAVINGS POTENTIAL (MTOE)	% SAVINGS POTENTIAL
Carbon Price 0 (EUR/tC02)		16.1	8%
Carbon Price 30 (EUR/tC02)		16.9	9%
Carbon Price 50 (EUR/tC02)		17.1	9%
Carbon Price 90 (EUR/tC02)		20.6	11%
Carbon Price 150 (EUR/tC02)		21.2	11%

Source: ICF Consulting

The following table (Table 34) provides a summary of the measures being implemented at the different carbon prices. Several of these measures relate to the GHG emissions from households' electricity consumption, which are already covered by the current ETS.

Table 34. Mitigation measures implemented at each carbon price

CARBON PRICE	RESIDENTIAL MITIGATION MEASURES IMPLEMENTED
Carbon Price 0 (EUR/tC02)	Adaptive Thermostats Advanced Power Strips RET Advanced Power Strips Air Infiltration Central Air Conditioner Tune-Up Central furnace efficient fan motor Central heat pump tune-up Condensing gas boilers and water heaters Insulation (draft proofing, duct sealing, piping) Efficient appliances (refrigerator, ceiling fans, dehumidifiers, clothes washer and dryer, television, window air conditioner) Heat pumps (electric air-source cold climate, ground source) Energy efficient homes (20% above code) Energy efficient pool pumps Lighting efficiency (exterior, CFL, incandescent) Water appliances (faucet Aerators, low flow shower head) Water heater (high efficiency gas storage water heater, hydronic heating, tankless) High efficiency windows

CARBON PRICE	**RESIDENTIAL MITIGATION MEASURES IMPLEMENTED**
	Social benchmarking and home energy monitoring
Carbon Price 30 (EUR/tC02)	Crawlspace insulation Early furnace replacement - 70% AFUE - 90% AFUE
Carbon Price 50 (EUR/tC02)	Integrated heating and domestic hot water (forced air heating)
Carbon Price 90 (EUR/tC02)	Insulation (attic/ceiling, basement Wall (R-12), slab (unfinished basement) High efficiency heat recovery ventilators (HRVs) Water heater replacement
Carbon Price 150 (EUR/tC02)	95% or higher efficiency furnaces Active solar water heating systems

Source: ICF Consulting

Above 150 EUR/tC0₂, several measures are available for implementation; however, they remain costly from an end-user perspective, with a higher carbon price required to improve their economic viability. These measures include central air conditioner replacement, energy efficient dishwashers, and personal computers, Net-Zero-Ready Homes, and wastewater heat recovery systems.

Table 35 presents the abatement potential at Member State level in 2030.

Table 35. Residential sector abatement potential by 2030 (mtC0_2)

MEMBER STATE	**BASELINE EMISSION (MTC02)**	**0 EUR/ TC02**	**30 EUR/ TC02**	**50 EUR/ TC02**	**90 EUR/ TC02**	**150 EUR/ TC02**	**% RED. AT 150 EUR/ TCO_2**
Austria	3.37	0.06	0.10	0.10	0.10	0.11	3%
Belgium	9.90	1.72	1.90	1.94	2.91	3.05	31%
Bulgaria	0.15	0.00	0.00	0.00	0.00	0.00	0%
Croatia	1.08	0.01	0.01	0.01	0.01	0.01	1%
Cyprus	0.07	0.03	0.03	0.03	0.04	0.04	59%
Czechia	4.31	0.54	0.61	0.66	0.68	0.79	18%
Denmark	1.39	0.04	0.04	0.04	0.04	0.04	3%
Estonia	0.15	0.01	0.01	0.01	0.01	0.01	6%
Finland	0.39	0.00	0.00	0.00	0.00	0.00	0%
France	16.99	0.05	0.07	0.07	0.07	0.07	0.4%
Germany	45.84	5.70	6.23	6.35	9.30	9.72	21%
Greece	1.48	0.07	0.08	0.08	0.11	0.12	8%

MEMBER STATE	BASELINE EMISSION (MTC02)	0 EUR/ TC02	30 EUR/ TC02	50 EUR/ TC02	90 EUR/ TC02	150 EUR/ TC02	% RED. AT 150 EUR/ TCO_2
Hungary	4.83	0.20	0.21	0.24	0.26	0.29	6%
Ireland	2.44	0.42	0.60	0.62	0.66	0.66	27%
Italy	35.78	9.83	9.83	9.83	10.51	10.51	29%
Latvia	0.32	0.02	0.02	0.02	0.02	0.03	8%
Lithuania	0.31	0.00	0.00	0.00	0.00	0.00	0%
Luxembourg	0.56	0.23	0.25	0.26	0.38	0.40	70%
Malta	0.02	0.00	0.00	0.01	0.01	0.01	31%
Netherlands	11.27	3.40	3.40	3.40	3.58	3.58	32%
Poland	15.42	2.05	2.08	2.08	2.59	2.60	17%
Portugal	0.74	0.00	0.00	0.00	0.00	0.00	0%
Romania	5.70	0.25	0.26	0.32	0.35	0.38	7%
Slovakia	1.74	0.34	0.37	0.40	0.40	0.46	26%
Slovenia	0.42	0.00	0.00	0.00	0.00	0.00	0%
Spain	4.76	0.23	0.24	0.24	0.33	0.38	8%
Sweden	0.08	0.00	0.00	0.00	0.00	0.00	0%
Total	**169.49**	**25.20**	**26.35**	**26.71**	**32.38**	**33.26**	**20%**

Source: ICF Consulting

As noted above, the abatement potential varies by Member State, with the amount dependent on the building typology, fuel mix, applicable abatement measures, the anticipated market penetration rate of the measure in the baseline, purchasing power parity, and retail fuel price. As an example, Italy achieves 27.5% abatement potential (9.83 $MtCO_2$) at a carbon price of 0 EUR/$tC0_2$, increasing to 29% (10.51 $MtCO_2$) at 150 EUR/$tC0_2$, whereas Germany has an abatement potential of 12.4% (5.7 $MtCO_2$) at 0 EUR/$tC0_2$ and 21% (9.72 $MtCO_2$) at 150 EUR/$tC0_2$. In this scenario, the retail fuel price of plays a key role, as Italy's high fuel costs result in larger cost effective savings and associated abatement at lower carbon prices, when compared to Germany which only achieves greater abatement at higher carbon prices (i.e., active solar water heating systems and net-zero-ready homes at a carbon price of 90 EUR/tC02) owing to their lower fuel prices.

For Bulgaria, Finland, Lithuania, Portugal, Slovenia, and Sweden, the EUCO3232.5 baseline scenario was assumed to capture all potential abatement, with no additional abatement available for these countries. In the case of Bulgaria and Slovenia, the current (2020) uptake of abatement measures is low. However, the EUCO3232.5 scenario anticipates a larger uptake in measures through 2030. Since these are captured in the baseline, there is limited scope for additional abatement. For countries, such as Finland and Sweden, where the average uptake of energy efficiency measures in 2020 is high, there is less energy saving potential, as they already have robust energy efficiency policies in place. This results in no additional abatement potential as the EUCO3232.5 scenario captures the available potential.

Commercial sector

The abatement ($MtCO_2$) and energy savings (mtoe) potential in the commercial sector in EU27 is presented in Table 36 and Table 37, respectively, at carbon prices of €0/tCO_2, €30/tCO_2, €50/tCO_2, €90/tCO_2 and €150/tCO_2. In 2030, 7.4 $MtCO_2$ (10% of the baseline) can be cost effectively abated from an end user (i.e., building owner) perspective, without a carbon price being applied. As the carbon price is increased from €30/tCO_2 to €150/tCO_2, the abatement potential increases from 11% (7.6 $MTCO_2$) to 13% (8.9 $MtCO_2$), as additional, costlier measures become economically viable for implementation.

Table 36. Marginal abatement potential ($MTCO_2$) for commercial buildings within EU27 in 2030

2030	EMISSIONS ($MTC0_2$)	ABATEMENT POTENTIAL ($MTCO_2$)	% ABATEMENT POTENTIAL
EUCO 3232.5 Baseline	71.4		
Carbon Price 0 (EUR/tC02)		7.4	10%
Carbon Price 30 (EUR/tC02)		7.6	11%
Carbon Price 50 (EUR/tC02)		8.1	11%
Carbon Price 90 (EUR/tC02)		8.3	12%
Carbon Price 150 (EUR/tC02)		8.9	13%

Source: ICF Consulting

Table 37. Marginal energy savings (mtoe) for commercial buildings sector within EU27 in 2030

2030	ENERGY CONSUMPTION (MTOE)	ENERGY SAVINGS POTENTIAL (MTOE)	% SAVINGS POTENTIAL
EUCO 3232.5 Baseline	107.1		
Carbon Price 0 (EUR/tC02)		6.4	6%
Carbon Price 30 (EUR/tC02)		6.5	6%
Carbon Price 50 (EUR/tC02)		6.7	6%
Carbon Price 90 (EUR/tC02)		6.9	6%
Carbon Price 150 (EUR/tC02)		7.3	7%

Source: ICF Consulting

Table 38 provides a summary of the measures being implemented at the different carbon prices.

Table 38. Mitigation measures implemented at each carbon price

CARBON PRICE	**COMMERCIAL MITIGATION MEASURES IMPLEMENTED**
Carbon Price 0 (EUR/tC02)	Unitary and Split System AC/HP Equipment Air or water-cooled chilling equipment Dual enthalpy economizer Lighting fixtures (linear florescent, high bay lighting, exterior, downlights, signs) Lighting controls (daylighting, occupancy sensor) Electronically commutated motors for refrigeration applications High efficiency appliances (dishwasher, fryer, griddles, electric convection ovens, steam cookers, fryers, broilers, extractor/ tunnel washers, pool pumps) Heat pump storage water heater Insulation (piping, ceiling, water heater) Power management (plug load occupancy sensors, computer, power strips) High efficiency air-cooled refrigeration compressor rack Variable refrigerant flow heat pump Energy recovery ventilation / heat recovery ventilation Tankless water heaters (condensing, electric) Air curtains (single, double door, walk-in freezers) Destratification fans Condensing storage water heaters
Carbon Price 30 (EUR/tC02)	Wall and roof insulation
Carbon Price 50 (EUR/tC02)	Solar preheat make-up air Electric ground source heat pumps
Carbon Price 90 (EUR/tC02)	Ground source heat pumps
Carbon Price 150 (EUR/tC02)	Solar water preheating (domestic hot water system, pools)

Source: ICF Consulting

Abatement measures that are economically viable, for the end user, at carbon prices greater than 150 EUR/$tC0_2$, include high efficiency hot food holding cabinets, commercial ice makers, drain water heat recovery, green roofs, and new constructions with greater than 25% efficiency improvements.

Table 39 presents the abatement potential at Member State level in 2030.

Table 39. Commercial sector abatement potential by 2030 (mtC0₂)

MEMBER STATE	BASELINE EMISSIONS (MTC02)	0 EUR / TC02	30 EUR / TC02	50 EUR / TC02	90 EUR / TC02	150 EUR / TC02	% RED AT 150 EUR / TCO2
Austria	0.47	0.11	0.11	0.11	0.11	0.12	25%
Belgium	4.46	0.83	0.85	0.85	0.85	0.88	20%
Bulgaria	0.12	0.08	0.08	0.08	0.09	0.09	78%
Croatia	0.28	0.05	0.05	0.06	0.06	0.07	25%
Cyprus	0.04	0.03	0.03	0.03	0.03	0.03	82%
Czechia	1.82	0.29	0.30	0.31	0.37	0.40	22%
Denmark	0.37	0.10	0.10	0.10	0.10	0.10	28%
Estonia	0.09	0.04	0.04	0.06	0.06	0.07	78%
Finland	0.28	0.14	0.14	0.14	0.15	0.15	53%
France	11.96	0.00	0.00	0.00	0.00	0.00	0%
Germany	17.80	0.00	0.00	0.00	0.00	0.00	0%
Greece	0.50	0.19	0.20	0.20	0.24	0.24	49%
Hungary	2.08	0.02	0.03	0.03	0.03	0.05	2%
Ireland	0.73	0.00	0.00	0.00	0.00	0.00	0%
Italy	12.17	2.02	2.05	2.05	2.05	2.12	17%
Latvia	0.17	0.01	0.01	0.01	0.02	0.02	11%
Lithuania	0.13	0.00	0.00	0.00	0.00	0.01	4%
Luxembourg	0.40	0.24	0.25	0.25	0.25	0.28	71%
Malta	0.01	0.01	0.01	0.01	0.01	0.01	83%
Netherlands	6.10	0.25	0.26	0.26	0.26	0.28	5%
Poland	4.68	2.64	2.69	3.22	3.27	3.62	77%
Portugal	0.27	0.01	0.01	0.01	0.01	0.01	3%
Romania	1.41	0.11	0.11	0.11	0.11	0.13	9%
Slovakia	1.44	0.06	0.06	0.06	0.08	0.08	6%
Slovenia	0.11	0.00	0.00	0.00	0.00	0.00	0%
Spain	3.10	0.10	0.10	0.10	0.10	0.10	3%
Sweden	0.36	0.07	0.07	0.08	0.08	0.08	23%
Total	**71.36**	**7.38**	**7.55**	**8.11**	**8.32**	**8.95**	**13%**

Source: ICF Consulting

As noted in Table 39, the abatement potential varies by Member State, with the amount dependent on the building typology, fuel mix, applicable abatement measures, the anticipated market penetration rate of the measure in the baseline, purchasing power parity, and retail fuel price. As an example, Denmark and Romania have an abatement potential at 150 EUR/tCO_2 of 28% and 9%, respectively. The increased marginal abatement potential in Denmark is realised due to its high retail fuel price of electricity, natural gas and coal, which is double Romanian energy tariffs.

For Germany, France, Ireland, and Slovenia, the EUCO3232.5 baseline scenario was assumed to capture all potential abatement, with no additional abatement available for these countries. In the case of Ireland and Slovenia, the current (2020) uptake of abatement measures is low. However, the EUCO3232.5 scenario anticipates a larger uptake in measures through 2030. Since these are captured in the baseline, the analysis indicated limited scope for additional abatement. For countries, such as Germany and France, where the average uptake of energy efficiency measures in 2020 is high, there is less energy saving potential, as they, already, have robust energy efficiency policies in place. This results in no additional abatement potential as the EUCO3232.5 scenario captures the available potential.

3.4.3.2 Transport sector

The marginal abatement and energy saving potential for the transport sector in the EU27 in 2030 is presented in Table 40 and Table 41. The analysis indicates that in 2030, the abatement potential in the EU27 is 7% (43.8 MtCO_2) at a zero-carbon price. At 150 EUR/tCO_2, the abatement potential increases to 13% (75.6 MtCO_2).

Like the buildings sector, a large proportion of the abatement potential can be achieved cost effectively (from the perspective of the vehicle owner) through the implementation of vehicle tyre efficiency standards, vehicle efficiency improvements of 3% in passenger cars and light commercial vehicle (LCV), and up to 25% in heavy duty vehicles (HDV). In addition to switching to electric vehicles, vehicle efficiency improvements for passenger cars are possible through technical measures, such as improving aerodynamics, motor efficiency, light-weighting, tyre resistance, etc. Due to the interaction of the technologies, these are aggregated and modelled as three overarching levels of improvement – 3%, 4% and 6%. For LDV and HDV, the vehicle efficiency can be improved through a range of technical measures, such as mass reduction, auxiliary systems (LED lighting, AC efficiency, cooling fan), transmission efficiency and advanced driver assistance systems (see Section 0 (Appendix D) for further details). Again, due to the interaction between the technical measures, and difference in costs, these are aggregated and modelled as different levels of vehicle efficiency improvement (e.g., LDV – 3%, 4% and 6%; HDV – 15%, 20%, 25%, 30% and 32.5%). As such, the uptake of improved efficiency measures in passenger vehicles, LCV and HDV varies across the Member States at different carbon prices due to the differing cost of fuel. The results for the transport sector do not consider non-technical energy efficiency measures[109], as costs for these measures are not readily known.

Table 40. Marginal abatement potential (MtCO_2) for road transport sector within EU27 in 2030

2030	EMISSIONS (MTC0_2)	ABATEMENT POTENTIAL (MTCO_2)	% ABATEMENT POTENTIAL
EUCO 3232.5 Baseline	590.2		

[109] Non-technical measures include Modal shift, and motorway speed reduction

2030	EMISSIONS ($MTC0_2$)	ABATEMENT POTENTIAL ($MTCO_2$)	% ABATEMENT POTENTIAL
Carbon Price 0 (EUR/tC02)		43.8	7%
Carbon Price 30 (EUR/tC02)		57.1	10%
Carbon Price 50 (EUR/tC02)		57.1	10%
Carbon Price 90 (EUR/tC02)		66.5	11%
Carbon Price 150 (EUR/tC02)		75.6	13%

Source: ICF Consulting

Table 41. Marginal energy savings potential (mtoe) for road transport sector within EU27 in 2030

2030	ENERGY CONSUMPTION (MTOE)	ENERGY SAVINGS POTENTIAL (MTOE)	% SAVINGS POTENTIAL
EUCO 3232.5 Baseline	276.2		
Carbon Price 0 (EUR/tC02)		16.9	6%
Carbon Price 30 (EUR/tC02)		22	8%
Carbon Price 50 (EUR/tC02)		22	8%
Carbon Price 90 (EUR/tC02)		25.5	8%
Carbon Price 150 (EUR/tC02)		29.1	11%

Source: ICF Consulting

Table 42. Transport sector abatement potential by 2030 ($mtC0_2$)

MEMBER STATE	BASELINE EMISSIONS (MTC02)	0 EUR/ TC02	30 EUR/ TC02	50 EUR/ TC02	90 EUR/ TC02	150 EUR/ TC02	% RED. AT 150 EUR/ TCO2
Austria	16.82	1.42	2.88	2.88	2.88	2.88	17%
Belgium	20.37	3.79	3.79	3.79	3.83	3.83	19%
Bulgaria	6.39	0.39	0.39	0.39	0.39	0.39	6%
Croatia	4.60	0.39	0.39	0.39	0.39	0.39	9%

MEMBER STATE	BASELINE EMISSIONS (MTC02)	0 EUR / TC02	30 EUR / TC02	50 EUR / TC02	90 EUR / TC02	150 EUR / TC02	% RED. AT 150 EUR / TCO2
Cyprus	1.52	0.20	0.20	0.20	0.20	0.20	13%
Czechia	14.22	0.05	0.05	0.05	0.05	0.07	0%
Denmark	8.57	1.34	1.34	1.34	1.34	1.34	16%
Estonia	1.61	0.08	0.12	0.12	0.12	0.12	8%
Finland	8.36	0.57	0.57	0.57	0.58	0.59	7%
France	96.87	10.20	10.20	10.20	10.25	10.25	11%
Germany	98.64	5.15	15.11	15.11	15.11	15.11	15%
Greece	12.93	0.46	0.46	0.46	0.49	0.53	4%
Hungary	9.61	0.23	0.23	0.23	0.23	0.25	3%
Ireland	10.57	1.80	1.80	1.80	1.80	1.80	17%
Italy	78.16	7.39	7.39	7.39	11.10	19.71	25%
Latvia	2.34	0.08	0.10	0.10	0.10	0.28	12%
Lithuania	3.59	0.04	0.05	0.05	0.05	0.06	2%
Luxembourg	6.49	0.58	0.58	0.58	0.58	0.58	9%
Malta	0.36	0.02	0.02	0.02	0.02	0.02	6%
Netherlands	23.11	1.87	1.89	1.89	1.89	1.89	8%
Poland	48.57	1.87	1.87	1.87	2.43	2.43	5%
Portugal	13.31	0.31	2.14	2.14	2.15	2.15	16%
Romania	13.79	0.21	0.21	0.21	0.21	0.21	2%
Slovakia	6.11	0.40	0.40	0.40	0.40	0.60	10%
Slovenia	4.47	0.75	0.75	0.75	0.75	0.75	17%
Spain	65.85	2.24	2.24	2.24	7.21	7.21	11%
Sweden	13.01	1.95	1.95	1.95	1.95	1.95	15%
Total	**590.23**	**43.80**	**57.14**	**57.14**	**66.53**	**75.62**	**13%**

Source: ICF Consulting

The abatement potential varies by Member State and relates closely with the rate of vehicle fleet renewal in Member States, baseline vehicle energy consumption, the anticipated market penetration rate of the measure in the baseline, and fuel prices.

Large increases in abatement potential are noticed for Italy (19.71 $MtCO_2$) and Germany (15.11 $MtCO_2$) owing to the uptake of electric vehicles (private car and light commercial vehicles). Italy realises this potential at 150 EUR/tCO_2, whereas Germany realises the abatement potential at 30 EUR/tCO_2. The reason for this is due to both higher fuel prices in Germany, and greater energy consumption in the average German vehicle compared to Italy during an annual period, leading to greater savings attributed with a switch to electric vehicles.

3.4.4 Investment barriers

The following sections highlight some of the key barriers to realise the abatement potential across the buildings and road transport sectors.

3.4.4.1 Buildings sector

Table 32 highlights the CO2 reduction potential in the residential and non-residential sectors. As noted, the reduction potential is not significant, but nonetheless, within that scope there are still cost-effective savings opportunities available. The policy frameworks related to the improvement of energy efficiency in buildings, include the 2002 Energy Performance in Buildings Directive (EPBD) and its 2010 recast, the Energy Efficiency Directive (EED), Renewable Energy Sources Directive (RESD), and the Eco-design Directive and the Energy Labelling Framework Regulation and their implementing acts. While the EPBD, for example, has seen many benefits, including the tightening of building standards across Member States, the certification of commercial buildings, and inspections of boilers and air conditioning systems, there are still overarching economic, behavioural and technical issues that are limiting the potential improvement of energy performance in the buildings sector.

3.4.5 Economic

Financial barriers associated with the high up-front capital costs of energy efficiency measures and renewable energy technologies, as well as and the lack of incentives to implement them, are the most persistent challenges to uptake, which also touches on numerous other issues raised below.

In non-residential buildings, **split incentives** between building owners, who would be required to pay for efficiency investments, and building occupants, who would reap the benefits of lower energy costs.

In organisations, budgets (profit and loss) and operations can be localised to specific retail units, restaurants, warehouses, etc. Consequently, awareness is impacted by **limited human and capital resources** required to investigate and implement energy efficiency opportunities.

During construction, there can be an unwillingness to install energy efficiency measures that go beyond the minimum standards set in building codes. Even though building codes do not always represent the optimum for efficiency, architects and builders can be inclined to meet these minimum requirements, due to cost pressures, and a **lack of incentive** to exceed these efficiency standards.

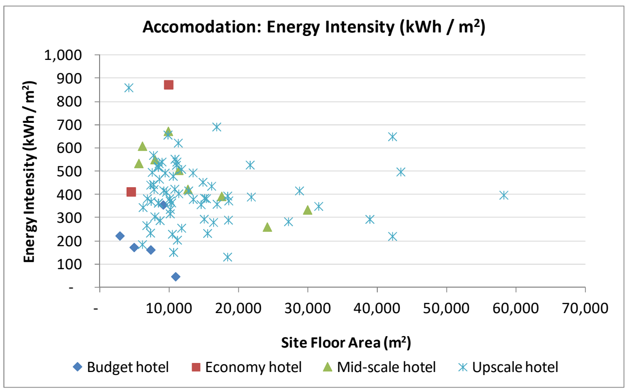
Intrusion and cost implications of deep renovation of existing buildings, such as those required to meet NZEB requirements, are a barrier to uptake. Because of the financial impact of purchasing new boilers, installing insulation and air conditioning units, building owners and occupiers typically undertake improvements or install new equipment only when issues arise, such as existing equipment failure, or maintenance costs become prohibitive.

Energy efficiency investments are dependent on the **risk associated with the investment class**. That is, the building owners opportunity cost of investing in the measure instead of other alternative investment classes with similar risk. For example, an enterprise would rather invest on expansion or marketing of its main business activity which has the potential to generate far greater benefits in comparison with the benefits associated with energy savings, assuming that both options are perceived to carry an equivalent amount of risk. Longer investment tenures also require higher expected returns, which makes energy efficiency measures with higher payback periods financially unattractive. Financial providers for energy efficiency investments typically prefer low risk investments, so an emphasis is placed on proven rather than new technologies.

3.4.6 Technical

Lack of standardised practices. Figure 54 presents the energy intensity (kWh/m2) spread for a subset of EU-based hotels belonging to the same organisation. Although the organisation has established an energy efficiency programme, there remains limited consistency in energy performance. This is due to various factors including, significant variation in the building fabric, due to issues that arise during the build process, such as design changes during construction; the quality of materials used; lack of communication between the construction company and the end-user at commissioning; as well as different operational and maintenance regimes across the portfolio, due to a lack of standardised building management practices and operator training.

Figure 54. Energy performance spread of EU-based hotels belonging to the same organisation



Source: ICF Consulting

There is a **lack of information and effective dissemination** of available information on energy efficient and renewable technologies; as such, builders and building owners and users are unaware of the associated costs and benefits. Linked to this, is a fragmented building sector supply chain, where knowledge and understanding of integrated solutions are limited, and competition between the various services (e.g., technology suppliers, builders), as well as the need for consumers to work with each party to obtain advice and solutions, can be time consuming and confuse decision making.

Builders and building owners often **lack the internal skills and competencies** to interpret technical information or evaluate energy efficiency opportunities, which can be highly complex and involve multiple system components across multiple technical disciplinaries (electrical, thermal, mechanical, civil, etc.). This is further compounded by new technologies, such as automated controls, smart building design and the 'Internet-of-Things' to transport, entering the market to support and enable the transition towards smart grids, demand response, etc. These technologies require a strong understanding of building infrastructure, technical disciplines, and sufficient resources.

3.4.7 **Behavioural**

For non-residential users of energy, the **priority** of energy performance and energy management issues is proportionate to their energy intensity and costs. That is, for low energy intensive buildings, the priority of energy issues slips down the rank as it is not considered to be a significant part of its business strategy. Furthermore, energy performance of an organisation is often not visible to senior managers. If the hierarchal distance between energy managers and decision makers is wide, it can result in poor communication of energy management issues at decision making level.

At the residential level, low prioritisation of energy efficiency inhibits renovations, with consumers more interested in aesthetics and floor space, as energy efficiency has limited impact on the property's valuation. Furthermore, residential building owners are not incentivised to improve energy performance required by regulation.

Inertia (or bounded rationalities) relates to the individual tendency to rely on established or familiar assumptions therefore exhibiting reluctance to revise those assumptions, even though the existing assumptions are irrelevant or obsolete. Builders are generally conservative and tend to build to the minimum requirements and lowest cost, while using potentially outdated practices or norms which they are most familiar with. This resistance to change carries on towards evaluation of energy efficiency measures whereby the more radical it is, the higher the resistance to accept the measure or change the set of prior assumptions. This results in favouring quick and low investment opportunities with lower expected returns, through familiar measures.

The decision to implement energy efficiency measures can often be based on **imperfect evaluation criteria**. For example, one of the key issues limiting evaluation is the lack of sub-metering. The lack of sub-metering may in turn lead to a split incentive as business units and staff are not responsible for the cost of energy. Furthermore, unlike energy supply, energy efficiency consists of a wide range of complex technologies and services, which are purchased infrequently and for which it is difficult to determine their quality either before or after purchase. Therefore, the transaction costs for obtaining and processing information on energy efficiency are higher than for energy supply. Without appropriate metering and sub-metering, it is difficult to assess and verify the benefits, making it much more challenging for decision makers to commit.

3.4.7.1 Road transport

Table 40 indicates that 7% can be abated from the transport sector at EU level at a cost of zero €/tCO2. These can be achieved with available technologies and practices. However, uptake and improvement of fuel economy performance is limited by several barriers, such as the expectations of individuals and companies about future energy prices, fuel availability, and government policies.

For many consumers, finance is a key issue. Energy efficient technologies can have high capital costs, which aligned to low fuel costs, and potentially longer payback periods may hinder the vehicle purchasing decisions.[110]

Linked to cost is consumer purchasing behaviour, and decisions on vehicle designs that emphasise convenience, style, and speed over fuel economy in automobiles and light duty trucks.[111] These have resulted in personal preferences overruling interest in economy-wide benefits. Generally, consumers choose to invest in these technologies, when they are convinced that energy price increases (or other factors that stimulate market demand, such as recharging/refuelling infrastructure for battery electric and fuel cell vehicles) will persist.[112]

Even when new or improved vehicle technologies are available on the market, behavioural barriers to purchase include safety concerns, reliability and durability concerns, as well as a lack of awareness. The lack of appropriate recharging or

---

[110] Kenneth S. Kurani, Automobile Buyer Decisions about Fuel Economy and Fuel Efficiency (2004). United States Department of Energy and Energy Foundation.

[111] ibid

[112] Real Prospects for Energy Efficiency in the United States (2010), Chapter: 3 Energy Efficiency in Transportation.

refuelling infrastructure for battery electric or fuel cell vehicles can be another barrier. For new technologies to reach a substantial fraction of vehicle sales usually takes more than a decade unless mandated by law or consumers clearly demand the new or improved technology.

The following table presents the range of barriers associated with different energy efficient technologies and practices

Table 43. Transport technologies and practices and related barriers to uptake

Transport technology or practice	**Barriers**
Battery EVs and Plug-in/ hybrid EVs	EV and battery costs reducing but still high. Lack of infrastructure, and recharging standards not uniform. Vehicle range anxiety.
CNG, LNG, CBG and LBG displacing gasoline in LDVs and diesel in HDVs.	Insufficient government programmes, conversion subsidies and local gas infrastructure and markets. Leakage of gas.
Biofuels displacing gasoline, diesel fuel.	Advanced biofuels (e.g., made of lignocellulosic feedstock) are expensive with production capacity limited. First-generation biofuels (i.e., cellulosic based) are environmentally poor and cause inequalities by inducing increases in food prices.
Improved vehicle ICE technologies and on-board information and communication technologies (ICT) in fuel efficient vehicles.	Insufficient regulatory support for vehicle emissions standards. On-road performance deteriorates compared with laboratory tests.
Modal shift by public transport displacing private motor vehicle use.	Availability of rail, bus, ferry, and other quality transit options. Density of people to allow more access to services. Levels of services and accessibility. Public perceptions.
Behavioural change from reducing private motor vehicle use through pricing policies, e.g., network charges and parking fees.	Political barriers due to perceived public opposition to increased pricing costs. Lack of administrative integration between transport, land-use and environment departments in city municipalities.
Behavioural change resulting from education to encourage gaining benefits of less motor vehicle use.	Lack of belief by politicians and professionals in the value of educational behaviour change programmes.

Source: IPCC (2018)

At a technology level, a barrier to rapid changes in the mix of LDV annual sales is the capacity of the automotive industry to change both power trains and platforms rapidly, across all models, and its ability to set up a high-volume supplier base in high-risk items such as high-energy-storage batteries. Furthermore, the vehicle design cycle can be 3–5 years if the change involves major new technologies or materials.

3.5 Question 2.2.1: Price elasticity of fuel demand and impact of a carbon price surcharge on fuel prices

This question is split into three parts: a brief literature review on price-elasticity of fuel demand in the two sectors, followed by a quantitative evaluation of price-elasticities based on the thorough data collection, and finally an assessment of how a carbon price could impact fossil fuel prices.

3.5.1 Literature review on price-elasticity of fuel demand

A brief literature review has been conducted to gather evidence on price elasticities of fuel demand in the sectors of interest. The objective of the literature review is to add a complementary source of data for the subsequent econometric assessment (section 3.5.2) in case non-significant results are achieved in some instances. The literature review has been conducted on 14 articles and reports published between 2012 and 2019, whose details are provided in section 7.

Numerous papers and reports exist in the literature providing price elasticities of energy demand, although they generally strongly differ in terms of the methodologies used (direct quantitative assessment, surveys), of the length of the historical time series considered (5 years, 10 years, 20+ years), of the geographical entities considered (individual countries, continents, global, averages) and on the sectors analysed. This diversity makes it very difficult to compare properly studies, as some are e.g. investigating elasticities to specific activity parameters (tkm, etc.) vs energy consumption, some are assessing average cross-sector elasticities (e.g. industry and residential together), which do not make it comparable with studies at the level of individual sectors, etc.

In this assessment, the focus has been set on available evidence in Europe, either as a whole and in individual Member States where data is available, and on the specific two sectors of interest for this study: road transport and buildings. No further disaggregation of the sub-sectors has been possible given the limited details available from the literature and the methodological propension of authors to attempt to provide the most robust information based on the highest possible number of observations.

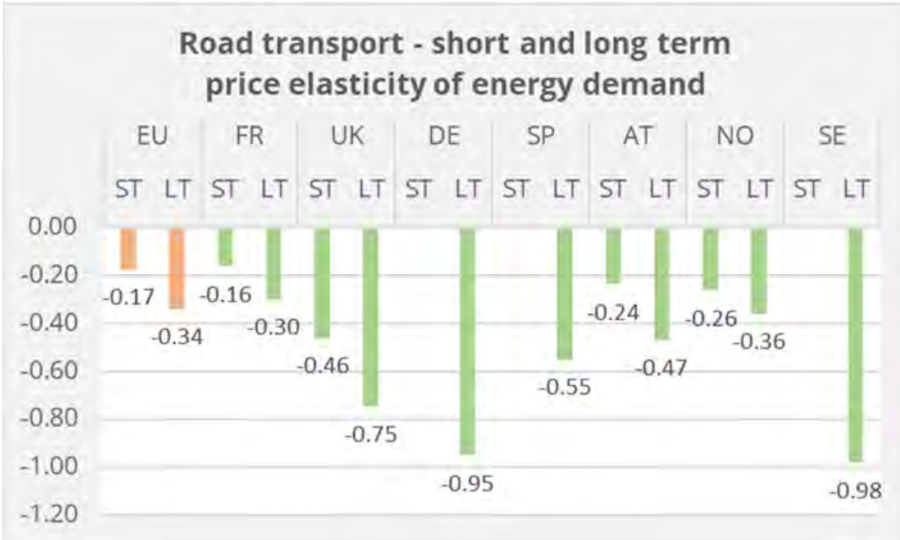
The literature study has been focusing on assessing price elasticities of *total energy consumption* in the sectors, as this is expected to provide the most useful benchmarking information for the purpose of the subsequent quantitative econometric assessment described further below: the first step of our approach is to estimate long-term elasticities of total energy consumption, so as to calculate the expected 2030 total energy consumption in an endogenous baseline scenario (see section 3.5.3 for a more detailed characterisation of the baseline scenario) without additional carbon price, before evaluating in a second step the likely impacts of carbon pricing, including those related to fuel switching, on the consumption of fossil fuels in the two sectors.[113]

In road transport (Figure 55), evidence could be gather both at EU level and for the following countries: France, United Kingdom, Germany, Spain, Austria, Norway and Sweden.

Results at EU level show that price elasticities of energy demand in road transport is -0.17 in average in the short-term and -0.34 in the long-term. However, important discrepancies may exist in the individual countries, like e.g. in Germany, where (Schade 2015) considers a long-term elasticity of -0.95 due to still untapped energy efficiency potentials of cars and potential improvements of alternative drive systems. Dunkerley (2014) made a thorough literature review and concludes that road traffic fuel price elasticities are within the narrow range [-0.1;-0.5].

[113] The baseline scenario used in sections 3.5 and 2.6 refers to an endogenous modelling scenario performed with the EnerNEO model. The EnerNEO model uses econometric relationships to dynamically calculate energy and emissions forecasts. The EUCO3232.5 scenario is not used since the objective is to assess the potential for energy efficiency and fuel switching as a response to carbon pricing only.

Figure 55. Literature review results of price elasticity of energy demand in road transport in Europe



Source: Own representation based on Delsaut 2014, Hössinger 2017, Labandeira 2017, Schade 2015, Thomas 2018

In the buildings sector (Figure 56), the information available from the literature is very limited as shown by the number of country values found. Still, results indicate that buildings' total energy consumption has a long-term price elasticity of -0.23 in average at the EU level, while figures available at country level are comprised in a range of -0.36 (Norway) to -0.5 (United Kingdom).

Figure 56. Literature review results of price elasticity of energy demand in buildings in Europe

Source: Own representation based on Charlier 2019, DECC 2016, Schulte 2016

Overall, the literature review shows limited information, e.g. it does not allow to retrieve precise data on price elasticities of energy demand in a more detailed sectoral breakdown that the two sectors road transport and buildings. However, the EU-level figures gathered in terms of long-term price elasticities of energy consumption, of -0.34 for the road transport sector and -0.23 for buildings, constitute a first indication, along with the country-level figures obtained.

Again, these figures from the literature are gathered here to complement outcomes of the following section (quantitative determination of price-elasticities) to be used for the subsequent calculation of baseline emissions and the impact of carbon pricing.

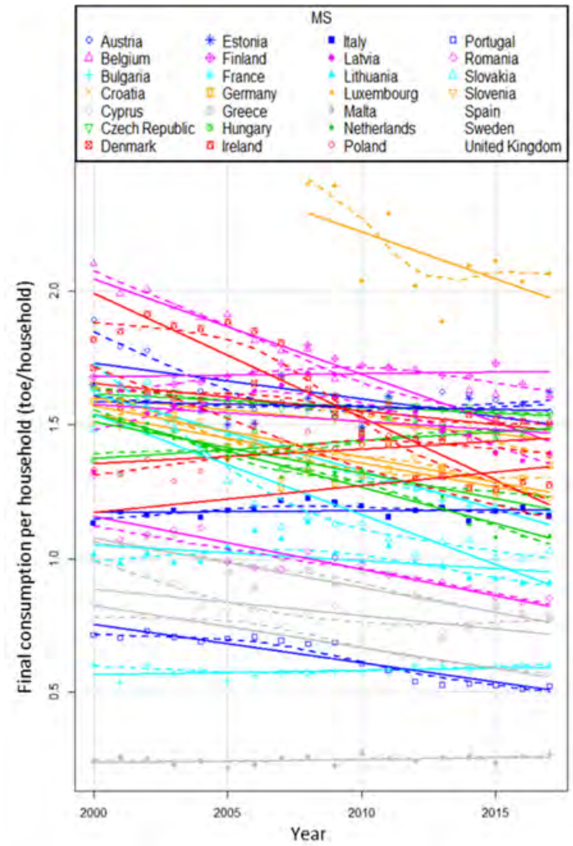
3.5.2 Quantitative determination of price-elasticities

An econometric assessment of historical data from Enerdata's Global Energy and CO_2 Database[114] complemented the elasticities gathered in the literature review. The econometric analysis was conducted using MS-Excel and R and focused on linear regression models, with a panel data analysis at the EU-level.

Panel data (also known as longitudinal or cross-sectional time-series data) includes behaviour of entities that are observed across time. Panel data allows to control for variables that cannot be observed or measured directly, like cultural factors or differences in business practices; or for variables that change over time but not across entities, like national policies. That is, it accounts for individual heterogeneity among panel entities. For this econometric study, the entities are Member States with observations of final consumption, number of vehicles, population, GDP, prices, etc. Because the same types of data are observed, but are grouped by Member State, panel data analysis for the complete EU dataset is the appropriate method to account for national differences. Figure 57 below graphically displays the panel data for residential final consumption per household.

[114] https://www.enerdata.net/research/energy-market-data-co2-emissions-database.html

Figure 57. Panel data of Member States (Final consumption per household)



Source: Enerdata

For each Member State, thermal and electricity demand was assessed using linear models based on several explanatory factors, including the lagged demand, macroeconomic activity variables, and energy prices. The *R* statistical software was used to perform the econometric analysis using the *plm*, *car*, and *lmtest* packages.

Like the analysis at the Member State-level, the EU analysis used linear models based on the same explanatory factors. To test different linear panel models, both fixed and random effects models were tested.

A Fixed-effects (least squares dummy variable) model explores the relationship between predictor and outcome variables within an entity. Each entity has its own individual characteristics that may or may not influence the predictor variables (for example, the political system of a country could have some effect on trade or GDP). An important assumption of the Fixed-effects model is that time-invariant characteristics are unique to the individual and should not be correlated with other individual characteristics. Each entity is different therefore the entity's error term and the constant (which captures individual characteristics) should not be correlated with the others. If the error terms are correlated, (i.e. the differences across entities have some influence on the dependent variable) then the Fixed-effects model is not suitable and an alternative, like random-effects, should be used. The Hausman test was used to confirm that a Fixed-effects model was appropriate for this analysis.

The objective of the econometric analysis was to transform the EnerNEO[115] demand equations to obtain the short-term and long-term effects of activity and price on energy demand. The standard form of demand equations in EnerNEO, which is based on a standard econometrics form, is:

$$ln\left(\frac{Y_n}{Y_{n-1}}\right) = a * ln\left(\frac{Activity_n}{Activity_{n-1}}\right) + b * ln\left(\frac{Price_n}{Price_{n-1}}\right) + c * ln\left(\frac{Y_{n-1}}{Y_{n-2}}\right)$$

Where:

Y is the demand variable
n is the target year being calculated
Activity is the activity driver variable for Y
Price is the average energy price associated with Y
a, b, and c are the model elasticities

The elasticities above can be interpreted as: *a* is the short-term activity, *b* is the short-term price, and *c* represents an inertia over time of the Y variable.

Based on the EnerNEO modelling, long-term elasticities (*a'* and b') are equal to:

$$a' = \frac{a}{1-c}$$

$$b' = \frac{b}{1-c}$$

The linear regression models found to have the best fit for the sectors analysed were:

Residential buildings

$$ln(PH\_FC_n) \sim a * ln(PH\_CONS_n) + b * ln(CP_n) + c * ln(PH\_FC_{n-1})$$

Where:

PH_FC is final energy consumption per household
PH_CONS is private consumption per household
CP is weighted-average price of energy in constant 2015 euros

Commercial buildings

$$ln(FC_n) \sim a * \ ln(VAD_n) + b * ln(CP_n) + c * ln(FC_{n-1})$$

Where:

FC is final energy consumption
VAD is valued added of the commercial sector
CP is weighted-average price of energy in constant 2015 euros

[115] EnerNEO is the MS-Excel energy model, developed by Enerdata, used in this study to assess the impact of carbon prices, see Question 2.2.2 for more details.

Transport-Private

Number of vehicles

$$ln(PC\_VEH_n) \sim a * ln(PC\_GDP_n) + c * ln(PC\_VEH_{n-1})$$

$$NEW\_VEH_{k,n} = (PC\_VEH_n * POP_n - REM\_VEH_n) * \frac{CC_{k,n}^{-e}}{\sum_1^j CC_{j,n}^{-e}}$$

Average consumption per vehicle

$$ln(AC_n) \sim b * ln(CP_n) + c * ln(AC_{n-1})$$

Where:

PC_VEH is number of vehicles per capita
PC_GDP is per capita Gross Domestic Product of the sector
POP is population
NEW_VEH is number of new vehicles by motor/fuel type
REM_VEH is number of remaining vehicles after retirement
CC is complete cost of vehicle by motor/fuel type
e reflects the sensitivity of the competition to cost
k is current motor/fuel type of **j** types
AC is average consumption per vehicle
CP is weighted-average price of energy in constant 2015 euros

Transport-Public/Freight

Number of vehicles

$$ln(VEH_n) \sim a * ln(GDP_n) + c * ln(VEH_{n-1})$$

$$NEW\_VEH_{k,n} = (VEH_n - REM\_VEH_n) * \frac{CC_{k,n}^{-e}}{\sum_1^j CC_{j,n}^{-e}}$$

Average consumption per vehicle

$$ln(AC_n) \sim b * ln(CP_n) + c * ln(AC_{n-1})$$

Where:

VEH is number of vehicles
GDP is Gross Domestic Product of the sector
NEW_VEH is number of new vehicles by motor/fuel type
REM_VEH is number of remaining vehicles after retirement
CC is complete cost of vehicle by motor/fuel type
e reflects the sensitivity of the competition to cost
k is current motor/fuel type of **j** types
AC is average consumption per vehicle
CP is weighted-average price of energy in constant 2015 euros

While all Member State-level data was tested using linear regression, the results were not considered robust across Member States. Often, only a few Member States had sufficient variation within their data to produce coefficients with good fit and significant results (determined by the p-value of the model). Due to this, only results from the linear panel regression models at EU-level were included in the final results. This means the same elasticity values were used for all Member States and for the EU.

The fitted coefficients from the linear panel regression models were used directly in the EnerNEO model as the elasticities in equations using the same predictor variables. The exception to this was for thermal and electricity demand in the residential sector. While the linear model based on historical private consumption per household had the best R^2 fit of the models tested, no forecast for this series was available. However, the year-on-year variation of historical private consumption per household and GDP per household were very similar. Since the EnerNEO equation is based on variation, the use of the GDP per household forecast was considered acceptable.

The results of the econometric analysis are included in Table 44 below. The coefficient values and R^2 values are shown for each linear regression model. A combination of coefficients from the econometric analysis and literature review were used as final values in the EnerNEO model. Literature values found to be robust and based on data appropriate to this analysis (i.e. similar perimeters of energy carriers and sectors) were given priority. Coefficients from the econometric analysis that had sufficient fit and had significant results were used to complement the literature values. For remaining sectors that did not have coefficients available, proxy values were used from sectors with similar attributes.

Table 44. Elasticity coefficients used in the EnerNEO forecast model

				Econometric					
				Coefficient	Model R^2	Literature	EnerNEO	Proxy value	Source
Residential	**Thermal**	**Activity**	**Short-term**	0.07	0.52		0.07		Econometric
			Long-term	0.17			0.17		Econometric
		Price	**Short-term**	-0.07			-0.09		Calculated
			Long-term	-0.17		-0.23	-0.23		Literature
		Inertia		0.61			0.61		Econometric
	Electricity	**Activity**	**Short-term**	0.18	0.56		0.10		Calculated
			Long-term	0.61			0.61		Econometric
		Price	**Short-term**	-0.05		-0.06	-0.06		Literature
			Long-term	-0.17		-0.38	-0.38		Literature
		Inertia		0.70		0.84	0.84		Literature
Services	**Thermal**	**Activity**	**Short-term**	0.10	0.26		0.10		Econometric
			Long-term	0.18			0.18		Econometric
		Price	**Short-term**	-0.11			-0.11		Econometric
			Long-term	-0.20			-0.20		Econometric
		Inertia		0.45			0.45		Econometric
	Electricity	**Activity**	**Short-term**	0.09	0.53		0.10	Res_Elec	Calculated
			Long-term	0.25			0.61	Res_Elec	Econometric
		Price	**Short-term**	0.03			-0.06	Res_Elec	Literature
			Long-term	0.09			-0.38	Res_Elec	Literature
		Inertia		0.63			0.84	Res_Elec	Literature
Transportation	**Cars - # of Vehicles**	**Activity**	**Short-term**	0.15	0.97		0.15		Econometric
			Long-term	1.10			1.10		Econometric
		Inertia		0.86			0.86		Econometric
	Cars - Consumption	**Price**	**Short-term**	-0.01	0.78	-0.17	-0.17		Literature
			Long-term	-0.10		-0.34	-0.34		Literature
		Inertia		0.92		0.49	0.49		Literature
	Buses - # of Vehicles	**Activity**	**Short-term**	0.06	0.97		0.06		Econometric
			Long-term	0.48			0.48		Econometric
		Inertia		0.87			0.87		Econometric
	Buses - Consumption	**Price**	**Short-term**	-0.02	0.56		-0.02		Econometric
			Long-term	-0.08			-0.08		Econometric
		Inertia		0.75			0.75		Econometric
	Freight - Vehicles	**Activity**	**Short-term**	0.13	0.97		0.13		Econometric
			Long-term	0.86			0.86		Econometric
		Inertia		0.85			0.85		Econometric
	Freight - Consumption	**Price**	**Short-term**	-0.08	0.80		-0.08		Econometric
			Long-term	-0.62			-0.62		Econometric
		Inertia		0.87			0.87		Econometric

Source: Enerdata

Note that some coefficients used in EnerNEO were re-calculated for the ratio between short-term and long-term parameters (inertia) to be the same for activity and price within a sub-sector. This reconciled the mixing of literature and econometric values.[116]

Some of the results in the elasticity assessment can appear counterintuitive; notably why do businesses, which should be cost minimising, have a smaller long-term price elasticity than households? This is the result of mixing literature and econometric values to use the most reliable data in the analysis. Because the econometric results for residential thermal did not have a statistically significant result, we feel these results cannot be relied on and the literature assessment value is seen as more robust. Even though this means the long-term elasticity for residential is larger than the value for services, the short-term values are intuitive relative to each other and these values play a more direct role in the EnerNEO model. Despite the contradiction between residential and commercial elasticities, we feel this approach is grounded in the most reliable data available.

Similarly, we have used a literature value for personal cars since the econometric determination for personal vehicles did not have statistically significant results. The best literature values available are from studies looking at total road transport energy use and do not separate personal and freight vehicles (Delsaut 2014, Thomas 2018). By using the available literature values for personal vehicles and econometric values for freight vehicles and buses in the EnerNEO model, we have implicitly used relative elasticities that are counterintuitive (more elastic for personal vehicles). Despite this contradiction between elasticities for different road vehicle classes, we feel that assessing each class independently in the EnerNEO model using differentiated investment costs, fuel uses, and activity drivers, rather than modelling total road transport, outweighs the shortcomings of the relative differences in price elasticities.

While the combined set of coefficients is taken from multiple sources and the econometric values are based on a limited range of years (2000-2017), the results were found to be coherent and within the range of results from similar studies (see the literature review above).

And while elasticities based on past observed actions may not perfectly represent future investment behaviour related to prices, we feel confident that consumer behaviour will change less than other factors included in the model (e.g. available technologies and energy prices). Since there is little evidence to inform how future investment behaviour might change, we think it is reasonable to maintain constant elasticities in the modelling and focus instead on the policies which could influence investment decisions.

3.5.3 Impact of a carbon price on fossil fuel prices

The Global Energy and CO_2 Database, developed by Enerdata, was first used to analyse the levels of historical fuel prices, including applicable Member State taxes. These prices form the starting point for the EnerNEO baseline forecast to 2030. The key features of the baseline forecast include:

1) Historical energy consumption and emissions by fuel type from Enerdata's Odyssee database and Global Energy and CO_2 Database, which are based on statistics from Eurostat, IEA and individual Member States;

[116] The inertia parameter represents the stability of energy use over time or auto-correlation with energy use in previous years. Since the inertia parameter relates short-term and long-term elasticities, it allows the EnerNEO model to capture short-term price and activity effects as well as broader long-term trends over time even though the long-term elasticity is not explicitly included in the model equations.

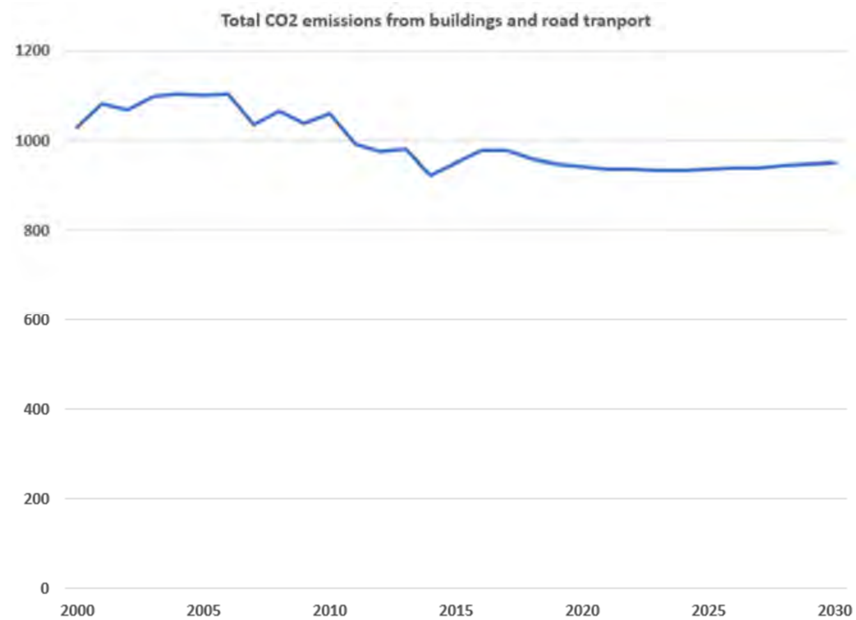
2) Fuel price forecasts follow the evolutions of international commodity prices: Brent crude oil, NG spot price, Coal price, Average electricity price for each Member State or the average for the EU;
3) Trends in energy efficiency and vehicle ownership from the POLES model database;
4) Forecasts of Population (UN), GDP (IMF and CEPII), number of households (POLES model database), and value added of the commercial sector (POLES model database); and
5) Investment costs for vehicles from the POLES model database.

International commodity prices are the main driver for forecast fuel prices. The commodity price forecasts show the following variation over the period 2020 to 2030 (the modelling period):

- Brent crude oil: -3%
- Natural gas spot: +13%
- Coal: -11%
- EU average electricity: -3%

The EnerNEO baseline forecast corresponds to a “frozen policy” scenario, in which policy measures in place are continued but no additional climate effort is made after 2018 compared to historical trends. This baseline does not include any carbon price and leads to the CO_2 emission trajectory displayed on the Figure 58. In this section and section 3.6, the EUCO3232.5 scenario is not used. The baseline used does not account for any planned policies beyond 2018 (e.g. CO_2 standards after 2020, Clean Vehicle Directive, Alternative Fuels Directive) since the objective is to assess the potential for energy efficiency and fuel switching as a response to carbon pricing only.

Figure 58. Total CO_2 emissions from fuel combustion in buildings and road transport in the EnerNEO baseline



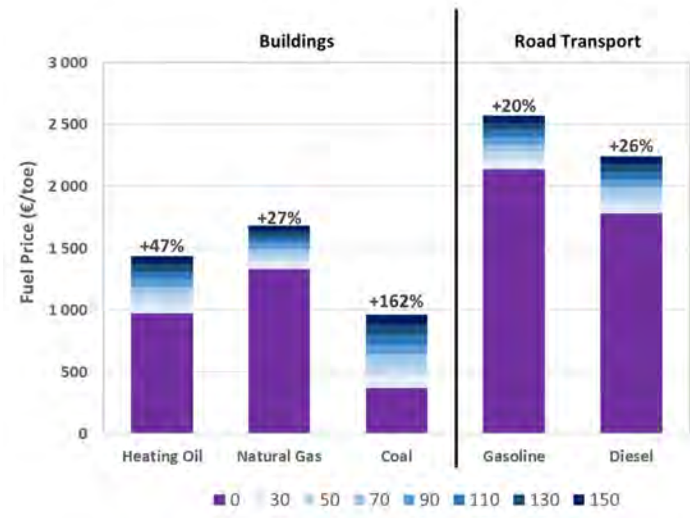
Source: Enerdata

The impact of a carbon price on fuel prices is related to the carbon content of fossil fuels and the relative price differential to electricity and biofuels. In the EnerNEO modelling, specific electricity uses (which are not impacted by the carbon price sensitivity) are considered separately from the energy consumption for thermal uses (which is impacted by the sensitivity). This allows for the determination of the precise impact of the carbon price on energy consumption in the buildings sector (which would have been less robust without the distinction between end-use types).

In the long-term to 2030, the relative fossil fuel, electricity, and biofuel prices shift as the carbon price increases over time and within the sensitivity (from €0/tCO_2 to €150/tCO_2). Below, Figure 59 shows the effects of the carbon price sensitivity on fuels in the buildings and road transport sectors in the EU in 2030; baseline prices are shown in purple and the increasing carbon prices from the sensitivity analysis are shown in blue (light to dark for increasing carbon prices). All prices are shown are for end users, include relevant taxes (i.e. excise duties and VAT) and are shown in €/toe for comparison. Taxes and levies, including carbon pricing, are assumed to fully pass through to consumers.

Domestic fuel prices are historical values up to 2017 and then follow the evolution of international prices (Brent crude oil, Rotterdam natural gas spot price, European coal export price). The year-on-year variation of international prices is applied to domestic prices including taxes. The forecasts of international prices come from Enerdata's EnerBlue central scenario, an NDC-compatible scenario elaborated with the POLES-Enerdata model.

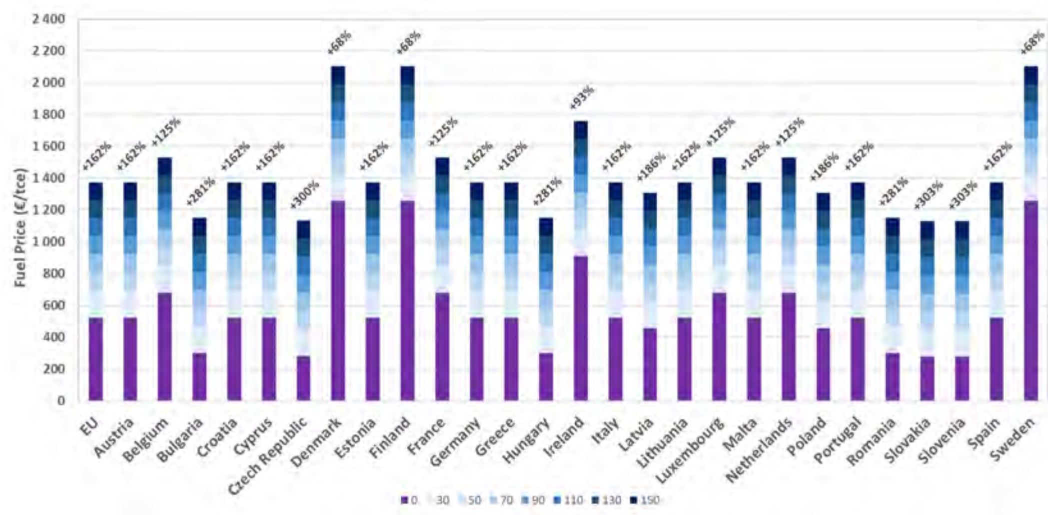
Figure 59. Baseline 2030 EU fuel prices and carbon price impacts in the buildings and road transport sectors



Below, Figure 60, Figure 61 and Figure 62 show the effects of the carbon price sensitivity on coal, natural gas and heating oil prices in the buildings sector in 2030 by Member State. At the largest carbon price considered, €150/tCO_2, coal prices in EU Member States increase by 68%-303%, depending on the baseline price. Natural gas prices increase by much more moderate amounts in the range of 16%-59%. Oil prices in the buildings sector shift by similar amounts as natural gas. The effects of these changes are to make coal less competitive relative to other fossil fuels, and all fossil fuels less competitive versus electricity and biofuels.

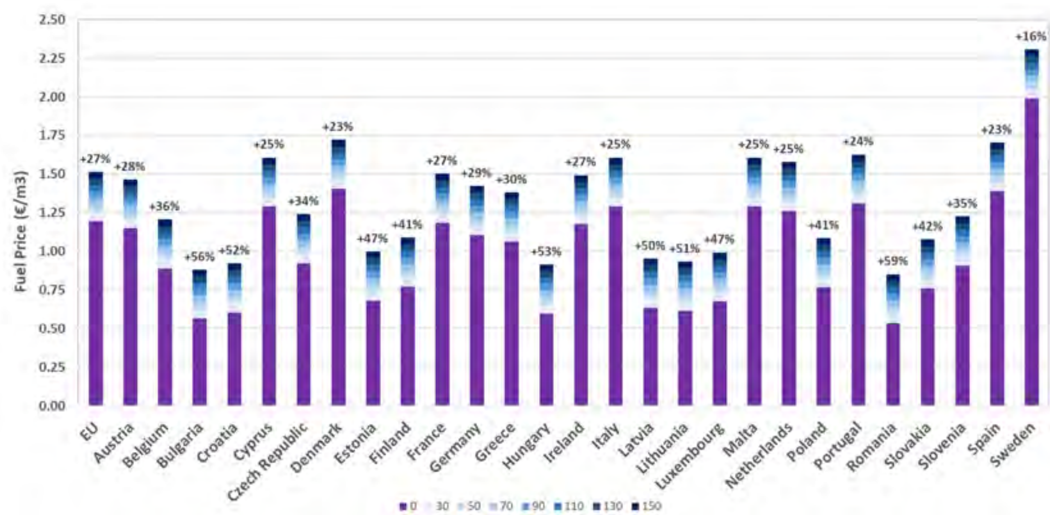
All prices shown are for end users, include relevant taxes (i.e. excise duties and VAT) and are shown in €/toe for comparison. Taxes and levies, including carbon pricing, are assumed to fully pass through to consumers.

Figure 60. Baseline 2030 coal prices and carbon price impacts



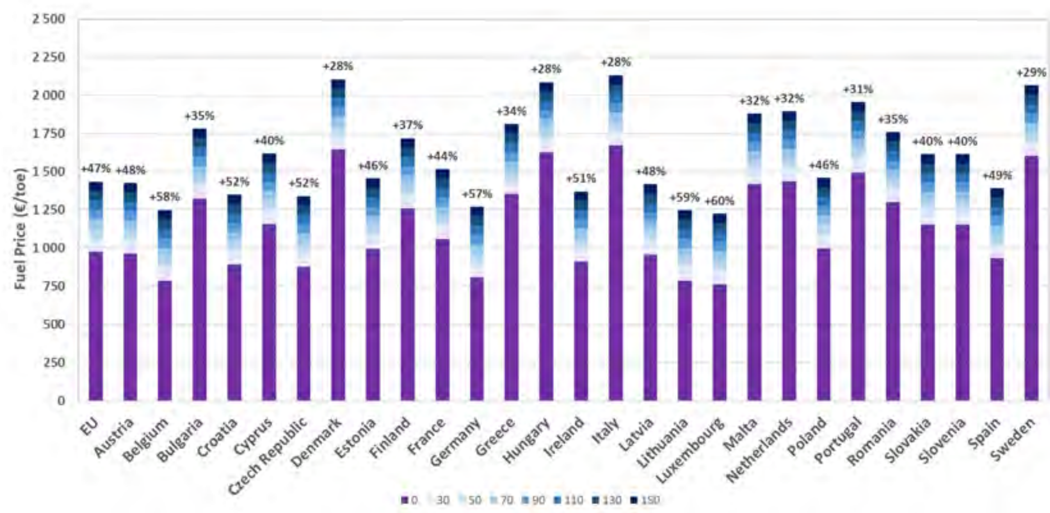
Source: Enerdata

Figure 61. Baseline 2030 natural gas prices and carbon price impacts



Source: Enerdata

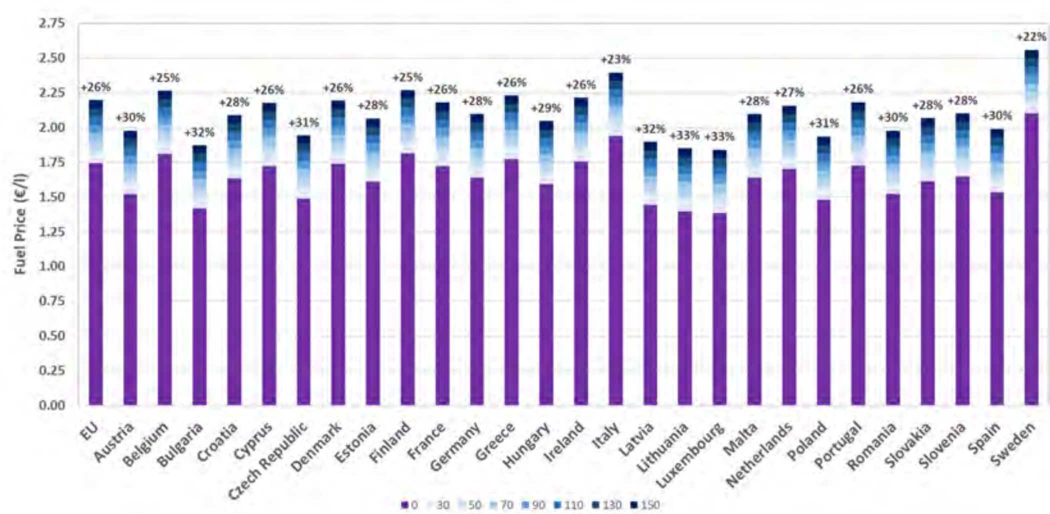
Figure 62. Baseline 2030 heating oil prices and carbon price impacts



Diesel and gasoline prices in the road transport sector increase by amounts that are more similar across Member States than in the buildings sector. Here, increases are in the range of 19%-27% for gasoline and 22%-33% for diesel, shown below in Figure 63. Again, the carbon price makes gasoline and diesel less competitive relative to electricity and biofuels.

All prices shown are for end users, include relevant taxes (i.e. excise duties and VAT) and are shown in €/toe for comparison. Taxes and levies, including carbon pricing, are assumed to fully pass through to consumers.

Figure 63. Baseline 2030 diesel prices and carbon price impacts



Source: Enerdata

3.6 Question 2.2.2: Impact of a carbon price on fossil fuels use

Findings from the previous questions were used to perform an impact assessment of various carbon prices on energy consumption, fuel prices, and achievable abatement in the buildings and road transport sectors.

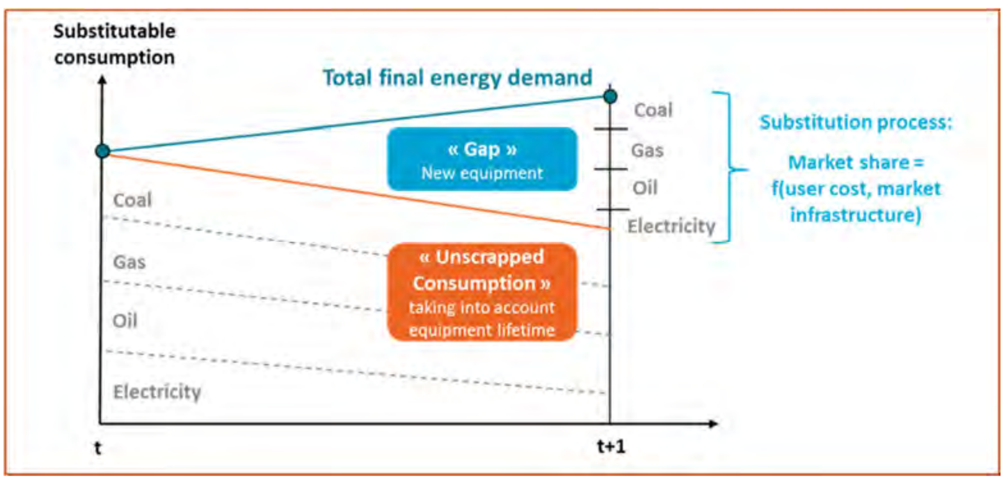
3.6.1 Methodology

In the first step, a baseline scenario was calculated for the two sectors using an MS-Excel model, EnerNEO, and findings from Question 2.1.a (historical energy use in buildings and road transport). This baseline scenario determined the expected evolution up to 2030 of energy consumption in the absence of an additional carbon price in these sectors. The main features of this baseline, including the corresponding CO_2 emission trajectory are presented in Section 3.5.3 above.

Then, in a second step, the Excel model and the findings from Question 2.2.1 (sensitivity of fuel demand to a carbon price surcharge) were used to calculate the energy savings achievable at a given level of carbon taxation by comparing each carbon price in 2030 to the baseline scenario. Carbon prices at steps of €20/tCO_2 were evaluated from €30/tCO_2 to €150/tCO_2. In the results below, a sample of outputs are provided to cover the range of the carbon prices considered.

The EnerNEO model is based on a realistic representation of energy using equipment and stock turnover.[117] To calculate the market shares of new equipment, a total energy demand envelop is first determined based on activity variables and energy prices. Then, after accounting for distributed energy supply (e.g. rooftop solar PV) and equipment stock remaining from previous years, the new energy demand is calculated (see Figure 64; illustrative figure of EnerNEO's equipment stock turnover methodology, not necessarily displaying all fuels/technologies used in the model).

Figure 64. Illustrative representation of EnerNEO new equipment stock calculation methodology



Source: Enerdata

This energy demand "gap" is filled with new equipment based on a standard market share equation.

[117] An 8% discount rate for equipment investment is applied in EnerNEO and POLES, which is within the range of conventional values used in energy system modelling. 8% corresponds to an average rate available in a low to middle risk environment. The IEA report *Projected Costs of Generating Electricity* uses 7% as the rate faced by a private investor in a low-risk technological option and favourable market environment, and 10% for higher financial, technological and price risks.

$$Market\ Share_v = \frac{A_v * C_v^e}{\sum_{v'} A_{v'} * C_{v'}^e}$$

Where:

A is an infrastructure coefficient, which includes all the non-economic effects in the competition and is based on calibration to historical data
C is the total final user cost (including taxes) and includes investment cost and fuel cost
e is a parameter which reflects the sensitivity of the competition to cost

The detailed modelling included in the EnerNEO model allows for energy-using equipment to respond over time to changes in energy prices, notably due to increases in the carbon price. Demand can respond to increased fuel prices through reduced consumption, for example by reducing total energy demand through efficiency measures or by adopting more energy efficient equipment to meet demand. Energy-using equipment can also respond to changes in energy price differentials that are induced through a carbon price. These equipment changes result in fuel switching, for example by decreased coal use in favour of natural gas to provide the same energy use.

The EnerNEO model is based on aggregate econometric equations and therefore contains a limited direct representation of specific technologies. In the buildings sector, EnerNEO distinguishes between fuel types including oil, natural gas, coal, substitutable and captive electricity and bioenergy. Solar heat and district energy are included but as exogenous forecasts (see below).

In the road transport sector, a similar approach is used to econometrically model technologies. Motor and fuel types are combined into aggregate “technologies” which include gasoline, diesel, liquified petroleum gas, ethanol, biodiesel, electricity, and natural gas. Technology costs are from the POLES-Enerdata model and represent conservative estimates of future cost decline. While explicit modelling of policies/actions beyond investment, variable and fuel costs by technology are not included in the EnerNEO model, considerations like the availability of charging and fuelling infrastructure, bioenergy supply, and competing electricity uses are considered in the POLES-Enerdata model that provides technology costs.

Note that the EnerNEO model does not explicitly account for modal shift in the transport sector. Passenger transport is covered by the personal and public transport sub-sectors, which each have an econometric relationship to income and population. While vehicle fleet size and average annual consumption per vehicle are endogenous variables of the model, kilometres travelled are not explicitly modelled, which prevents any explicit representation of modal shift between private and public sub-sectors. Freight transport also does not include modal shift because only road freight is included in the EnerNEO model; air, rail and maritime freight are not modelled.

EnerNEO accounts for existing vehicle emissions standards through historical energy consumption data but does not explicitly include policies on increased emission standards.

Note that district heating is included in the EnerNEO model, but since its implementation is tied to many drivers other than price (e.g. regulatory decisions on building development), its forecast is set exogenously and not directly the result of price feedbacks. Bioenergy is partially set in a similar manner: the base forecast for the share of biofuels in transportation fuel is an exogenous assumption derived from the POLES-Enerdata model and EnerFuture scenarios (6% in 2017 and 11.5% in 2030). For the calculation of MAC curves, even though a price feedback is included in EnerNEO to provide an endogenous response to fuel price changes, the model results for the highest carbon price (150 €/tCO_2) show a very limited additional development of bioenergy (12% in 2030), illustrating that bioenergy does not necessarily become competitive through a price signal alone over a 10-year period, but rather depends on regulatory blending shares. Emissions covered by EnerNEO are CO_2 emissions from fuel combustion. These are derived in the model from energy consumptions and IPCC emission factors, which make the results coherent with the historical figures provided in Question 2.1a: Analysis of energy use in road transport and buildings.

3.6.2 Impact on energy consumption

Table 45 to Table 51 provide the results in the buildings and road transport sectors, respectively, for the total energy consumption in 2030 and the reductions at each level of carbon price.

In the buildings sector, Member States see a maximum reduction in total energy use at €150/tCO_2 ranging from the low end at less than 1% (e.g. Sweden) to the high end at over 4% (e.g. Luxembourg and Slovakia). Poland has the highest reduction in buildings energy use at 6.4%, largely to reduced coal use. Generally, the countries with higher fuel prices before adding the carbon tax see the lowest reductions. Due to a smaller percentage increase in the final user price the impact which is felt by the consumer of adding the carbon price is smaller.

Table 45. Total energy consumption and energy savings relative to baseline by carbon price in buildings in 2030

	Total energy consumption (Mtoe)	Reduction (Mtoe)				Reduction (%)			
	Carbon price (€/tCO2)								
	0	30	50	90	150	30	50	90	150
European Union	375.0	2.8	4.6	7.7	12.0	0.8%	1.2%	2.1%	3.2%
Austria	9.6	0.1	0.1	0.2	0.3	0.6%	1.0%	1.8%	2.7%
Belgium	12.3	0.1	0.2	0.3	0.5	1.0%	1.6%	2.8%	4.3%
Bulgaria	3.4	0.0	0.0	0.0	0.1	0.5%	0.7%	1.2%	1.9%
Croatia	3.1	0.0	0.0	0.1	0.1	0.7%	1.1%	1.8%	2.8%
Cyprus	0.7	0.0	0.0	0.0	0.0	0.5%	0.8%	1.4%	2.2%
Czech Republic	10.6	0.1	0.2	0.3	0.4	1.0%	1.5%	2.6%	4.0%
Denmark	7.4	0.0	0.0	0.1	0.1	0.3%	0.5%	0.9%	1.4%
Estonia	1.3	0.0	0.0	0.0	0.0	0.4%	0.7%	1.2%	1.9%
Finland	7.5	0.0	0.0	0.1	0.1	0.3%	0.5%	0.9%	1.4%
France	58.9	0.3	0.5	0.9	1.4	0.6%	0.9%	1.6%	2.4%
Germany	84.4	0.7	1.2	2.1	3.2	0.9%	1.4%	2.5%	3.8%
Greece	6.6	0.0	0.1	0.1	0.1	0.5%	0.8%	1.4%	2.1%
Hungary	9.1	0.1	0.1	0.2	0.4	1.0%	1.6%	2.6%	4.0%
Ireland	4.2	0.0	0.1	0.1	0.2	0.9%	1.4%	2.5%	3.8%
Italy	49.7	0.3	0.5	0.8	1.3	0.6%	1.0%	1.7%	2.6%
Latvia	1.8	0.0	0.0	0.0	0.0	0.6%	1.0%	1.8%	2.7%
Lithuania	2.1	0.0	0.0	0.0	0.1	0.7%	1.1%	1.9%	2.9%
Luxembourg	1.1	0.0	0.0	0.0	0.1	1.1%	1.8%	3.1%	4.8%
Malta	0.2	0.0	0.0	0.0	0.0	0.3%	0.5%	0.9%	1.4%
Netherlands	15.6	0.1	0.2	0.3	0.5	0.7%	1.1%	1.9%	3.0%
Poland	27.4	0.4	0.7	1.2	1.8	1.6%	2.6%	4.3%	6.4%
Portugal	4.4	0.0	0.0	0.0	0.1	0.4%	0.6%	1.0%	1.5%
Romania	10.0	0.1	0.2	0.3	0.4	1.0%	1.6%	2.7%	4.1%
Slovakia	3.6	0.0	0.1	0.1	0.2	1.1%	1.7%	2.9%	4.3%
Slovenia	1.7	0.0	0.0	0.0	0.0	0.5%	0.9%	1.5%	2.2%
Spain	26.5	0.1	0.2	0.4	0.6	0.5%	0.8%	1.4%	2.2%
Sweden	11.6	0.0	0.0	0.0	0.1	0.1%	0.2%	0.4%	0.6%

Source: Enerdata

Table 46. Total energy consumption and energy savings relative to baseline by carbon price in residential buildings in 2030

	Total energy consumption (Mtoe)	Reduction (Mtoe)				Reduction (%)			
	Carbon price (€/tCO2)								
	0	30	50	90	150	30	50	90	150
European Union	242.7	2.1	3.4	5.7	8.9	0.9%	1.4%	2.4%	3.7%
Austria	7.0	0.0	0.1	0.1	0.2	0.7%	1.2%	2.0%	3.1%
Belgium	7.4	0.1	0.1	0.2	0.4	1.2%	1.9%	3.2%	5.0%
Bulgaria	2.2	0.0	0.0	0.0	0.0	0.5%	0.8%	1.4%	2.2%
Croatia	2.3	0.0	0.0	0.0	0.1	0.7%	1.1%	1.9%	2.9%
Cyprus	0.4	0.0	0.0	0.0	0.0	0.6%	1.0%	1.8%	2.7%
Czech Republic	7.2	0.1	0.1	0.2	0.3	1.1%	1.7%	2.8%	4.3%
Denmark	5.3	0.0	0.0	0.0	0.1	0.3%	0.5%	0.9%	1.4%
Estonia	0.9	0.0	0.0	0.0	0.0	0.4%	0.6%	1.0%	1.6%
Finland	4.5	0.0	0.0	0.0	0.1	0.3%	0.5%	0.8%	1.3%
France	37.7	0.2	0.4	0.6	1.0	0.6%	0.9%	1.6%	2.6%
Germany	53.5	0.6	0.9	1.5	2.4	1.0%	1.7%	2.9%	4.4%
Greece	4.4	0.0	0.0	0.1	0.1	0.6%	1.0%	1.7%	2.7%
Hungary	6.7	0.1	0.1	0.2	0.3	0.9%	1.5%	2.6%	4.0%
Ireland	2.6	0.0	0.0	0.1	0.1	1.1%	1.7%	2.9%	4.5%
Italy	32.5	0.2	0.4	0.6	1.0	0.7%	1.1%	1.9%	3.0%
Latvia	1.2	0.0	0.0	0.0	0.0	0.7%	1.1%	1.8%	2.8%
Lithuania	1.4	0.0	0.0	0.0	0.0	0.7%	1.1%	1.9%	2.9%
Luxembourg	0.6	0.0	0.0	0.0	0.0	1.4%	2.3%	3.8%	5.9%
Malta	0.1	0.0	0.0	0.0	0.0	0.3%	0.5%	0.9%	1.5%
Netherlands	8.9	0.1	0.1	0.2	0.3	0.8%	1.3%	2.2%	3.4%
Poland	19.4	0.4	0.6	1.0	1.5	2.0%	3.1%	5.2%	7.8%
Portugal	2.3	0.0	0.0	0.0	0.0	0.4%	0.7%	1.2%	1.9%
Romania	7.8	0.1	0.1	0.2	0.3	1.0%	1.7%	2.8%	4.3%
Slovakia	2.4	0.0	0.0	0.1	0.1	1.2%	1.9%	3.1%	4.8%
Slovenia	1.1	0.0	0.0	0.0	0.0	0.6%	0.9%	1.5%	2.3%
Spain	15.4	0.1	0.1	0.3	0.4	0.6%	1.0%	1.6%	2.6%
Sweden	7.4	0.0	0.0	0.0	0.0	0.1%	0.2%	0.4%	0.6%

Source: Enerdata

Table 47. Total energy consumption and energy savings relative to baseline by carbon price in commercial buildings in 2030

	Total energy consumption (Mtoe)	Reduction (Mtoe)				Reduction (%)			
	Carbon price (€/tCO2)								
	0	30	50	90	150	30	50	90	150
European Union	132.3	0.7	1.2	2.0	3.1	0.6%	0.9%	1.5%	2.3%
Austria	2.6	0.0	0.0	0.0	0.0	0.4%	0.7%	1.2%	1.8%
Belgium	4.9	0.0	0.1	0.1	0.2	0.8%	1.3%	2.1%	3.3%
Bulgaria	1.2	0.0	0.0	0.0	0.0	0.3%	0.5%	0.9%	1.3%
Croatia	0.8	0.0	0.0	0.0	0.0	0.6%	0.9%	1.6%	2.4%
Cyprus	0.2	0.0	0.0	0.0	0.0	0.3%	0.4%	0.7%	1.1%
Czech Republic	3.4	0.0	0.0	0.1	0.1	0.8%	1.2%	2.0%	3.1%
Denmark	2.1	0.0	0.0	0.0	0.0	0.3%	0.4%	0.8%	1.2%
Estonia	0.4	0.0	0.0	0.0	0.0	0.6%	1.0%	1.7%	2.5%
Finland	3.0	0.0	0.0	0.0	0.0	0.3%	0.6%	1.0%	1.5%
France	21.2	0.1	0.2	0.3	0.5	0.5%	0.8%	1.4%	2.3%
Germany	30.9	0.2	0.3	0.5	0.8	0.6%	1.0%	1.8%	2.7%
Greece	2.2	0.0	0.0	0.0	0.0	0.2%	0.4%	0.7%	1.0%
Hungary	2.4	0.0	0.0	0.1	0.1	1.0%	1.6%	2.8%	4.2%
Ireland	1.5	0.0	0.0	0.0	0.0	0.6%	1.0%	1.6%	2.6%
Italy	17.2	0.1	0.1	0.2	0.3	0.5%	0.8%	1.3%	2.0%
Latvia	0.7	0.0	0.0	0.0	0.0	0.6%	1.0%	1.7%	2.6%
Lithuania	0.7	0.0	0.0	0.0	0.0	0.7%	1.1%	1.8%	2.8%
Luxembourg	0.5	0.0	0.0	0.0	0.0	0.8%	1.3%	2.2%	3.4%
Malta	0.1	0.0	0.0	0.0	0.0	0.3%	0.5%	0.9%	1.3%
Netherlands	6.7	0.0	0.1	0.1	0.2	0.5%	0.9%	1.5%	2.3%
Poland	8.0	0.1	0.1	0.2	0.3	0.8%	1.2%	2.1%	3.2%
Portugal	2.1	0.0	0.0	0.0	0.0	0.3%	0.4%	0.7%	1.1%
Romania	2.2	0.0	0.0	0.0	0.1	0.8%	1.3%	2.2%	3.4%
Slovakia	1.3	0.0	0.0	0.0	0.0	0.9%	1.4%	2.3%	3.5%
Slovenia	0.6	0.0	0.0	0.0	0.0	0.5%	0.8%	1.4%	2.1%
Spain	11.1	0.0	0.1	0.1	0.2	0.4%	0.6%	1.0%	1.6%
Sweden	4.2	0.0	0.0	0.0	0.0	0.2%	0.3%	0.5%	0.8%

Source: Enerdata

In the road transport sector, maximum reductions in total energy use at €150/tCO_2 range from less than 6% (Greece and Italy) up to over 8% (Lithuania and Poland), with an even distribution of reductions between these end values. These differences in reduction potentials are driven by the amount of fossil fuels used in the baseline scenario and the fuel prices excluding carbon pricing. Countries with large amounts of gasoline and diesel used in the baseline and low prices for these fuels achieve the largest reductions under carbon pricing and vice versa for countries with smaller amounts used and higher prices.

Table 48. Total energy consumption and energy savings relative to baseline by carbon price in road transport in 2030

	Total energy consumption (Mtoe)	Reduction (Mtoe)				Reduction (%)			
	Carbon price (€/tCO2)								
	0	30	50	90	150	30	50	90	150
European Union	187.7	2.4	4.5	8.1	13.0	1.3%	2.4%	4.3%	6.9%
Austria	4.7	0.1	0.1	0.2	0.4	1.5%	2.7%	4.8%	7.7%
Belgium	5.4	0.1	0.1	0.2	0.4	1.2%	2.2%	4.1%	6.5%
Bulgaria	1.9	0.0	0.0	0.1	0.2	1.0%	2.5%	4.7%	7.7%
Croatia	1.9	0.0	0.0	0.1	0.1	1.2%	2.4%	4.4%	7.2%
Cyprus	0.7	0.0	0.0	0.0	0.0	1.0%	2.2%	4.1%	6.7%
Czech Republic	5.3	0.1	0.1	0.3	0.4	1.4%	2.6%	4.8%	7.6%
Denmark	3.2	0.0	0.1	0.1	0.2	1.3%	2.2%	4.0%	6.3%
Estonia	0.7	0.0	0.0	0.0	0.0	1.3%	2.4%	4.3%	7.0%
Finland	2.7	0.0	0.1	0.1	0.2	1.1%	2.1%	3.8%	6.1%
France	26.3	0.4	0.6	1.1	1.8	1.4%	2.4%	4.2%	6.8%
Germany	47.3	0.6	1.1	2.0	3.2	1.2%	2.3%	4.1%	6.7%
Greece	3.7	0.0	0.1	0.1	0.2	0.8%	1.8%	3.4%	5.5%
Hungary	2.8	0.0	0.1	0.1	0.2	1.3%	2.5%	4.4%	7.1%
Ireland	2.7	0.0	0.1	0.1	0.2	1.3%	2.4%	4.2%	6.7%
Italy	17.1	0.2	0.3	0.6	1.0	0.9%	1.9%	3.5%	5.8%
Latvia	0.8	0.0	0.0	0.0	0.1	1.6%	2.8%	5.0%	7.9%
Lithuania	1.5	0.0	0.0	0.1	0.1	1.5%	2.8%	5.1%	8.1%
Luxembourg	1.4	0.0	0.0	0.1	0.1	0.5%	2.2%	4.6%	7.8%
Malta	0.2	0.0	0.0	0.0	0.0	1.3%	2.3%	4.0%	6.4%
Netherlands	6.5	0.1	0.1	0.3	0.4	1.3%	2.2%	3.9%	6.2%
Poland	13.5	0.2	0.4	0.7	1.1	1.7%	3.0%	5.3%	8.3%
Portugal	3.0	0.0	0.1	0.1	0.2	1.5%	2.4%	4.2%	6.6%
Romania	4.0	0.1	0.1	0.2	0.3	1.4%	2.5%	4.4%	7.1%
Slovakia	1.5	0.0	0.0	0.1	0.1	0.6%	2.0%	3.9%	6.6%
Slovenia	1.5	0.0	0.0	0.1	0.1	1.3%	2.5%	4.5%	7.3%
Spain	21.7	0.3	0.6	1.1	1.7	1.4%	2.7%	4.9%	7.8%
Sweden	5.5	0.1	0.1	0.2	0.3	1.1%	2.1%	3.7%	5.9%

Source: Enerdata

Table 49. Total energy consumption and energy savings relative to baseline by carbon price in private road transport in 2030

	Total energy consumption (Mtoe)	Reduction (Mtoe)				Reduction (%)			
	Carbon price (€/tCO2)								
	0	30	50	90	150	30	50	90	150
European Union	150.3	2.4	3.8	6.7	10.5	1.6%	2.6%	4.4%	7.0%
Austria	4.1	0.1	0.1	0.2	0.3	1.8%	2.9%	5.0%	7.8%
Belgium	4.4	0.1	0.1	0.2	0.3	1.5%	2.4%	4.2%	6.6%
Bulgaria	1.0	0.0	0.0	0.1	0.1	1.9%	3.1%	5.3%	8.3%
Croatia	1.5	0.0	0.0	0.1	0.1	1.6%	2.7%	4.6%	7.3%
Cyprus	0.5	0.0	0.0	0.0	0.0	1.5%	2.4%	4.2%	6.7%
Czech Republic	3.8	0.1	0.1	0.2	0.3	1.8%	2.9%	5.0%	7.9%
Denmark	2.8	0.0	0.1	0.1	0.2	1.4%	2.4%	4.1%	6.5%
Estonia	0.6	0.0	0.0	0.0	0.0	1.6%	2.6%	4.5%	7.1%
Finland	2.2	0.0	0.0	0.1	0.1	1.4%	2.3%	4.0%	6.3%
France	23.4	0.4	0.6	1.0	1.6	1.5%	2.5%	4.3%	6.8%
Germany	37.4	0.6	0.9	1.6	2.5	1.5%	2.5%	4.3%	6.7%
Greece	2.4	0.0	0.0	0.1	0.1	1.2%	2.0%	3.4%	5.5%
Hungary	2.2	0.0	0.1	0.1	0.2	1.6%	2.7%	4.6%	7.3%
Ireland	2.4	0.0	0.1	0.1	0.2	1.5%	2.5%	4.3%	6.8%
Italy	12.2	0.2	0.3	0.5	0.7	1.3%	2.1%	3.7%	5.9%
Latvia	0.7	0.0	0.0	0.0	0.1	1.9%	3.0%	5.2%	8.2%
Lithuania	1.1	0.0	0.0	0.1	0.1	1.9%	3.1%	5.4%	8.4%
Luxembourg	0.3	0.0	0.0	0.0	0.0	1.8%	2.9%	5.0%	7.9%
Malta	0.1	0.0	0.0	0.0	0.0	1.5%	2.5%	4.3%	6.8%
Netherlands	6.2	0.1	0.1	0.2	0.4	1.4%	2.3%	3.9%	6.2%
Poland	12.0	0.2	0.4	0.7	1.0	1.9%	3.2%	5.4%	8.5%
Portugal	2.9	0.0	0.1	0.1	0.2	1.5%	2.5%	4.3%	6.7%
Romania	3.1	0.1	0.1	0.2	0.2	1.7%	2.8%	4.8%	7.6%
Slovakia	0.6	0.0	0.0	0.0	0.0	1.6%	2.6%	4.4%	7.0%
Slovenia	1.2	0.0	0.0	0.1	0.1	1.6%	2.7%	4.6%	7.3%
Spain	16.5	0.3	0.5	0.8	1.3	1.8%	2.9%	5.0%	7.9%
Sweden	4.7	0.1	0.1	0.2	0.3	1.3%	2.2%	3.8%	6.0%

Source: Enerdata

Table 50. Total energy consumption and energy savings relative to baseline by carbon price in public road transport in 2030

	Total energy consumption (Mtoe)	Reduction (Mtoe)				Reduction (%)			
	Carbon price (€/tCO2)								
	0	30	50	90	150	30	50	90	150
European Union	4.4	0.0	0.0	0.1	0.1	0.5%	0.9%	1.6%	2.5%
Austria	0.1	0.0	0.0	0.0	0.0	0.5%	0.9%	1.6%	2.6%
Belgium	0.1	0.0	0.0	0.0	0.0	0.3%	0.6%	1.0%	1.7%
Bulgaria	0.2	0.0	0.0	0.0	0.0	0.7%	1.1%	1.9%	3.1%
Croatia	0.1	0.0	0.0	0.0	0.0	0.6%	1.0%	1.9%	3.0%
Cyprus	0.0	0.0	0.0	0.0	0.0	0.4%	0.7%	1.3%	2.2%
Czech Republic	0.4	0.0	0.0	0.0	0.0	0.8%	1.4%	2.4%	3.8%
Denmark	0.1	0.0	0.0	0.0	0.0	0.4%	0.6%	1.1%	1.8%
Estonia	0.0	0.0	0.0	0.0	0.0	0.4%	0.7%	1.3%	2.1%
Finland	0.1	0.0	0.0	0.0	0.0	0.4%	0.6%	1.1%	1.7%
France	0.2	0.0	0.0	0.0	0.0	0.4%	0.7%	1.2%	2.0%
Germany	0.5	0.0	0.0	0.0	0.0	0.4%	0.6%	1.1%	1.8%
Greece	0.1	0.0	0.0	0.0	0.0	0.3%	0.6%	1.0%	1.6%
Hungary	0.1	0.0	0.0	0.0	0.0	0.5%	0.9%	1.6%	2.5%
Ireland	0.0	0.0	0.0	0.0	0.0	0.3%	0.5%	0.9%	1.5%
Italy	0.3	0.0	0.0	0.0	0.0	0.3%	0.5%	0.8%	1.4%
Latvia	0.0	0.0	0.0	0.0	0.0	0.5%	0.8%	1.4%	2.2%
Lithuania	0.1	0.0	0.0	0.0	0.0	0.6%	1.0%	1.8%	2.9%
Luxembourg	0.1	0.0	0.0	0.0	0.0	0.5%	0.8%	1.4%	2.3%
Malta	0.0	0.0	0.0	0.0	0.0	0.5%	0.8%	1.4%	2.3%
Netherlands	0.1	0.0	0.0	0.0	0.0	0.6%	0.9%	1.7%	2.7%
Poland	0.3	0.0	0.0	0.0	0.0	0.4%	0.7%	1.2%	1.9%
Portugal	0.1	0.0	0.0	0.0	0.0	0.4%	0.6%	1.1%	1.8%
Romania	0.4	0.0	0.0	0.0	0.0	0.5%	0.8%	1.5%	2.5%
Slovakia	0.0	0.0	0.0	0.0	0.0	0.4%	0.6%	1.0%	1.7%
Slovenia	0.0	0.0	0.0	0.0	0.0	0.5%	0.8%	1.3%	2.2%
Spain	0.8	0.0	0.0	0.0	0.0	0.8%	1.3%	2.3%	3.7%
Sweden	0.1	0.0	0.0	0.0	0.0	0.4%	0.6%	1.1%	1.8%

Source: Enerdata

Table 51. Total energy consumption and energy savings relative to baseline by carbon price in freight road transport in 2030

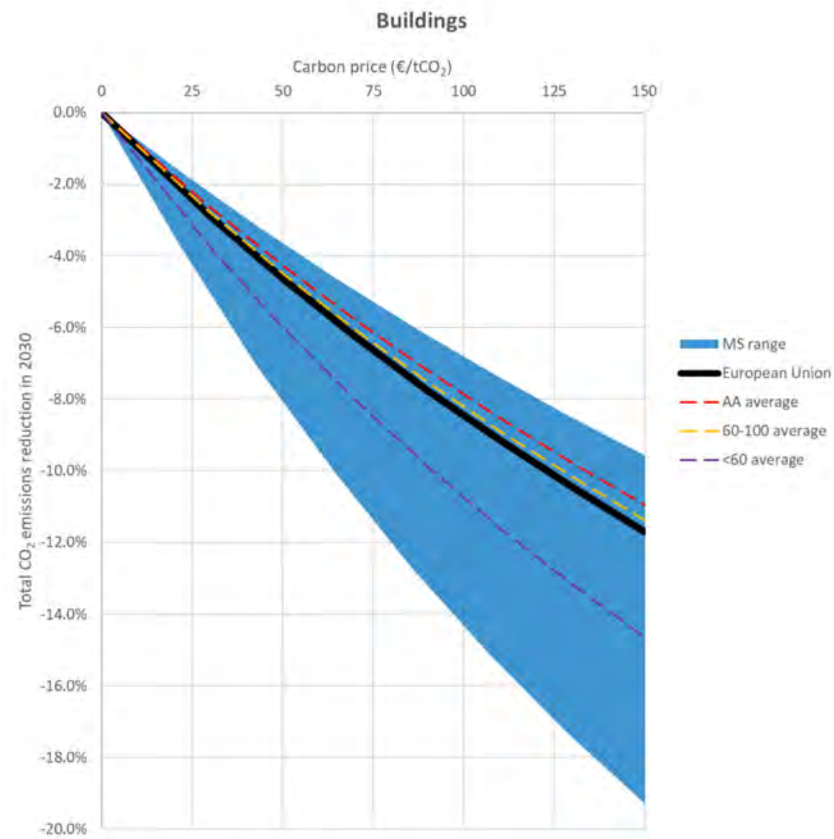
	Total energy consumption (Mtoe)	Reduction (Mtoe)				Reduction (%)			
	Carbon price (€/tCO2)								
	0	30	50	90	150	30	50	90	150
European Union	33.0	0.0	0.6	1.3	2.3	0.0%	1.8%	4.0%	7.0%
Austria	0.5	0.0	0.0	0.0	0.0	0.0%	2.0%	4.6%	8.0%
Belgium	0.9	0.0	0.0	0.0	0.1	0.0%	1.6%	3.7%	6.6%
Bulgaria	0.8	0.0	0.0	0.0	0.1	0.0%	2.0%	4.6%	8.0%
Croatia	0.4	0.0	0.0	0.0	0.0	0.0%	1.9%	4.2%	7.5%
Cyprus	0.2	0.0	0.0	0.0	0.0	0.0%	1.9%	4.2%	7.4%
Czech Republic	1.1	0.0	0.0	0.0	0.1	0.0%	2.1%	4.6%	8.1%
Denmark	0.3	0.0	0.0	0.0	0.0	0.0%	1.7%	3.8%	6.8%
Estonia	0.1	0.0	0.0	0.0	0.0	0.0%	1.8%	4.1%	7.3%
Finland	0.4	0.0	0.0	0.0	0.0	0.0%	1.5%	3.4%	6.1%
France	2.7	0.0	0.0	0.1	0.2	0.0%	1.7%	3.8%	6.7%
Germany	9.4	0.0	0.2	0.4	0.6	0.0%	1.7%	3.9%	6.9%
Greece	1.2	0.0	0.0	0.0	0.1	0.0%	1.5%	3.4%	6.1%
Hungary	0.5	0.0	0.0	0.0	0.0	0.0%	1.8%	4.1%	7.3%
Ireland	0.3	0.0	0.0	0.0	0.0	0.0%	1.6%	3.5%	6.2%
Italy	4.6	0.0	0.1	0.2	0.3	0.0%	1.4%	3.3%	5.8%
Latvia	0.1	0.0	0.0	0.0	0.0	0.0%	1.9%	4.3%	7.5%
Lithuania	0.3	0.0	0.0	0.0	0.0	0.0%	2.0%	4.5%	7.9%
Luxembourg	1.0	0.0	0.0	0.0	0.1	0.0%	2.1%	4.7%	8.2%
Malta	0.0	0.0	0.0	0.0	0.0	0.0%	1.6%	3.7%	6.5%
Netherlands	0.2	0.0	0.0	0.0	0.0	0.0%	1.6%	3.6%	6.4%
Poland	1.3	0.0	0.0	0.1	0.1	0.0%	2.0%	4.6%	8.1%
Portugal	0.0	0.0	0.0	0.0	0.0	0.0%	1.6%	3.5%	6.2%
Romania	0.5	0.0	0.0	0.0	0.0	0.0%	1.9%	4.3%	7.5%
Slovakia	0.9	0.0	0.0	0.0	0.1	0.0%	1.6%	3.7%	6.5%
Slovenia	0.3	0.0	0.0	0.0	0.0	0.0%	1.8%	4.2%	7.3%
Spain	4.3	0.0	0.1	0.2	0.4	0.0%	2.2%	4.8%	8.4%
Sweden	0.6	0.0	0.0	0.0	0.0	0.0%	1.5%	3.4%	6.0%

Source: Enerdata

3.6.3 Marginal abatement cost curves

The addition of carbon pricing to fossil fuels in the buildings and road transport sectors leads to change in CO_2 emissions, as well as energy demand. Changes in CO_2 emissions can be due to both energy efficiency measures and fuel switching. By testing a range of carbon prices in the EnerNEO model, a curve of the marginal abatement at various costs (carbon prices) can be generated. The marginal abatement cost curves for EU Member States in each sector are shown in Figure 65 and Figure 66. The results are normalised by presenting the percentage change from the baseline scenario emissions in 2030.

Figure 65. Buildings sector marginal abatement cost curves in 2030 by Member State



*Note: **AA** includes Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Netherlands, and Sweden*

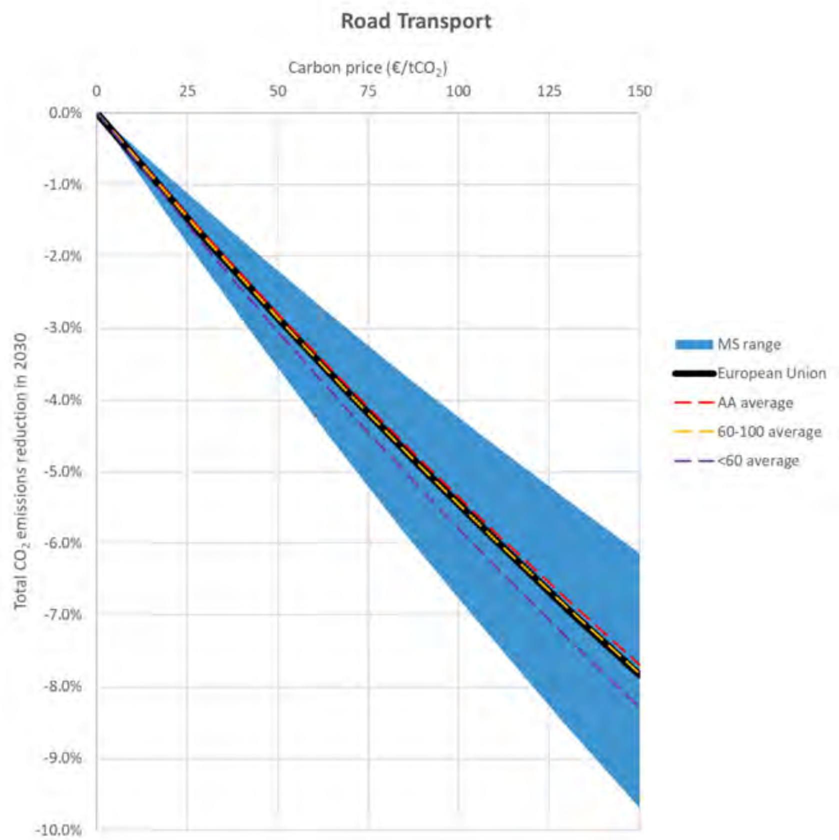
***60-100** includes Cyprus, Czech Republic, Estonia, Italy, Malta, Portugal, Slovenia, and Spain*

***<60** includes Bulgaria, Croatia, Greece, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia*

Source: Enerdata

For buildings, at a carbon price of €150/tCO_2 reductions in total CO_2 emissions range from 9.6% (Ireland) to almost 19% (Sweden, Estonia, and Bulgaria). In road transport, emissions reductions have less variability and range from just over 6% (e.g. Italy and Greece) to over 9% (e.g. Luxembourg, Lithuania, and Poland) at a carbon price of €150/tCO_2.

Figure 66. Road transport sector marginal abatement cost curves in 2030 by Member State



Note: ***AA*** *includes Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Netherlands, and Sweden*

60-100 *includes Cyprus, Czech Republic, Estonia, Italy, Malta, Portugal, Slovenia, and Spain*

<60 *includes Bulgaria, Croatia, Greece, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia*

Source: Enerdata

To differentiate the types of CO_2 emissions reductions, either from energy efficiency or from fuel switching, EnerNEO uses econometric relationships between energy demand/type and price. These include building thermal and electricity use, annual vehicle energy consumption, and vehicle type by fuel (e.g. conventional gasoline and battery electric).

In EnerNEO, the following fuel/technology options exist:

Buildings:

- Natural gas
- Coal
- Liquid Propane Gas
- Electricity
- Bioenergy
- District heating
- Solar heat

Transport:

- Gasoline (conventional and plug-in hybrid)
- Diesel (conventional and plug-in hybrid)
- Liquid Petroleum Gas (conventional)
- Biogasoline (conventional and plug-in hybrid)
- Biodiesel (conventional and plug-in hybrid)
- Battery electric vehicle
- Natural Gas

The personal transport sub-sector includes all vehicle technology options, while freight transport and buses include all options except (bio)gasoline and liquid petroleum gas.

Energy efficiency emissions reductions in EnerNEO include decreased energy per unit of activity (number of households or kilometres travelled) or switching to a more efficient equipment or vehicle type.[118] While building energy consumption is treated at an aggregate level through an econometric relationship, vehicle choice in EnerNEO is based on fixed investment costs (from the POLES model) and variable costs that respond to price (aggregates kilometres travelled and engine efficiency).

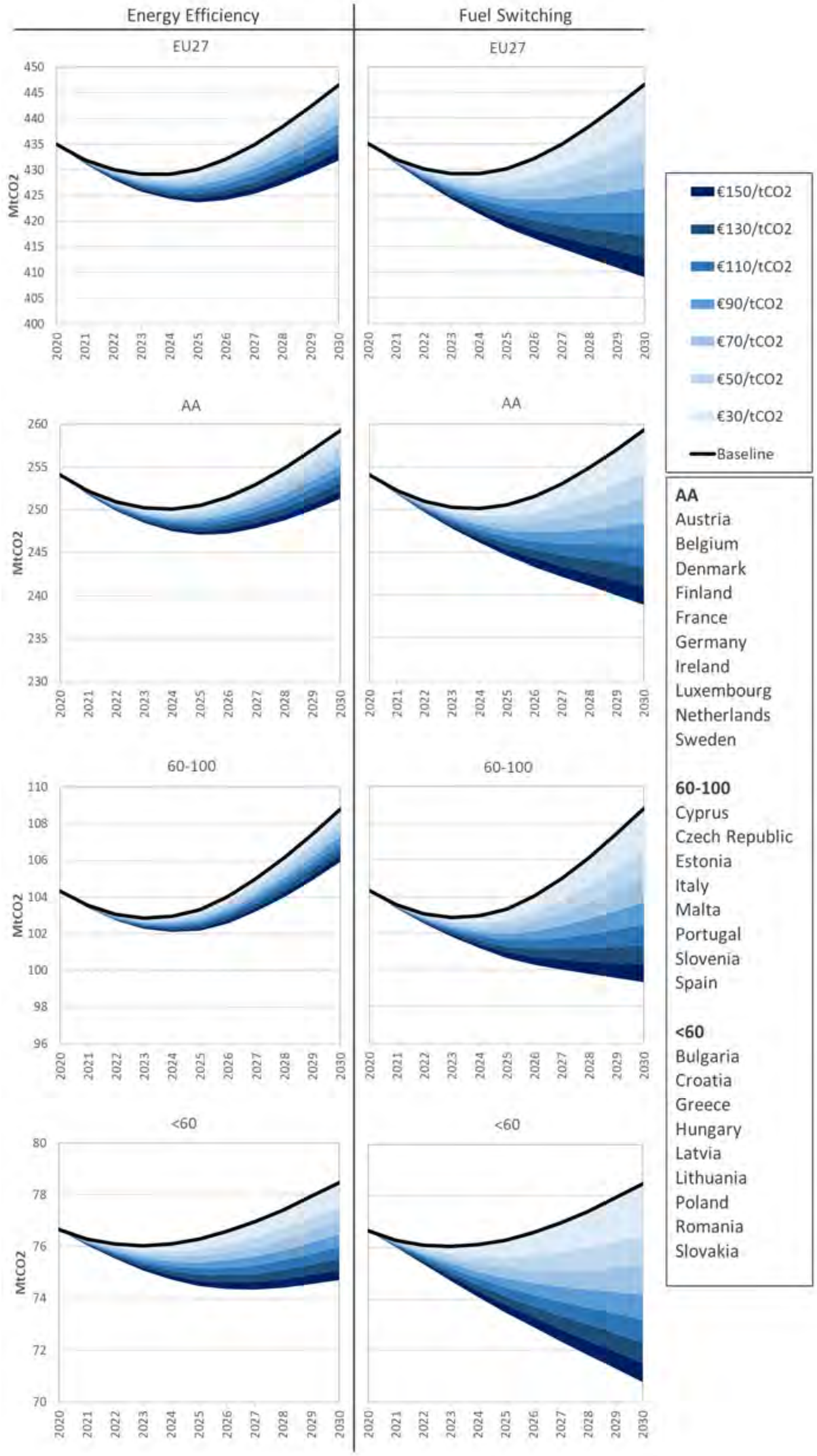
Reductions due to fuel switching are captured via market share changes in the energy types of new equipment stock. As noted above, these changes are determined using a cost competition process based on the total costs of equipment, including investment, fuel, and carbon costs. The methodology described here is fully inspired by the POLES model, used internally at Enerdata and at the JRC-Seville of the European Commission.

3.6.4 Impact on buildings' CO2 emissions

Figure 67, Table 52 and Table 53 detail the emissions reductions in the buildings sector from energy efficiency and fuel switching, compared to the baseline described in paragraph 3.5.3 above.

[118] The EnerNEO model represents vehicles by annual vintage and vehicle lifetime. This representation accounts for a vehicle being sold through the second-hand market until the end of the vehicle's useful life and the associated energy use that occurs.

Figure 67. Buildings sector CO_2 emissions reductions for European Union



Source: Enerdata

Table 52. CO_2 emissions reductions from energy efficiency relative to baseline by carbon price in buildings in 2030

	Energy Efficiency							
	Reduction (MtCO2)				Reduction (%)			
	Carbon price (€/tCO2)							
	30	50	90	150	30	50	90	150
European Union	3.5	5.6	9.5	14.6	0.8%	1.2%	2.1%	3.3%
Austria	0.1	0.1	0.2	0.2	0.7%	1.1%	1.9%	2.9%
Belgium	0.2	0.4	0.6	0.9	1.0%	1.7%	2.9%	4.5%
Bulgaria	0.0	0.0	0.0	0.0	0.5%	0.7%	1.3%	1.9%
Croatia	0.0	0.0	0.0	0.1	0.7%	1.1%	1.8%	2.8%
Cyprus	0.0	0.0	0.0	0.0	0.6%	0.9%	1.6%	2.4%
Czech Republic	0.1	0.2	0.3	0.5	1.0%	1.6%	2.6%	4.0%
Denmark	0.0	0.0	0.0	0.1	0.3%	0.5%	0.9%	1.4%
Estonia	0.0	0.0	0.0	0.0	0.5%	0.8%	1.3%	2.0%
Finland	0.0	0.0	0.0	0.0	0.3%	0.5%	0.9%	1.4%
France	0.4	0.6	1.0	1.5	0.6%	0.9%	1.6%	2.5%
Germany	1.2	1.9	3.2	5.0	0.9%	1.5%	2.5%	3.9%
Greece	0.0	0.1	0.1	0.2	0.6%	0.9%	1.6%	2.4%
Hungary	0.1	0.2	0.3	0.4	1.0%	1.6%	2.6%	4.0%
Ireland	0.1	0.1	0.2	0.3	0.9%	1.5%	2.6%	4.0%
Italy	0.4	0.7	1.1	1.8	0.6%	1.0%	1.7%	2.7%
Latvia	0.0	0.0	0.0	0.0	0.6%	1.0%	1.8%	2.7%
Lithuania	0.0	0.0	0.0	0.0	0.7%	1.1%	1.9%	2.9%
Luxembourg	0.0	0.0	0.1	0.1	1.2%	2.0%	3.4%	5.2%
Malta	0.0	0.0	0.0	0.0	0.3%	0.5%	0.9%	1.4%
Netherlands	0.2	0.3	0.4	0.7	0.7%	1.1%	2.0%	3.1%
Poland	0.7	1.2	1.9	2.9	1.7%	2.8%	4.6%	6.9%
Portugal	0.0	0.0	0.0	0.1	0.4%	0.6%	1.0%	1.6%
Romania	0.1	0.1	0.2	0.4	1.0%	1.6%	2.7%	4.1%
Slovakia	0.0	0.1	0.1	0.2	1.1%	1.7%	2.9%	4.4%
Slovenia	0.0	0.0	0.0	0.0	0.5%	0.9%	1.5%	2.3%
Spain	0.1	0.2	0.4	0.6	0.5%	0.8%	1.4%	2.2%
Sweden	0.0	0.0	0.0	0.0	0.1%	0.2%	0.4%	0.6%

Source: Enerdata

In the buildings sector, Member States see most CO_2 reductions in the form of fuel switching. On average, fuel switching effects make up about 72% of a country's reductions. This is largely due to the shift from coal to bioenergy and electric heating. Some countries with much higher baseline energy prices, like Finland and Sweden, see almost all their emissions reductions come from fuel switching. Other countries with lower baseline prices, like Poland, have a much more even split with energy efficiency.

Table 53. CO_2 emissions reductions from fuel switching relative to baseline by carbon price in buildings in 2030

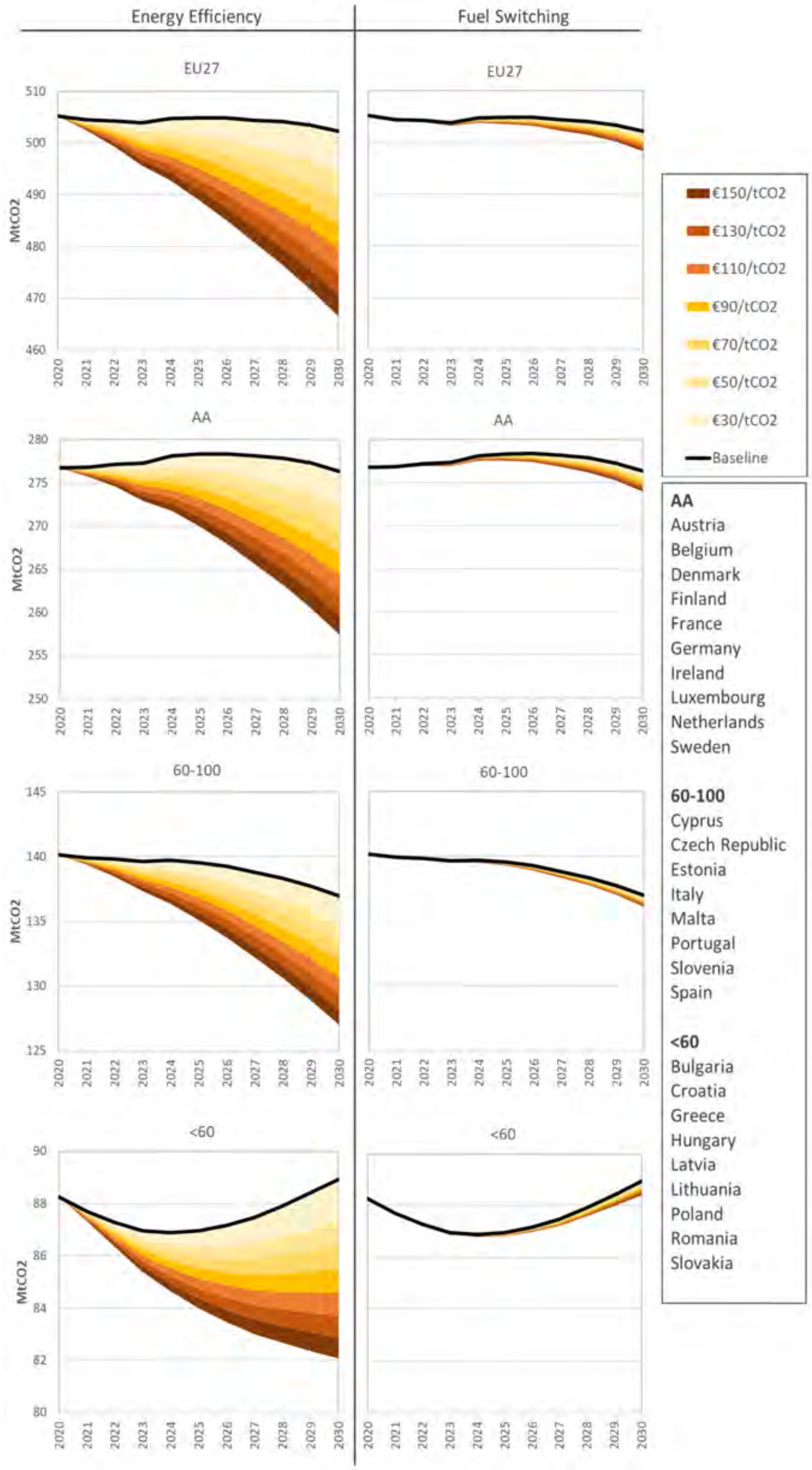
	Fuel Switching							
	Reduction (MtCO2)				Reduction (%)			
	Carbon price (€/tCO2)							
	30	50	90	150	30	50	90	150
European Union	9.4	15.1	25.1	37.6	2.1%	3.4%	5.6%	8.4%
Austria	0.2	0.4	0.6	0.9	2.6%	4.2%	7.0%	10.5%
Belgium	0.3	0.5	0.8	1.2	1.4%	2.2%	3.7%	5.6%
Bulgaria	0.1	0.1	0.2	0.2	4.7%	7.4%	12.0%	17.4%
Croatia	0.1	0.1	0.2	0.3	3.1%	4.9%	8.2%	12.2%
Cyprus	0.0	0.0	0.0	0.1	2.7%	4.4%	7.3%	11.0%
Czech Republic	0.4	0.6	0.9	1.4	2.9%	4.6%	7.5%	11.0%
Denmark	0.1	0.2	0.3	0.5	2.7%	4.3%	7.4%	11.4%
Estonia	0.0	0.0	0.1	0.1	4.2%	6.8%	11.3%	17.0%
Finland	0.1	0.1	0.3	0.4	3.4%	5.5%	9.3%	14.3%
France	1.3	2.1	3.6	5.4	2.1%	3.4%	5.7%	8.6%
Germany	2.2	3.5	5.8	8.7	1.7%	2.8%	4.6%	6.9%
Greece	0.2	0.3	0.4	0.7	2.6%	4.2%	7.1%	10.6%
Hungary	0.3	0.4	0.7	1.1	2.6%	4.1%	6.6%	9.7%
Ireland	0.1	0.2	0.3	0.4	1.3%	2.1%	3.6%	5.5%
Italy	1.3	2.0	3.4	5.1	1.9%	3.1%	5.2%	7.8%
Latvia	0.0	0.1	0.1	0.2	4.1%	6.5%	10.7%	15.9%
Lithuania	0.0	0.1	0.1	0.1	3.5%	5.6%	9.1%	13.2%
Luxembourg	0.0	0.0	0.1	0.1	1.6%	2.5%	4.1%	6.0%
Malta	0.0	0.0	0.0	0.0	3.0%	4.8%	8.0%	12.0%
Netherlands	0.4	0.6	1.0	1.5	1.6%	2.6%	4.3%	6.5%
Poland	0.9	1.4	2.2	3.2	2.1%	3.3%	5.3%	7.7%
Portugal	0.1	0.2	0.3	0.4	3.1%	5.0%	8.3%	12.4%
Romania	0.3	0.5	0.7	1.1	3.2%	5.0%	8.1%	11.8%
Slovakia	0.1	0.2	0.3	0.4	2.4%	3.8%	6.3%	9.3%
Slovenia	0.1	0.1	0.1	0.2	3.6%	5.8%	9.5%	14.2%
Spain	0.5	0.9	1.5	2.2	2.1%	3.4%	5.8%	8.7%
Sweden	0.1	0.2	0.3	0.5	4.5%	7.2%	12.2%	18.6%

Source: Enerdata

3.6.5 Impact on road transport's CO_2 emissions

Figure 68, Table 54 and Table 55 detail the emissions reductions in the transport sector from energy efficiency and fuel switching.

Figure 68. Road transport sector CO_2 emissions reductions for European Union



Source: Enerdata

In the road transport sector, CO_2 emissions reductions are primarily from buildings; energy efficiency with limited fuel switching apparent. This owes largely to the relatively short timeframe for reductions to occur by 2030, the lower purchase costs for internal combustion fossil fuel-based vehicles relative to alternative motor options and the small current fleet of hybrid and electric vehicles. Between 2018 and 2030, the market share for new vehicle purchases shifts from 95% for gasoline and diesel internal combustion vehicles to 82%-84% in the baseline and carbon price scenarios. Therefore, electric and hybrid motors make gains in the new vehicle segment. But fuel switching does not have enough time to make large reductions overall since only 10% of total vehicle stock is purchased each year. Energy efficiency provides most of the emissions reductions because of the number of internal combustion engine vehicles still purchased before 2030.

Table 54. CO_2 emissions reductions from energy efficiency relative to baseline by carbon price in road transport in 2030

	Energy Efficiency							
	Reduction (MtCO2)				Reduction (%)			
	Carbon price (€/tCO2)							
	30	50	90	150	30	50	90	150
European Union	7.9	12.9	22.4	35.3	1.6%	2.6%	4.4%	7.0%
Austria	0.2	0.4	0.6	1.0	1.8%	2.9%	5.0%	7.8%
Belgium	0.2	0.4	0.6	1.0	1.5%	2.4%	4.2%	6.7%
Bulgaria	0.1	0.2	0.3	0.4	1.8%	2.9%	5.0%	7.8%
Croatia	0.1	0.2	0.3	0.4	1.6%	2.7%	4.6%	7.3%
Cyprus	0.0	0.1	0.1	0.1	1.6%	2.6%	4.4%	7.0%
Czech Republic	0.3	0.4	0.7	1.1	1.8%	2.9%	5.0%	7.9%
Denmark	0.1	0.2	0.3	0.5	1.4%	2.3%	4.0%	6.4%
Estonia	0.0	0.0	0.1	0.1	1.6%	2.6%	4.5%	7.1%
Finland	0.1	0.1	0.2	0.4	1.4%	2.2%	3.9%	6.2%
France	1.0	1.6	2.8	4.4	1.5%	2.5%	4.3%	6.9%
Germany	1.9	3.2	5.5	8.7	1.5%	2.5%	4.3%	6.9%
Greece	0.1	0.2	0.4	0.6	1.3%	2.1%	3.6%	5.8%
Hungary	0.1	0.2	0.3	0.6	1.6%	2.6%	4.6%	7.2%
Ireland	0.1	0.2	0.3	0.5	1.5%	2.5%	4.3%	6.8%
Italy	0.6	1.0	1.8	2.9	1.3%	2.1%	3.7%	5.9%
Latvia	0.0	0.1	0.1	0.2	1.8%	2.9%	4.9%	7.7%
Lithuania	0.1	0.1	0.2	0.3	1.8%	3.0%	5.2%	8.1%
Luxembourg	0.1	0.1	0.2	0.3	1.9%	3.2%	5.5%	8.6%
Malta	0.0	0.0	0.0	0.0	1.4%	2.3%	4.1%	6.4%
Netherlands	0.2	0.4	0.7	1.1	1.4%	2.2%	3.9%	6.1%
Poland	0.7	1.1	1.9	3.0	1.8%	3.0%	5.1%	8.0%
Portugal	0.1	0.2	0.4	0.6	1.5%	2.4%	4.2%	6.6%
Romania	0.2	0.3	0.5	0.8	1.6%	2.6%	4.5%	7.2%
Slovakia	0.1	0.1	0.2	0.3	1.6%	2.6%	4.5%	7.1%
Slovenia	0.1	0.1	0.2	0.3	1.7%	2.7%	4.7%	7.4%
Spain	1.0	1.7	2.9	4.6	1.8%	3.0%	5.1%	8.0%
Sweden	0.2	0.3	0.5	0.9	1.3%	2.2%	3.8%	6.0%

Source: Enerdata

Most of the fuel switching emissions reductions come from the ability to quickly blend biofuels into the fuel mix for the existing fleet of vehicles without changing motors. Electric and hybrid vehicles do provide some reductions, but the 10-year timespan where carbon prices are applied in the study does not allow for an extensive amount of stock turnover.

Table 55. CO_2 emissions reductions from fuel switching relative to baseline by carbon price in road transport in 2030

	Fuel Switching							
	Reduction (MtCO2)				Reduction (%)			
	Carbon price (€/tCO2)							
	30	50	90	150	30	50	90	150
European Union	0.8	1.4	2.4	3.8	0.2%	0.3%	0.5%	0.7%
Austria	0.0	0.0	0.1	0.1	0.2%	0.3%	0.5%	0.8%
Belgium	0.0	0.0	0.1	0.1	0.2%	0.3%	0.5%	0.8%
Bulgaria	0.0	0.0	0.0	0.0	0.2%	0.3%	0.5%	0.8%
Croatia	0.0	0.0	0.0	0.0	0.1%	0.2%	0.3%	0.5%
Cyprus	0.0	0.0	0.0	0.0	0.1%	0.1%	0.2%	0.4%
Czech Republic	0.0	0.0	0.1	0.1	0.2%	0.3%	0.6%	0.9%
Denmark	0.0	0.0	0.0	0.1	0.2%	0.3%	0.4%	0.7%
Estonia	0.0	0.0	0.0	0.0	0.3%	0.5%	0.8%	1.3%
Finland	0.0	0.0	0.0	0.1	0.2%	0.4%	0.7%	1.1%
France	0.2	0.3	0.5	0.8	0.3%	0.4%	0.8%	1.2%
Germany	0.2	0.3	0.6	0.9	0.2%	0.3%	0.5%	0.7%
Greece	0.0	0.0	0.0	0.0	0.1%	0.1%	0.2%	0.3%
Hungary	0.0	0.0	0.0	0.1	0.2%	0.3%	0.4%	0.7%
Ireland	0.0	0.0	0.0	0.0	0.1%	0.2%	0.4%	0.6%
Italy	0.0	0.1	0.1	0.2	0.1%	0.1%	0.2%	0.3%
Latvia	0.0	0.0	0.0	0.0	0.1%	0.2%	0.4%	0.6%
Lithuania	0.0	0.0	0.0	0.0	0.2%	0.3%	0.5%	0.9%
Luxembourg	0.0	0.0	0.0	0.0	0.2%	0.4%	0.7%	1.1%
Malta	0.0	0.0	0.0	0.0	0.1%	0.2%	0.4%	0.6%
Netherlands	0.0	0.0	0.1	0.1	0.1%	0.2%	0.4%	0.7%
Poland	0.0	0.1	0.1	0.2	0.1%	0.2%	0.4%	0.6%
Portugal	0.0	0.0	0.0	0.0	0.1%	0.1%	0.3%	0.4%
Romania	0.0	0.0	0.0	0.1	0.1%	0.2%	0.4%	0.7%
Slovakia	0.0	0.0	0.0	0.0	0.1%	0.1%	0.2%	0.3%
Slovenia	0.0	0.0	0.0	0.0	0.1%	0.2%	0.4%	0.6%
Spain	0.1	0.2	0.3	0.5	0.2%	0.3%	0.5%	0.8%
Sweden	0.0	0.0	0.1	0.1	0.2%	0.3%	0.5%	0.8%

Source: Enerdata

Overall, a carbon price applied to the buildings and transport sectors can cause reduced emissions even within the 2030 timeframe. Emission reductions relative to the baseline in 2030 at the EU-level range from:

- Buildings: 2.9% at €30/tCO_2 to 11.7% at €150/tCO_2
- Transport: 1.8% at €30/tCO_2 to 7.8% at €150/tCO_2

While the reductions at the high end of €150/tCO_2 are significant in a 10-year period, the carbon price used implies an annual increase of €15/tCO_2. To achieve this rate of price increase, an aggressive emissions cap would be needed, which may not be achievable if these sectors are included along with industry and electricity generation in the EU-ETS.

Even the lowest carbon prices considered in this study achieve tangible emissions reductions of 3%-5% overall. And prices of €30/tCO_2 or €50/tCO_2 may be more in line with projected prices in the EU-ETS by 2030. The energy savings achieved in the buildings and road transport sector are substantially lower than the maximum economic potentials identified in Question 2.1d, especially at low carbon prices. For example, with a €30/tCO_2 price, 0.8% energy savings are achieved in 2030 in buildings (compared to the baseline), and 0.6% in road transport, whereas in Question 2.1d, the energy savings are estimated to be 9% (residential), 6% (commercial) and 6% (road transport). For higher carbon prices, this gap decreases: at €150/tCO_2, the EnerNEO results are 3.2% for buildings and 2.6% for transport, compared to 11% and 7% for residential and commercial buildings, respectively, and 11% for transport in Question 2.1d.

These discrepancies are due to the difference in the approaches used. In addition to the different baseline assumptions, the EnerNEO model uses a top-down approach for demand based on econometric relations and price effects; as such it reflects achievable abatement (considering elasticities from past trends). The abatement potentials estimated in Question 2.1d are based on a bottom-up approach, and therefore represent a maximum economic potential (upper bound); that is, the measure is implemented when it becomes cost-effective, regardless of consumer behaviour. The EnerNEO model results include considerations of rigidity of the energy systems, through equipment lifetime, and behaviour considerations (through elasticities). These constraints may prevent energy consumption to respond to a carbon price signal quickly and strongly enough to reach the maximum potentials, especially for low price signals.

4 TASK 3. General architecture of a possible inclusion

4.1 Question 3.1: Design options & robustness criteria

4.1.1 Design options

Possibilities of an extension of the existing EU ETS have been discussed already during the impact assessment after the end of the second trading period in 2012. Accordingly, various design options have been assessed in several reports in 2012-14 (e.g. CE Delft 2014, Öko-Institut 2014, I4CE 2015)). A second round of analyses can be found from more recent years, primarily, but not exclusively in the context of the introduction of an emissions trading system for fossil fuels in Germany (e.g. Matthes 2019, FOES 2016 or cep 2015 with a German angle, Achtnicht 2019 or Greenstream 2017 for broader analyses). Those studies analyse to a different degree and from different angles.

Different design elements need to be defined in the context of discussing the integration of road transport and buildings into the EU ETS. For the general decision on which parts of those sectors should be integrated and whether they should be integrated into the EU ETS or whether a separate ETS is more suitable in that case, not all design elements are of similar importance. Therefore, we differentiate the design elements for the following analyses. The design elements most relevant for the above described question are used to define design options (see sections 4.1.1.1 and 4.1.1.2). Those design options are later analysed applying different robustness criteria (defined in section 4.1.2). A second set of design elements is analysed in advance to looking in more detail into the defined design options as they are not strongly linked to those design options (see sections 4.2 to 4.6) but important for the definition of emissions trading in the focus sectors. Where relevant, reference is made to the different design options. Some design elements are not analysed at all at this point in time. For the sake of completeness, they are listed in section 4.1.1.3.

4.1.1.1 General design elements regarding scope of the new system and legal implementation in the context of existing EU legislation

The most important design elements and related options regarding scope and legal implementation in the context of existing EU legislation of an inclusion of road transport and the buildings sector are:

- Opt-in into existing ETS or creation of separate ETSs: Article 24 of the ETS regulation in principle allows Member States to include include further emissions into the existing scheme. A scope extension of the EU ETS could include in general and for all Member States under common rules new sectors into the EU ETS. Alternatively, separate emission trading schemes may be created for certain (sub-)sectors, with or without linking to the existing ETS.
- Full or partial inclusion of sectors: In case that sub-sectors can be clearly separated from each other, there is the option to include only those parts for which an ETS is expected to be more useful (e.g. freight transport and/or non-residential buildings).
- Linking with other systems: Linking between systems provides further flexibilities. This can be particularly relevant in cases where individual systems are small or large price differences are to be expected. Based on the current use of flexibilities within ETS systems it seems likely that if separate system(s) are being created for transport and/or buildings at least limited linking between those system(s) and the EU ETS will be allowed to allow for a certain easing of price pressure in the system(s) with higher prices. Such linking does not necessarily have a direct impact on the auction process or on the spot or derivatives market. An upper limit would be enforceable, for example, if the

allowances of a system could not be used directly, but only indirectly, via an exchange into the correct allowance. If this exchange has to take place at the regulating authority, the authority can easily track the quantity and stop the exchange when the limit is reached. How the limit is set must be weighed against risks such as importing a price decline from one ETS to another ETS. Whether a linking or a single system would be preferable in the long run can depend on many influencing factors. A single system compared to a linked system has the advantage of lower transaction costs, especially for the regulatory authorities, and in theory unrestricted trading is the most cost-effective way to reduce greenhouse gases. On the other hand, a unified or fully linked system has the disadvantage that in case of very different abatement costs and very different investment cycles of the individual sectors, a unified system can lead to the fact that necessary long-term abatement investments in sectors with high abatement costs and long investment cycles are made too late, which in the long run could lead non-achievement of the climate targets.

- Coverage by ESR: A specific aspect in the context of the EU climate and energy framework is whether the ESR will continue to apply to the sectors for which an integration into an ETS is planned or not. Different implications arise: as long as sectors remain part of the ESR limited flexibilities build into the ESR need to be taken into account when thinking about an integration/ linking with the existing EU ETS. To date, only a limited amount of allowances from the EU ETS are allowed for compliance under the ESR. Similarly, trading between MS - which is allowed to help countries comply with their obligations under the ESR - under the ESR is only allowed as long as a country was in compliance in earlier years. However, if ESR sectors are being regulated under an ETS, trading needs to be allowed at all times.
- Immediate or gradual extension: The ETS could be established for all additional (sub-)sectors at once or in a step-by-step approach, i.e. certain sub-sectors could be included at a later point in time.

4.1.1.2 Definition of Design Options

Based on those design elements we choose specific design options for further analysis. The following considerations were used as starting point for choosing the specific design options:

- Extension of the EU ETS by MS opt-ins: Individual countries can decide to include other sectors' emissions based on the opt-in option provided by the current EU ETS. In that case, it is very likely that coverage and regulation in the different MS will differ. In case of an extension purely based on national opt-ins, the current cap-setting (I.e. in particular the LRF) of the EU ETS will likely not be changed (except for an increase in the total emission level) and the opt-in sectors will need to reduce emissions at same speed as current EU ETS sectors. Accordingly, the ESR targets no longer apply for the opt-in sectors. In general, MS can decide about the if, when and how of the opt-in on their own as long as they follow existing regulations for opt-in. Hence, it is likely that in addition to a heterogeneous design also the timing for the opt-in will differ between countries. However, this option does not differ from the current baseline. MS can already use this option today, but it is an option for ambitious MS to use it more in the future.
- Scope-extension of the EU ETS to include new sectors: The other option is an extension of the scope of the EU ETS similarly to the scope extension in Phase III of the EU ETS. Accordingly, uniform regulations would apply to all MS and all MS would need to start to be covered at the same time (no later inclusion). As in the first option, the new sectors would be covered under the target setting

rules for the EU ETS. However, it is more likely that in case of a scope extension also cap-setting rules for the EU ETS will be revised (in particular the LRF) to reflect the emission reduction potential of the newly-included sectors. While it seems plausible that in such a case the ESR would no longer apply for those sectors, we also analyse a case where the ESR remains in place for those sectors and hence double regulation applies. In both cases of extension, the amount of emissions that will be integrated and the number of regulated entities is not such a relevant topic as the new sectors will be integrated into a liquid market. Also, the danger of market power by individual entities should be manageable in both contexts. A question that arises, however, is whether sever impacts on the current EU ETS can be expected from such an extension.

- One or more separate ETS for transport and buildings: In case of the definition of separate ETS market(s) for transport and buildings (either in one combined market or in two separate markets), again a common regulatory framework can be expected (to be defined by the EU Commission). In that case, the ESR could well continue to apply to the emissions for transport and buildings. However, depending on the linking options with the EU ETS the ESR could require a revision regarding the existing flexibility options that allow only a limited use of EU ETS allowances under the ESR.
- Separate ETS markets for freight transport or non-residential buildings: In case of separate markets for parts of the transport or buildings sector, it needs to be ensured that amount of emissions covered under the systems legitimizes the transaction costs related with the design and operation of an ETS. Also, the definition of the point of regulation needs to take into account that a liquid market without too much market power is the preferable aim.

Based on the above considerations, the following design options for the integration of road transport and buildings into an ETS are being defined for the follow-up analyses (see also Table 56):

- Option 0 - baseline: As baseline we use a scenario with an EU ETS without scope extension at the EU-level. Scope of the system is as defined for Phase III and IV. No new ETS systems are introduced for transport and buildings, but both sectors remain covered under the ESR and other measures as defined on the EU level or the MS level remain in place. It is possible for individual MS to opt-in certain sectors, but for the sake of the analysis we will assume that this opt-in option is not used to a greater extent. Hence, we assume no effects on the EU ETS as it currently is.
- Option 1a - full scope extension: In this scenario we assume that an EU-wide scope extension of the EU ETS takes place to include emissions from road transport and buildings in the existing EU ETS. We further assume, that this scope extension implies that the sectors become fully regulated under the EU ETS and are no longer part of the ESR, so scope of the EU ETS and the ESR change significantly compared to today.
- Option 1b - full scope extension under existing ESR: Like in Option 1a, in this scenario we assume that an EU-wide scope extension of the EU ETS takes place to include emissions from road transport and buildings in the existing EU ETS. In contrast to Option 1a, we assume that the ESR remains in place for the sectors newly covered under the EU ETS.
- Option 1c – scope extension for freight transport and commercial buildings: Like in Option 1, we assume that an EU-wide scope extension of the EU ETS takes place, but limited to freight transport and commercial buildings, this could reduce the direct cost pressure on private households and could lead to greater acceptance. Other design options apply as in Option 1a. Option 1c could at a later point in time be extended to Option 1a. As per in option 1b, other road-

transport subsectors and residential buildings remain to be covered by the ESR as it currently is.

- Option 2a – EU-wide scope extension of the EU ETS to road transport: This scenario is similar to Option 1a, but only road transport is being included in the EU ETS. The ESR remains valid for all other sectors including buildings, while road transport is no longer part of the ESR. Option 2a could at a later point be extended to Option 1a.
- Option 2b – EU-wide scope extension of the EU ETS to buildings: This scenario is similar to Option 1a and 2a, but this time only the buildings sector is being included in the EU ETS. The ESR remains valid for all other sectors including road transport, while the buildings sector is no longer part of the ESR. Option 2b could at a later point be extended to Option 1a.
- Option 3a - separate ETS for road transport + buildings with limited flexibilities with the EU ETS: In this scenario we assume that a new ETS market is designed for road transport and buildings with the current EU ETS continuing to exist. The ESR remains in place for this new ETS, i.e. the new ETS is an additional instrument under the ESR. The two emissions trading systems (EU ETS and "new ETS") are linked to a certain extent, i.e. use of allowances from one system in the other system for compliance is possible but with upper limits. Whether the link is one-way or two-way is not specified. Option 3a could at a later point in time be extended to Option 1a assuming that the design of the systems allows for that.
- Option 3b - separate ETS for freight transport and commercial buildings with limited flexibilities with the EU ETS: Like in Option 3a we assume that a new ETS market is designed, but limited to freight transport and commercial buildings. Other design options apply as in Option 3a. In particular, the ESR remains in place for the new ETS. Option 3b could at a later point in time be extended to Option 3a.
- Option 3c - two separate new ETS, one for road transport, one for buildings with limited flexibilities with the EU ETS and between the two new ETS: In this scenario we assume that two new ETS markets are designed, one for road transport and one for the buildings sector. As in Option 3a, the ESR remains in place for the new ETSs. We assume that a certain amount of trade will be allowed between the systems (the two new systems as well as the new systems and the current EU ETS), however, the trade will be limited to prevent that too many allowances are shifted between systems. Whether the link is one-way or two-way is not yet specified. Option 3c could at a later point in time be extended to Option 3a or Option 1a assuming that the design of the systems allows for that.

Table 56. General design options regarding scope of the new system and legal implementation in the context of existing EU legislation

Design Options	Sectors	Flexibilities	ESR applies	Possibilities for extension
Option 0 (baseline)	No EU-wide extension of the EU ETS, potential opt-in by individual MS	n/a	yes	---

Design Options	Sectors	Flexibilities	ESR applies	Possibilities for extension
Option 1a - full scope extension	Full EU-wide scope extension of the EU ETS to include road transport + buildings	n/a	no	---
Option 1b - full scope extension under existing ESR	Full EU-wide scope extension of the EU ETS to include road transport + buildings	n/a	yes	Later extension to Option 1a possible (after 2030)
Option 1c - scope extension for freight transport and commercial buildings	EU-wide scope extension of the EU ETS to include freight transport + commercial buildings	n/a	no	Later extension to Option 1a possible
Option 2a - scope extension for road transport	EU-wide scope extension of the EU ETS to include road transport	n/a	no	Later extension to Option 1a possible
Option 2b - scope extension for buildings	EU-wide scope extension of the EU ETS to include buildings	n/a	no	Later extension to Option 1a possible
Option 3a - separate ETS for road transport + buildings with limited linking to the EU ETS	Separate ETS scheme for road transport + buildings	With (limited) linking between ETSs	yes	Later extension to Option 1a possible if design of the systems allows for a merger
Option 3b - separate ETS for freight transport + commercial buildings with limited linking to the EU ETS	Separate ETS scheme for freight transport + commercial buildings	With (limited) linking between ETSs	yes	Later extension to Option 3a possible

Design Options	Sectors	Flexibilities	ESR applies	Possibilities for extension
Option 3c - two separate ETS, one for road transport, one for buildings with limited linking between new systems and with the EU ETS	Two separate ETS schemes, one for road transport, one for buildings	With (limited) linking between all three ETSs	yes	Later extension to Option 3a and option 1a possible if design of the systems allows for a merger

Source: Fraunhofer ISI

4.1.1.3 Further design elements

The design elements used for the specification of the design options do not cover all relevant aspects when designing an ETS. Relevant design elements that will be assessed before the specific analysis of the above defined options as their link with the options is weak are:

- Point of regulation (see section 4.2)
- Cap setting (see section 4.3)
- Allocation of allowances (see section 4.1.2.1)
- System integration (see sections 4.5 and 4.6)
- MRV (see section 4.5)
- Use of auction revenues (see section 4.1.2.1)
- One design element that will not be assessed in the context of this report is the use of a carbon price floor/ceiling/corridor or the market stability reserve. In case of an integration into the existing EU ETS, the market stability reserve (MSR) will apply also to the newly defined sectors. There is, however, the need to assess whether the limits for the MSR need to be redefined. In case of separate systems, it can be decided whether carbon price measures or quantity control mechanisms like the MSR should become part of the new systems. While in the past in light of the low prices in the EU ETS price floors were of more relevance than price ceilings, this could change in case of separate ETS systems for transport and/or buildings. On the one hand, prices needed for reactions in those sectors are likely to be higher than in the EU ETS. On the other hand, emission reductions for the sectors in the past were much slower so and have - in particular for the buildings sector - long implementation periods making it more realistic that allowances may be short in a given year. Here, price ceilings can prevent too strong price increases that would result in unwantedly high financial burdens for households as well as for small enterprises.

4.1.2 Robustness criteria

This section discusses the social and regulatory criteria that apply independently of the individual design options. Section 4.6 then analyses all criteria listed in Table 57 for each design option.

Table 57 shows the robustness criteria used for a first assessment of the design options defined under 4.1.1.2.

Table 57. Robustness criteria for assessment of design options

Environmental criteria	**Indicators**
Current and future magnitude of sectoral emissions	Absolute and relative emissions per sub-sector today Current emission trend and emission projection for 2030
Availability of emission reduction measures	Technical abatement potential per sub-sector
Economic criteria	
Costs of emission reductions	Marginal abatement costs of the decarbonisation options per sub-sector
Administrative costs	Administrative costs and transaction costs
Social criteria	
Impact on individual spending on transport and heating fuels	Price impact on transport and heating fuels Spending on transport and heating fuels
Use of auction revenues	Redistribution mechanism in using auction revenues
Regulatory criteria	
EU competence and legal basis. Subsidiarity and proportionality principles	Compliance with EU Treaty regarding scope of measures (e.g. to cover intra-EU transport)
Implementation, compliance and enforcement measures	Measures proposed are implementable and enforceable Measures proposed comply with MRV rules Definition of penalties for entities not complying with MRV and surrendering obligations

Source: Fraunhofer ISI

4.1.2.1 Social criteria

This task looks into how changes with the extension of the ETS would impact households. In this section, we analyse how spending on transport and heating fuels changes with an increased price, and explore implications of a set of core options for the recycling of auctioning revenues. Finally, section 5.3 will look into differentiated impacts across different deciles of households.

In our analysis we build on detailed consumer expenditure data for EU-27 provided for the analysis by the European Commission, DG Climate Action: focusing on Decile 5 Middle class households. This dataset includes absolute values in EUR per household values of final consumption expenditure by key consumption categories relevant to our analysis: food and non-alcoholic beverages; household energy costs; transport and other expenditure.

Furthermore, we use a dataset (own collection by Fraunhofer ISI) containing the following data for each EU-27 country, for the year 2017:

- the distribution of the shares of key energy carrier categories in the residential sector and in the transport sector (energy use in ktoe) collected from Eurostat Energy Balances
- the related EUR expenses for these energy carriers in these two sectors taken from the enerdata data base and
- the CO_2 emissions in tCO_2 attributed to the energy used calculated based on emission factors taken from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy as well as conversion factors taken from the methodology of the 5th IPCC assessment report and 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

In case of household energy use, the key covered energy carrier categories are:

- Natural gas
- Gas oil and diesel oil (excluding biofuel)
- Renewables and biofuels
- Other (incl. coal, electricity, district heating).

For the transport-related energy carriers used by the residential sector, the key covered energy carrier categories are:

- LPG
- Motor gasoline (excluding biofuel)
- CNG
- Gas oil and diesel oil (excluding biofuel) and
- Renewables (biofuels, biogases and the renewable part of industrial and municipal waste)
- Other (electricity).

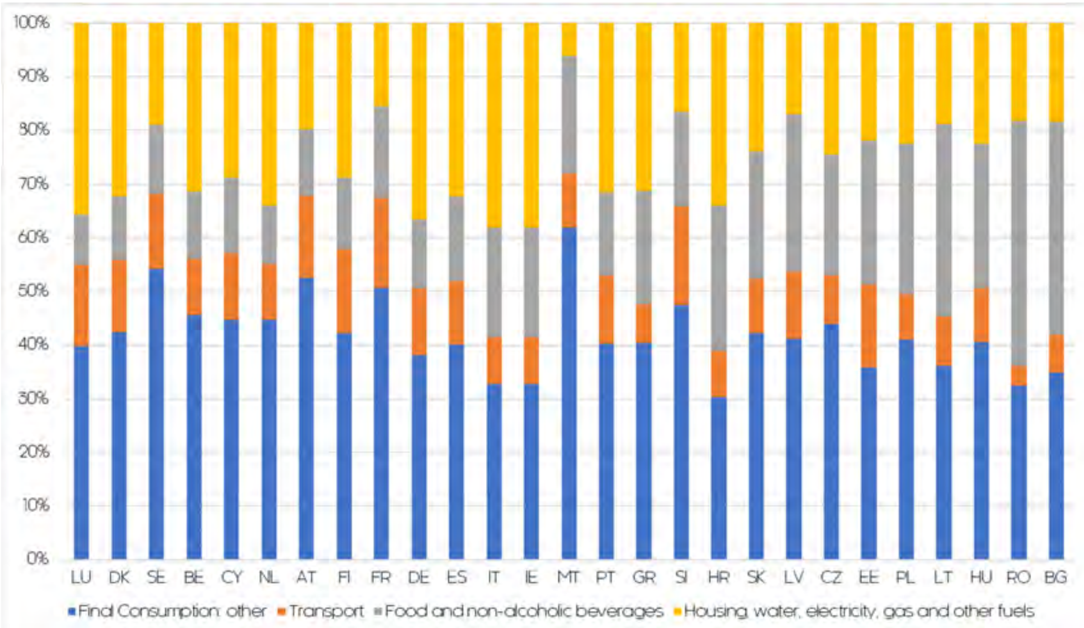
Our findings

We investigated how total final expenditure is distributed across the main consumption categories for a representative middle-class household decile (represented by Decile 5 by household income), for EU-27 countries.

As the below chart illustrates, household energy costs, expected to increase as a result of a price change of fossil fuels, represent a significant share of total final expenditure of middle-class households, even in rich countries, such as Denmark or Ireland. There is no clear tendency for Decile 5 income group of poor countries to spend a larger share of final consumption expenditure on energy than the same group in richer countries does, rather the opposite is true: wealthier countries (in terms of total final consumption expenditure) tend to spend a relatively larger share of their total consumption on housing, water, electricity, gas and other fuels, which is likely to be driven by a relatively high energy use per person, and an overall larger energy consumption on a national level.

Share of expenditure on transport represents a more stable 10-15% share in total final consumption across EU-27 countries.

Figure 69. Distribution of final household expenditure (as % of total) across main expenditure categories in EU-27, Middle-class households (Decile 5), EUR per household, data of latest available year



Source: Cambridge Econometrics calculations, based on final household expenditure data provided by the European Commission, DG Climate Action. Data is for latest available year for all countries (oldest year: 2010, latest year: 2015). Ordered by total final consumption expenditure, largest to smallest.

Based on the 2017 household energy use dataset, we have investigated how household energy use is distributed across different energy carriers in the residential and in the transport sector. The table below presents the distribution of the EU 27 average in the two sectors of interest. A key observation is that in EU 27 countries on average, disregarding electricity and district heating as those emissions are already covered under the EU ETS, there is a clear dominance of natural gas amongst residential energy carriers, while gas oil is the primary source of energy used in the transport sector.

Table 58. Share of different energy carriers in households' energy use in Residential / Transport sectors, EU 27 average, 2017

Sector	Energy carriers	Share (%)
Residential	Natural gas	31.9
	Gas oil and diesel oil (excluding biofuel)	9.2
	Renewables (biofuels, biogases and the renewable part of industrial and municipal waste)	19.6
	Other (incl. coal, electricity, district heating)	39.3
Transport	LPG	2.2
	Motor gasoline (excluding biofuel)	24.2
	Gas oil and diesel oil (excluding biofuel)	67.7

Sector	Energy carriers	Share (%)
	Renewables (biofuels, biogases and the renewable part of industrial and municipal waste)	5.1
	Other (electricity)	0.6

Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on households' energy use by different energy carriers in Residential / Transport sectors. Simple average calculated based on total energy use in EU 27 countries.

To estimate the amount of additional expenses that households would face as a result of an inclusion of the buildings and the transport sector in the EU-ETS, we have exemplarily investigated what expenses would arise if the CO_2 emissions attributed to the energy used in residential and in transport sectors would be costed at an assumed carbon price of 20, 30 and 50 €/tCO_2. Table 59 gives an overview of the price increase per sales unit that would be expected at prices of 20/30/50€ per tonne of CO_2.

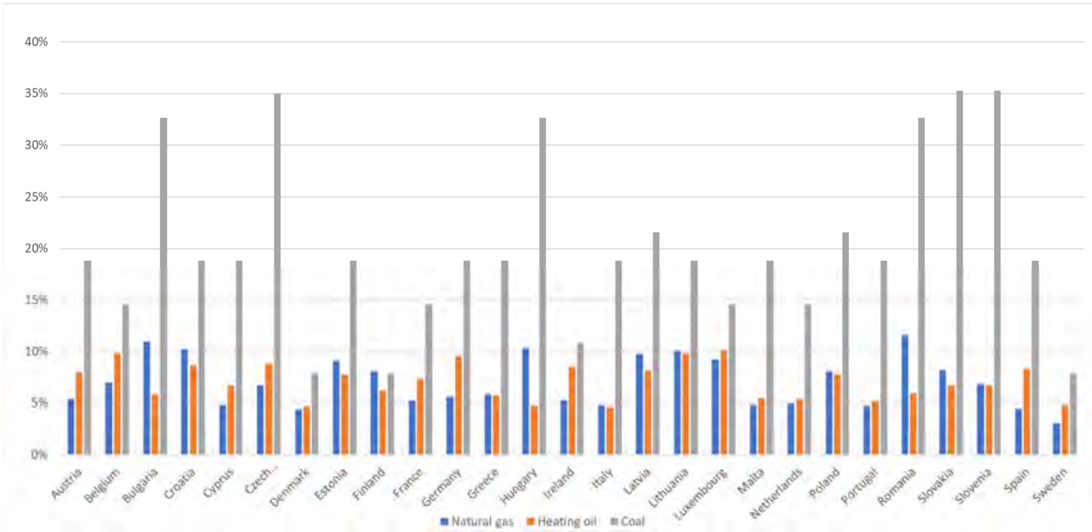
Table 59. CO_2 costs per sales unit at a price of 20€/30€/50€ per ton of CO_2 for the year 2017

Sector	Energy carriers	CO_2 price per sales unit
Residential	Natural gas	0.004/0.006/0.001€ per kWh
	Gas oil and diesel oil (excluding biofuel)	0.052/0.079/0.131€ per Litre
Transport	LPG	0.031/0.047/0.079€ per Litre
	Petrol (excluding biofuel)	0.042/0.063/0.105€ per Litre
	Gas oil and diesel oil (excluding biofuel)	0.052/0.079/0.131€ per Litre

Calculation based on the above mentioned conversion and emission factors, fuel prices based on enerdata data base

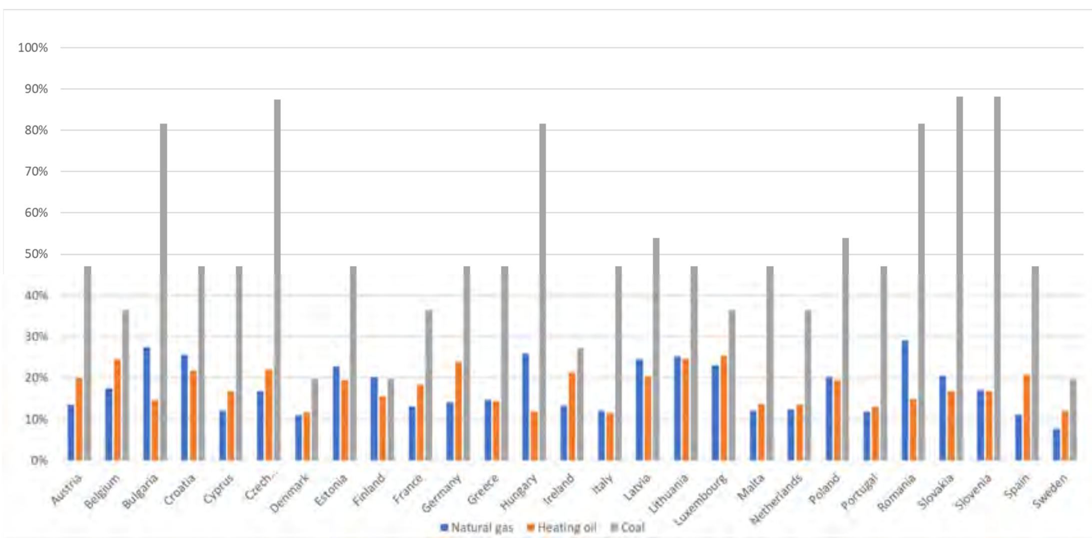
In addition to the absolute price increase per sales unit of the respective fuel, the relative end-user price increase due to a CO_2 price is also of importance to consumers, as this shows by what percentage the fuel price would increase. Figure 70 to Figure 73 give an overview of the expected percentage price increase of fuels in the building and transport sector per Member State. For the buildings sector, the relative price increases of the fuels vary considerably between Member States. In Romania, Croatia or Hungary, for example, the price increase for natural gas is in relative terms very high, whereas in Lithuania, Luxembourg, Belgium or Germany the price increase for heating oil is in relative terms higher. In the transport sector, in contrast, the picture is more homogeneous. In this sector, the price of CO_2 leads to a very strong relative price increase of LPG in almost all Member States, whereas petrol has the lowest relative price increase. This is because petrol is the most expensive fuel in almost all Member States, whereas LPG is the cheapest fuel almost everywhere. Consequently, a CO_2 price leads to a strong relative increase in the price of LPG, whereas the price of petrol increases less in relative terms, even though in absolute terms the price mark-up on LPG is lower than on petrol.

Figure 70. Fuel price increase due to CO_2 price in building sector for a fuel price of 20€ per ton



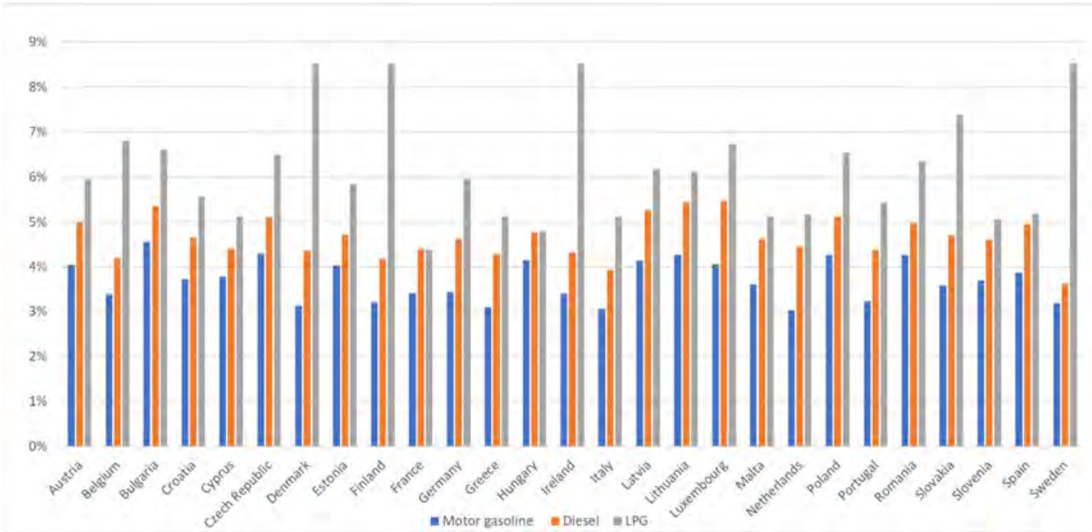
Calculations based on Fraunhofer ISI/enerdata data set on energy prices by different energy carriers in Residential / Transport sectors per Member State

Figure 71. Fuel price increase due to CO_2 price in building sector for a fuel price of 50€ per ton



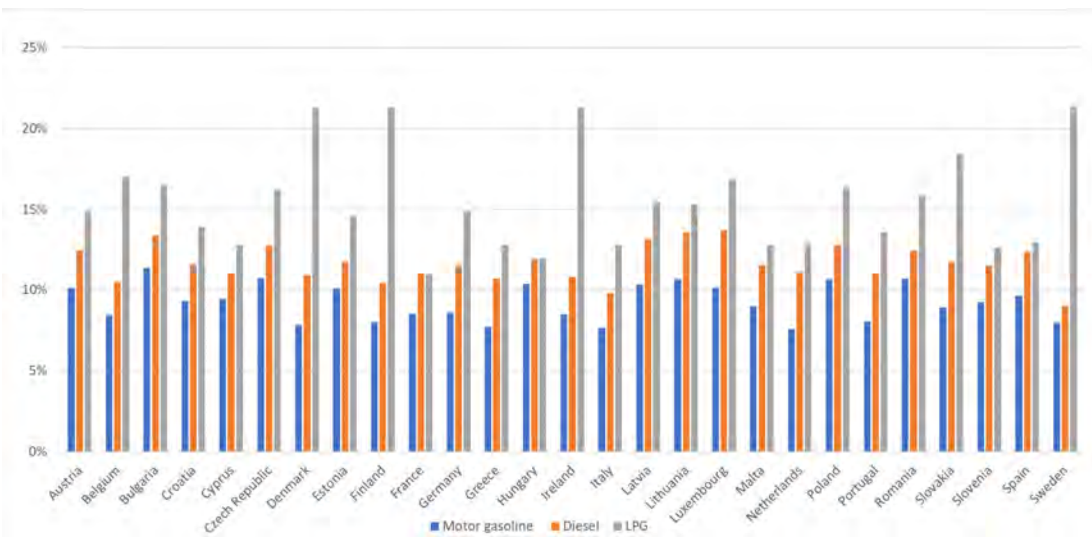
Calculations based on Fraunhofer ISI/enerdata data set on energy prices by different energy carriers in Residential / Transport sectors per Member State

Figure 72. Fuel price increase due to CO_2 price in transport sector for a price of 20€ per ton



Calculations based on Fraunhofer ISI/enerdata data set on energy prices by different energy carriers in Residential / Transport sectors per Member State

Figure 73. Fuel price increase due to CO_2 price in transport sector for a price of 50€ per ton



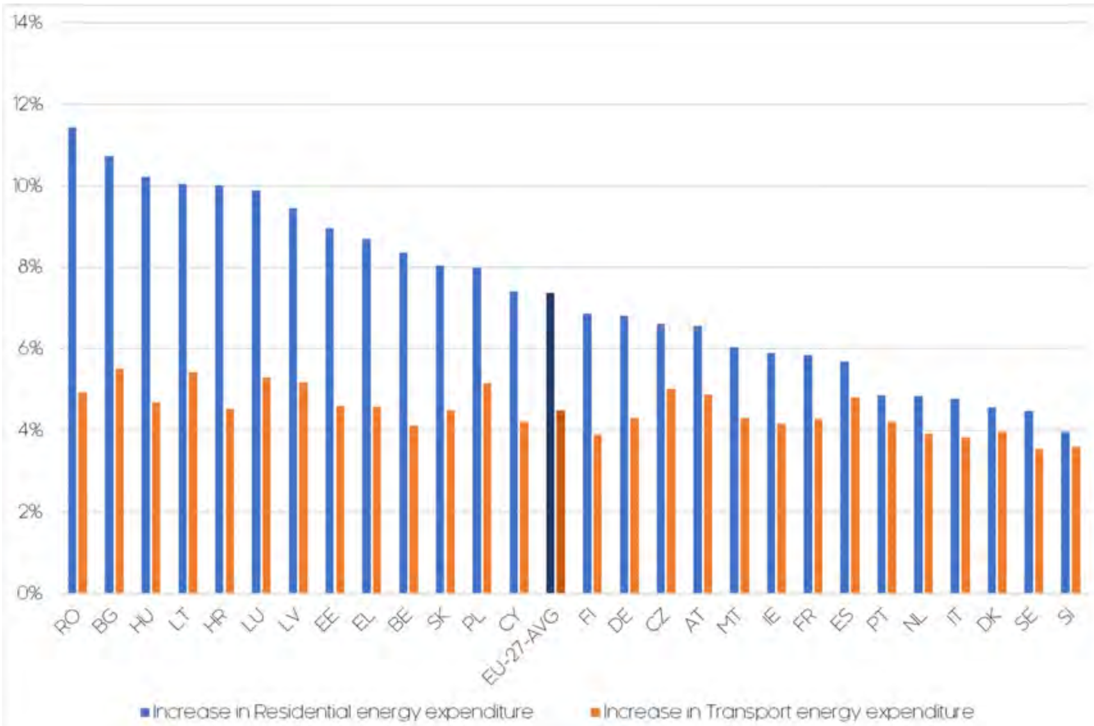
Calculations based on Fraunhofer ISI/enerdata data set on energy prices by different energy carriers in Residential / Transport sectors per Member State

The charts below present headline results with regards to the amount of additional expenses households would face as a result of including buildings and transport in the EU ETS. Additional expenses are calculated for each member states based on an assumption of a carbon price of 20 EUR/tCO_2 and the current (2017) emission levels attributed to the household energy and residential transport energy volumes.

In addition, percentage increases in Residential energy expenses and Transport energy expenses are presented for the EU-27 average based on an assumption of a carbon price of 30 and 50 EUR/tCO_2.

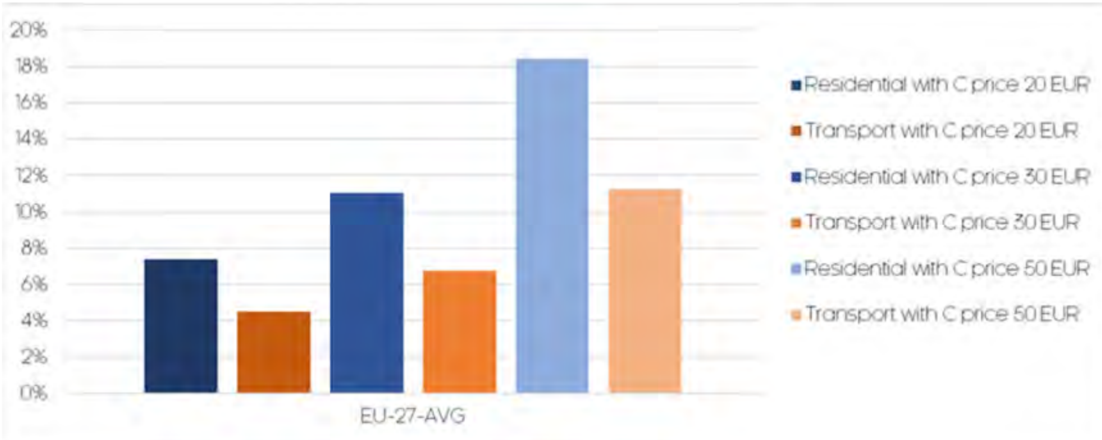
Charts presenting EUR volume increases in household energy and transport energy expenditure are calculated for each member states with carbon price assumptions of 20, 30 and 50 EUR/tCO_2, respectively.

Figure 74. Increase in Residential energy expenses and Transport energy expenses under an EU-ETS as a percentage of initial expenses, EU-27 member state level and EU-27 average, with a carbon price of 20 EUR/tCO_2, %, 2017



Source: Cambridge Econometrics calculations, based on Fraunhofer ISI dataset on households' energy use, residential transport energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 20 EUR/tCO_2. Measured as a percentage increase of initial spending on household energy use and on transport fuel use, respectively. Ordered by increase in Residential energy expenditure, largest to smallest.

Figure 75. Increase in Residential energy expenses and Transport energy expenses under an EU-ETS as a percentage of initial expenses with a carbon price assumption of 20, 30 and 50 EUR /tCO₂, EU-27 average, 2017



Source: Cambridge Econometrics calculations, based on Fraunhofer ISI dataset on households' energy use, residential transport energy use, the related CO2 emissions as of 2017, and an assumed carbon price of 20, 30 and 50 EUR/tCO₂.

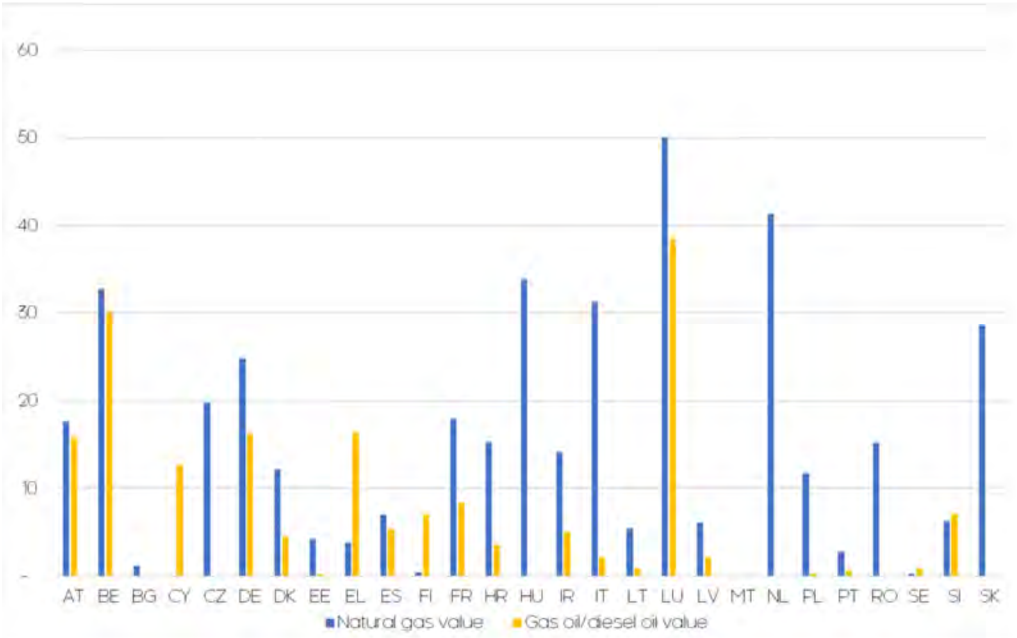
On average, the additional expenses arising as a result of an ETS inclusion, would be proportionally higher in case of household energy expenses than in case of transport expenses.

Three key insights can be inferred based on the presented charts.

- Additional expenses would be in volume terms higher, on average, in the case of passenger transport expenditure, than in the case of household energy expenditure[119]. However, the additional costs arising as a result of ETS inclusion, in percentage terms, would yield a more drastic increase in household energy expenditure (+7.4% increase on average across EU-27) than in case of transport expenditure (+4.5% increase on average across EU-27) compared to no inclusion. This observation supports our assumptions underlying Section 4.3 of this study (Just transition) in terms of demand response to changes in costs (of, i.e. household fossil fuel or transport fuel) in that price elasticity of household natural gas demand is expected to be inherently lower than price elasticity of households' demand for transport fuels.
- The results for additional expenses on household energy expenses show relatively large variance across countries, which is ultimately driven by the initial share of natural gas in the households energy mix. For instance, Italy, Ireland or the Netherlands would face relatively larger increase of additional expenses on gas.
- While the additional expenses on transport energy by households are expected to be less volatile across countries (with most of the countries facing relatively similar expenditure increases), there is a clear tendency for these expenses to be driven by increased expenditure on gas oil / diesel oil.

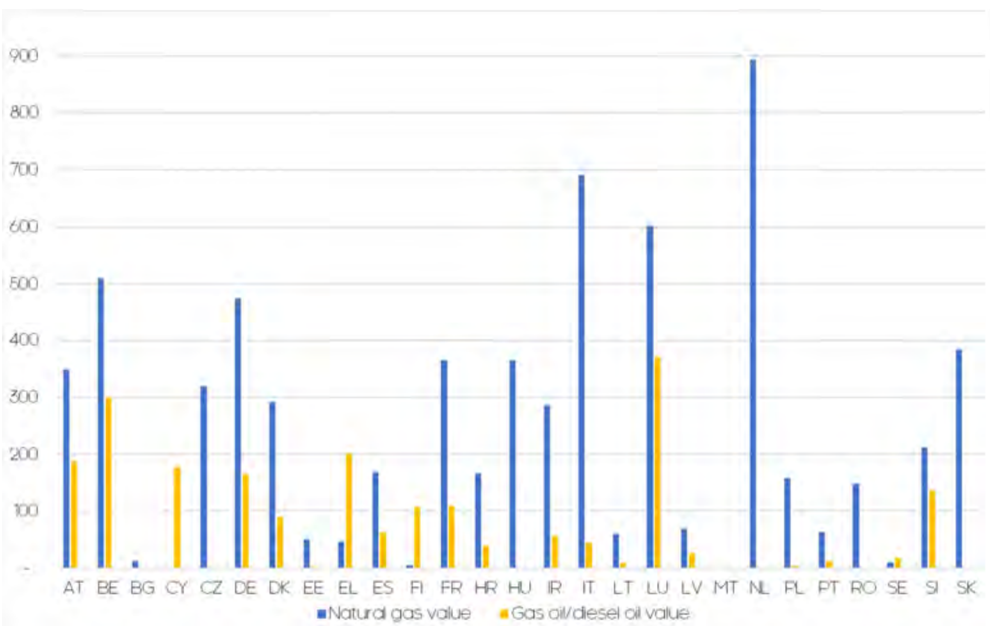
[119] This difference, theoretically, could be explained by the different normalization method applied: while total expenses on household energy are normalized based on the number of households, total expenses on passenger transport energy use are normalized across countries based on the number of passenger cars. However, with a passenger car per household ratio of 1.18 on average in EU-27, the two normalization methods are considered to yield comparably scaled results in terms of normalization.

Figure 76. Additional CO_2 costs in the Residential sector under EU-ETS in EU-27, with a carbon price of 20 EUR/tCO_2, 2017 (normalized by the number of households, in EUR)



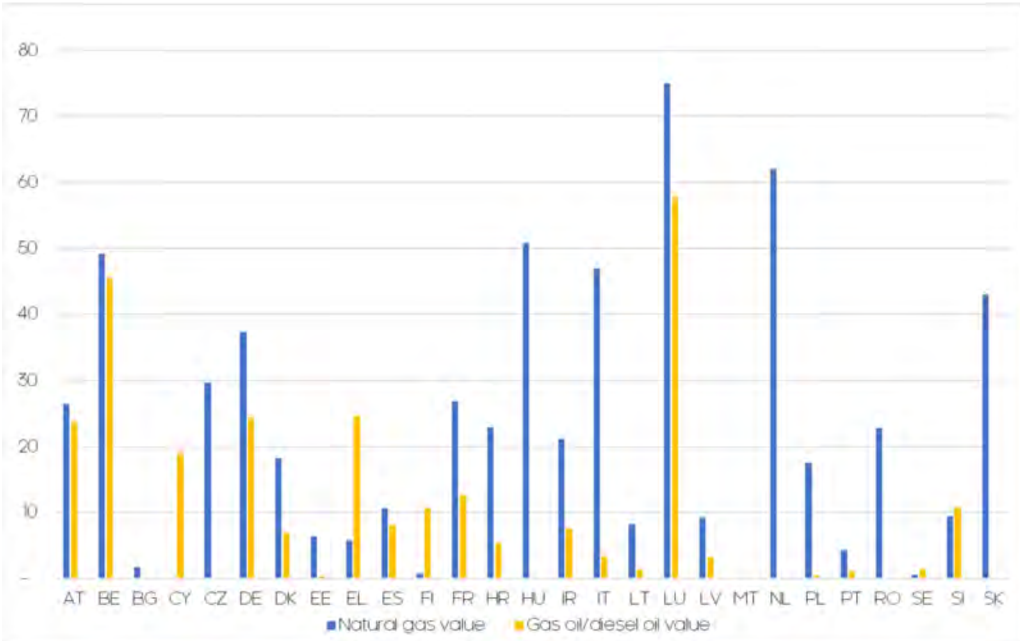
Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on households' energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 20 EUR/tCO_2.

Figure 77. Total expenses (with additional CO_2 expenses) in the residential sector under EU-ETS in EU-27, with a carbon price of 20 EUR/tCO_2, 2017 (normalized by the number of households, in EUR)



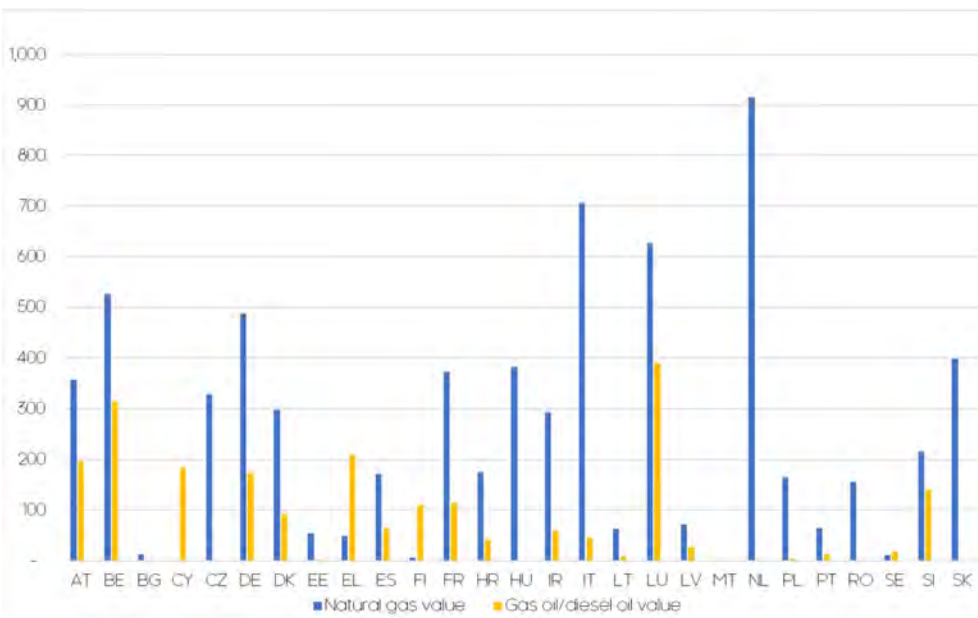
Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on households' energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 20 EUR/tCO_2.

Figure 78. Additional CO_2 costs in the Residential sector under EU-ETS in EU-27, with a carbon price of 30 EUR/tCO_2, 2017 (normalized by the number of households, in EUR)



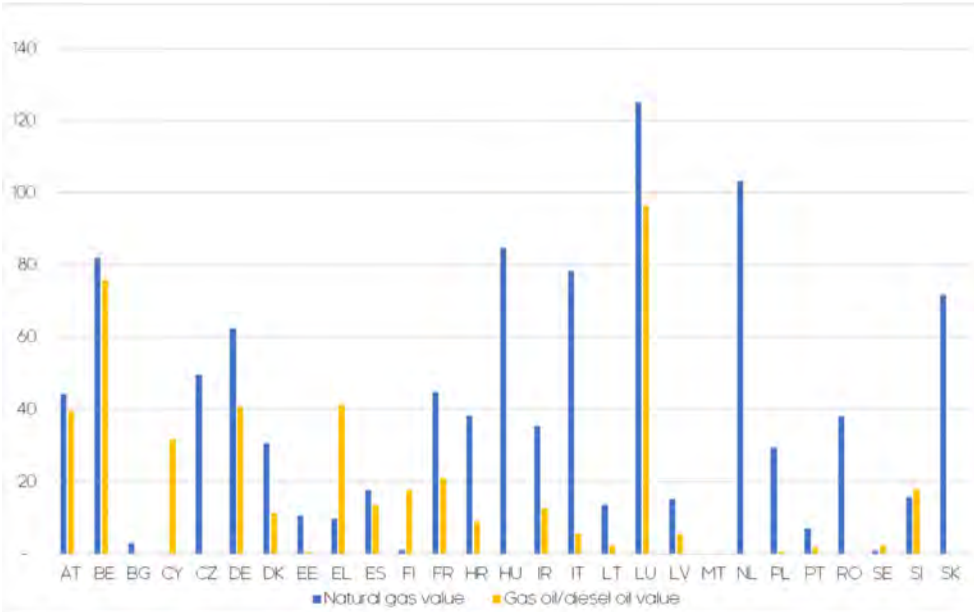
Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on households' energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 30 EUR/tCO_2.

Figure 79. Total expenses (with additional CO_2 expenses) in the residential sector under EU-ETS in EU-27, with a carbon price of 30 EUR/tCO_2, 2017 (normalized by the number of households, in EUR)



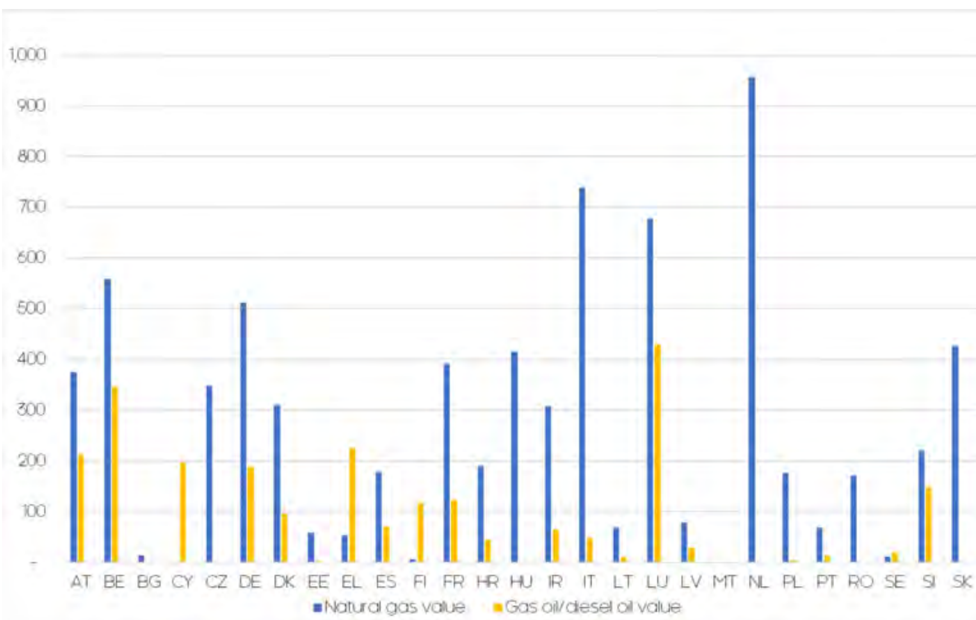
Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on households' energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 30 EUR/tCO_2.

Figure 80. Additional CO_2 costs in the Residential sector under EU-ETS in EU-27, with a carbon price of 50 EUR/tCO_2, 2017 (normalized by the number of households, in EUR)



Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on households' energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 50 EUR/tCO_2.

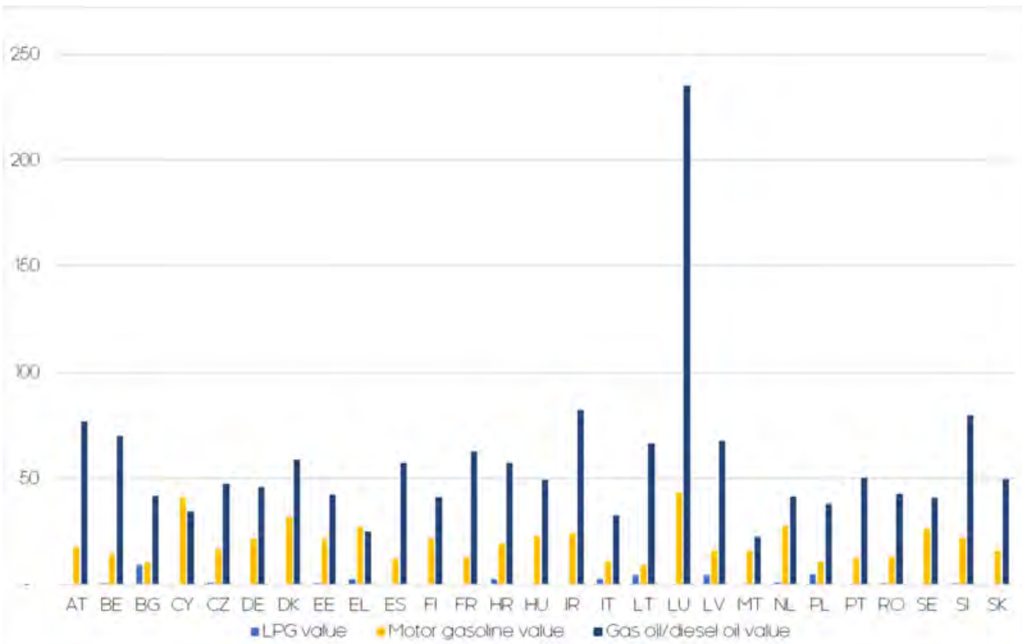
Figure 81. Total expenses (with additional CO_2 expenses) in the residential sector under EU-ETS in EU-27, with a carbon price of 50 EUR/tCO_2, 2017 (normalized by the number of households, in EUR)



Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on households' energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 50 EUR/tCO_2.

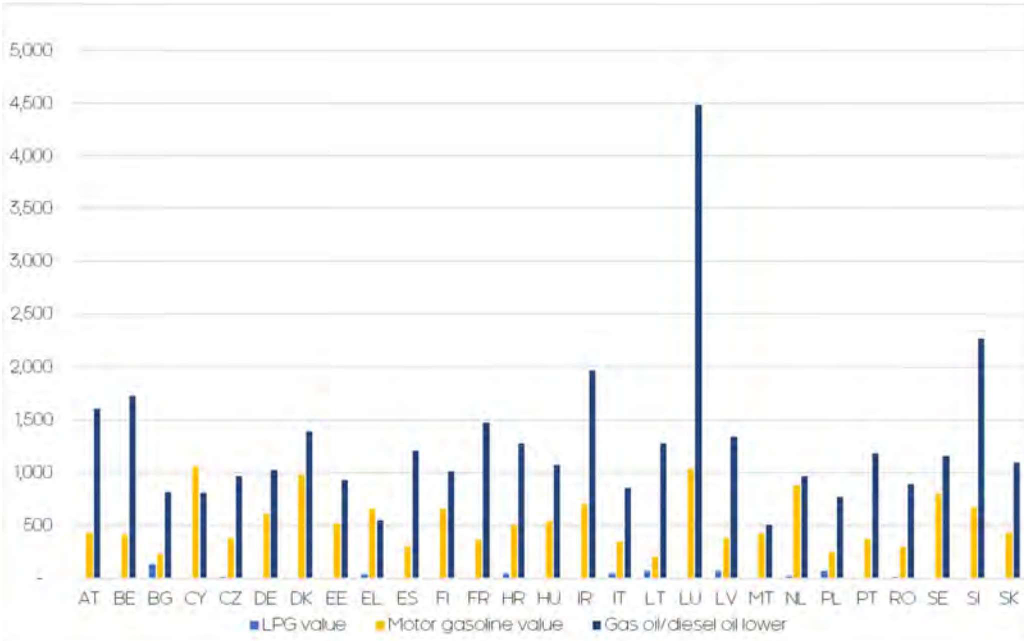
Figure 82-87 show what additional CO_2 expenses would arise, on a per-passenger car basis, under a carbon price of 20, 30 and 50 EUR/tCO_2, and what would be the total expenses (including these additional CO_2 expenses) under the same scenarios. In all charts, axis shows EUR values, various column colours show different fuel types. Additional expenses are expressed as EUR / passenger car (calculated based on country-level data) in order to better capture the magnitude of impact at the individual household level.

Figure 82. Additional CO_2 expenses in the road transport sector under EU-ETS in EU-27, with a carbon price of 20 EUR/tCO_2, 2017 (normalized by the amount of passenger cars, in EUR)



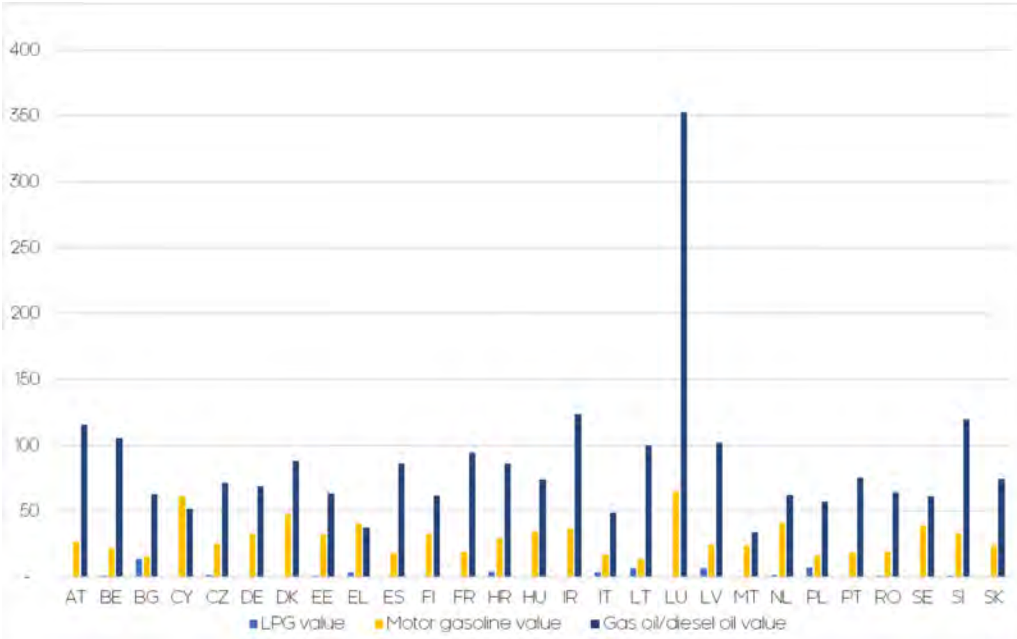
Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on transport energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 20 EUR/tCO_2.

Figure 83. Total expenses (with additional CO_2 expenses) in the road transport sector under EU-ETS in EU-27, with a carbon price of 20 EUR/tCO_2, 2017 (normalized by the amount of passenger cars, in EUR)



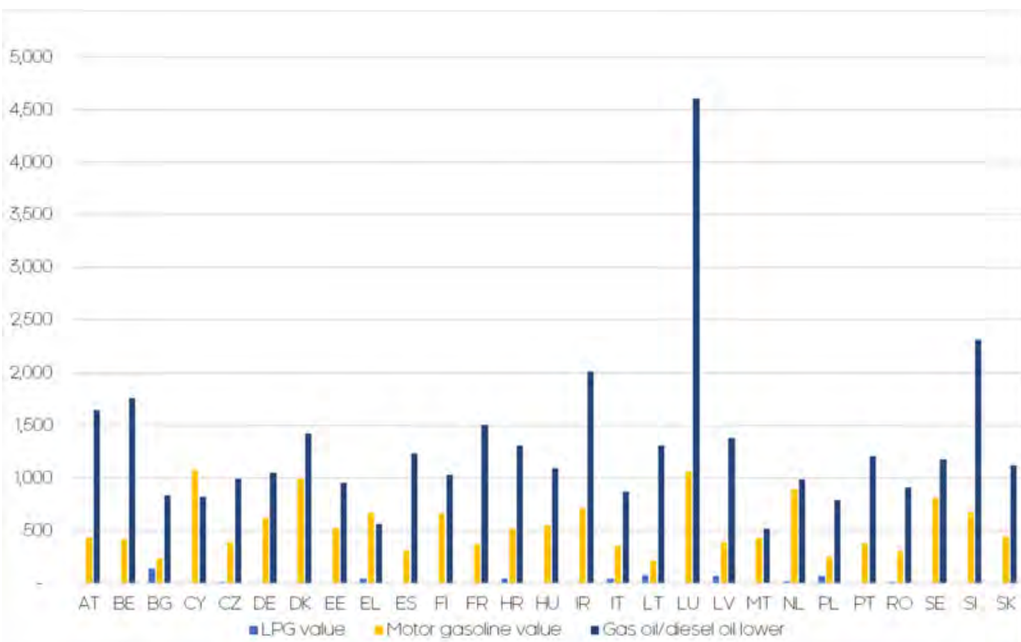
Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on transport energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 20 EUR/tCO_2.

Figure 84. Additional CO_2 expenses in the road transport sector under EU-ETS in EU-27, with a carbon price of 30 EUR/tCO_2, 2017 (normalized by the amount of passenger cars, in EUR)



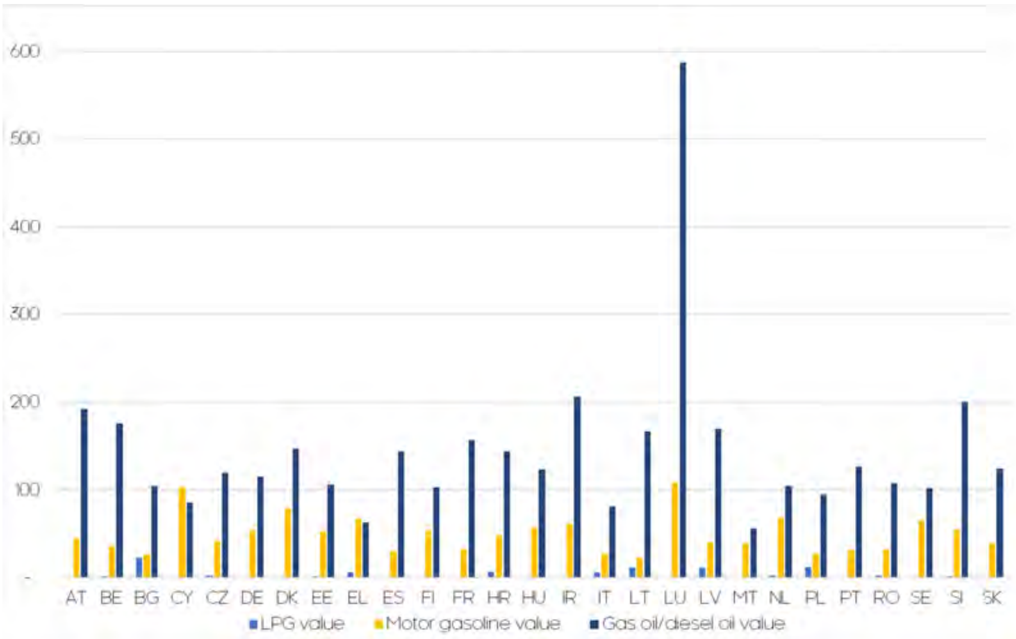
Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on transport energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 30 EUR/tCO_2.

Figure 85. Total expenses (with additional CO_2 expenses) in the road transport sector under EU-ETS in EU-27, with a carbon price of 30 EUR/tCO_2, 2017 (normalized by the amount of passenger cars, in EUR)



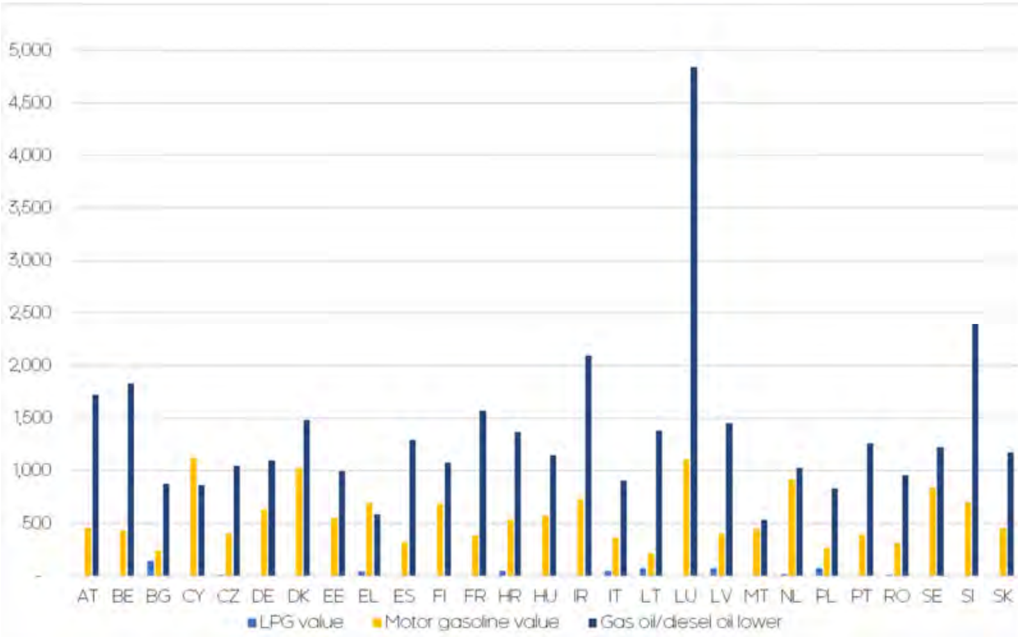
Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on transport energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 30 EUR/tCO_2.

Figure 86. Additional CO_2 expenses in the road transport sector under EU-ETS in EU-27, with a carbon price of 50 EUR/tCO_2, 2017 (normalized by the amount of passenger cars, in EUR)



Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on transport energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 50 EUR/tCO_2.

Figure 87. Total expenses (with additional CO_2 expenses) in the road transport sector under EU-ETS in EU-27, with a carbon price of 50 EUR/tCO_2, 2017 (normalized by the amount of passenger cars, in EUR)



Source: Cambridge Econometrics calculations, based on Fraunhofer ISI data set on transport energy use, the related CO_2 emissions as of 2017, and an assumed carbon price of 50 EUR/tCO_2.

Use of auction revenues

- In a mid- or upstream system the whole concept of putting a price on CO_2 is based on the assumption that those prices can be passed on along the supply chain to the end user (who is then able to react to the price signal and reduce emissions accordingly). In case of free allocation of allowances to the regulated entities, two things could happen: if the price signal is passed on along the supply chain (as assumed), regulated entities receiving free allocation of allowances could generate windfall profits similar to the case of electricity generators in the first years of the EU ETS. If, on the other hand, the price signal cannot be passed on along the supply chain free allocation can prevent high costs for regulated entities. However, in that case it is not very likely that the introduction of the ETS results in incentives to reduce emissions for the end-user. In that case, it needs to be considered whether an ETS is the appropriate policy instrument or if other instruments are more likely to result in the necessary emission reductions. Therefore, auctioning of allowances to the regulated entities is the logic choice in such a system (see e.g. Agora 2019, CE Delft 2014 or Oeko-Institut 2014).
- Some literature suggestes free allocation based on (fuel) benchmarks (see CE Delft 2014, Agora 2019) in line with the EU ETS regulations. This presents an option in sectors where part of the installations are covered by the EU ETS while others would be regulated under a separate system (e.g. small and medium industry installations, which are not addressed in our case) and hence distortion of competition could occur (Agora 2019) or for selected sectors that are not able to pass on costs but for which an exemption from the regulation is more costly than an inclusion combined with free allocation of allowances. For the design options analysed within this report, this would only apply the options

that only include the commercial parts of the two sectors and if it was found that a differentiation of end use of fuels is more complex than a system with free allocation of allowances for the non-regulated private parts of the sectors. As emissions from the private parts are, however, higher compared to the commercial parts, it seems unlikely that in any of the design options analysed here free allocation of allowances presents a reasonable solution.
To deal with unwanted distributive effects or cost burdens in the context of a mid- or upstream system compensation schemes similar to the provision allowing for compensation of the national electricity price increase due to CO_2 costs under the EU ETS are preferable options.

Assuming that (at least part of the) allowances are being auctioned, the use of the auction revenues can be seen as an integral part of an ETS to compensate regulated entities and consumers who face higher prices but have difficulties in dealing with the effects.

While there are many variants as to how (at least part of) the allowances would be auctioned; here three “archetypes” of recycling options are briefly presented with regards to expected social outcomes: Full recycling, Low-carbon investment support, Government debt paydown. What influence the design options have on the government's decision cannot be fully determined here, as this depends in particular on the governments in the Member States. In principle, however, it can be assumed that the higher the revenues from the auctions, the more will or political pressure there is to pay them back to the population. It can therefore be assumed that regulation of the entire transport and building sector will lead to a greater willingness to pay back the collected money to the population, in other words, to recycle it. On the other hand, including only commercial buildings and freight transport would possibly lead to more lobbying, which could possibly improve the position of certain interest groups. This may lead to increased low carbon investment support for some interest groups.

Full recycling

In this exemplary option, 100% of revenues are recycled through reductions in income tax, employers’ social security contributions and VAT (e.g. in equal proportions).

Outcomes: it is expected that an ease of employers’ burdens may result in positive social impacts through employers providing more benefits to those socially in need.

Low-carbon investment support

In this exemplary option, revenues are recycled as follows:

- 90% through tax cuts (as in case of Full recycling)
- 9% through investment specifically in energy efficiency improvements (most typically, as also assumed by the 2018 Energy Efficiency Report[120] of the IEA in fuel efficiency and electric vehicles in Transport sector and in supporting building envelopes and efficient appliances in the Buildings sector)
- 1% through direct subsidies for investment in RES technologies (primarily, in wind and solar technologies)

Outcomes: recycling some revenues to low-carbon investment is expected to lead to a higher share of renewables in generation, which is expected to result in a lower ETS price (compared to the option of Full recycling) because abatement costs, in general, are reduced. The underlying mechanism here is as follows: policy measures that lower

[120] IEA (2018) Market Report Series: Energy Efficiency 2018. Available at: https://webstore.iea.org/market-report-series-energy-efficiency-2018

the cost of new technologies in fact increase the price elasticity of harmful emissions, thereby bringing down the ETS price.

Government debt paydown

In this exemplary option, 90% of revenues are recycled through tax cuts (as in case of Full recycling) and 10% is not recycled, but used to pay down government debt instead.

Outcomes: this option, while can be considered to be politically fairly rational, is less likely to bring about positive social outcomes (through redistributive mechanisms). In this option, money is effectively taken out of the economy and thus cannot be used, e.g. to mitigate potentially negative impacts on specific income groups.

4.1.2.2 Regulatory criteria

The analysis of the designed options should also be based on established regulatory criteria which determine their legal feasibility and EU level justification to act in relation to the effectiveness and efficiency of the measure.

The Regulatory criteria requires for each option the analysis of the EU competence to legislate on the specific matter depending on the scope and the EU added value of the designed measures according to the subsidiarity and proportionality principle requirements under EU law. Furthermore, ensuring that the designed options are feasible to implement and enforceable is critical for the credibility of the EU.

EU competence and legal basis. Subsidiarity and proportionality principles

The extension of the ETS entails the adoption of an EU legislative act whatever options are designed except for the Option 0 (baseline) and the act would probably be adopted as a measure whose main objective would be to ensure protection of the environment. The EU competence on environment and climate action policy is recognised in the Treaties, under Article 4 TFEU amongst the policies of shared competence and includes the objective to promote measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change (Article 191 TFEU). Since all measures required for each option have an emissions reduction objective, the analysis of the EU competence is similar to all of them and responds to the requirements to adopt an act under Article 192 TFEU.

All options considered except for Option 0 require the adoption of one or more **legislative acts** amending, *inter alia*, the ETS Directive 2003/87/EC, and the Effort Sharing Regulation (EU) 2018/842 and/or **non-legislative acts** such as Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions amending Commission Regulation (EU) No 601/2012, Commission Implementing Regulation (EU) 2018/2067 on the verification of data and on the accreditation of verifiers; Commission Regulation (EU) No 389/2013 establishing a Union Registry as amended in 2018 and 2019.

Table 60. ***Regulatory measures likely needed for each design option***

Design Options	Sectors	ETS Directive amendment	ESR amendment	MRV and other acts (e.g. Registry Regulation)
Option 0 (baseline)	No EU-wide extension of the EU ETS,	n/a	n/a	n/a

Design Options	Sectors	ETS Directive amendment	ESR amendment	MRV and other acts (e.g. Registry Regulation)
	potential opt-in by individual MS			
Option 1a - full scope extension	Full EU-wide scope extension of the EU ETS to include road transport + buildings	Yes	Yes (to take into account the road transport and buildings are not covered by the ESR)	Likely, to incorporate new sectors
Option 1b - full scope extension under existing ESR	Full EU-wide scope extension of the EU ETS to include road transport + buildings	Yes	Yes (to take into account that road transport and buildings are also regulated under the ETS)	Likely, to incorporate new sectors
Option 1c - scope extension for freight transport and commercial buildings	EU-wide scope extension of the EU ETS to include freight transport + commercial buildings	Yes	Yes (to take into account that freight road transport and commercial buildings are not in the ESR)	Likely, to incorporate new sectors
Option 2a - scope extension for road transport	EU-wide scope extension of the EU ETS to include road transport	Yes	Yes (to take into account the ESR does not cover road transport)	Likely, to incorporate new sectors
Option 2b - scope extension for buildings	EU-wide scope extension of the EU ETS to include buildings	Yes	Yes 9 (to take into account that buildings are not covered by ESR)	Likely, to incorporate new sectors
Option 3a - separate ETS for road transport + buildings	Separate ETS scheme for road transport + buildings	Yes	Yes (to take into account that ESR applies	Likely, to incorporate new sectors

Design Options	Sectors	ETS Directive amendment	ESR amendment	MRV and other acts (e.g. Registry Regulation)
with limited linking to the EU ETS			together with ETS)	
Option 3b - separate ETS for freight transport + commercial buildings with limited linking to the EU ETS	Separate ETS scheme for freight transport + commercial buildings	Yes	Yes (to take into account that ESR applies together with ETS)	Likely, to incorporate new sectors
Option 3c - two separate ETS, one for road transport, one for buildings with limited linking between new systems and with the EU ETS	Two separate ETS schemes, one for road transport, one for buildings	Yes	Yes (to take into account that ESR applies together with ETS)	Likely, to incorporate new sectors

Source: Fraunhofer ISI

The legislative acts under consideration in each option need to be analysed on the basis of their specific design to determine the justification for the EU to act (the EU added value) according to the principles of 'subsidiarity' and 'proportionality' established under Article 5 of the Treaty of the European Union (TEU)[121]. These principles are not applicable to the adoption of measures defined as non-legislative acts as their justification and legal basis is established in the legal acts that require their adoption (Article 290 and 291 TFEU).

Subsidiarity is a principle which governs the choice of who should act, in situations with potentially more than one appropriate actor. Under this provision the analysis regarding each of the EU acts to be adopted should determine whether the objectives of the proposed action cannot be sufficiently achieved by the Member States in isolation at either central or local level, but can be better achieved at Union level for reasons of scale or effects of the proposed action. This analysis is linked to the effectiveness of the act. Similarly, based on the design details of each act to be considered, the analysis will need to cover the principle of proportionality which requires that the content and form of any EU action does not exceed what is necessary to achieve the intended objective. This implies that the act will achieve its objectives

[121] https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en

in the most efficient way, which might not necessarily be at the lowest possible cost and including governance procedures. The implementation of these principles means that each option needs to be analysed in relation to their contribution to the EU's emissions reduction objective.

Implementation, compliance and enforcement measures

The second set of regulatory criteria is linked to the compliance system required for the effectiveness of the ETS that would need to be applied to the new sectors. The ETS implementation is based on clear rules for Monitoring, Reporting and Verification (MRV) of emissions and the definition of enforcement measures to ensure implementation of the regulated entities' obligations and effective penalties for lack of compliance.

The design of the different options for the integration of the road transport and buildings sector in the ETS needs to consider the feasibility of implementation of the existing rules established under Monitoring and Reporting Regulation (EU) 2018/2066[122] and the Verification Regulation (EU) 2018/2067[123] which set a robust system for monitoring, reporting and verification (MRV) of emission where "one tonne emitted is one tonne reported". For this purpose, a strong compliance system is currently in place, requiring operators to:

- monitor emissions based on a monitoring plan approved by the competent authority (CA). The Monitoring plans must comply with defined minimum quality criteria;
- report emissions every year to the competent authority and
- surrender enough allowances to cover all its verified emissions

The 2015 evaluation of the EU ETS Directive recognises that the MRVA have increased the robustness of the system and improved the level playing field for participating industries[124]. The evaluation also recognises that the minimum requirements set for the development of the monitoring plan, and the Commission's publication of electronic templates, have led to a strong improvement of monitoring plan quality.[125] Regulated entities integrating the ETS from the road transport and buildings sector would need to fulfil similarly effective requirements such as listing all the metering instruments and monitoring approaches, outlining the data flows and implemented control procedures in place as they are essential for competent authorities to approve monitoring plans. For those options where the sectors would be integrated in the current ETS, the analysis will need to ensure that the current compliance rules for monitoring and reporting are feasible for the regulated entities. Under the options where the sectors integrate a separated ETS system, similar rules would need to be designed to ensure a level playing field and the robustness of the system.

It is also important that regulated entities are subject to similar rules regarding the verification of emissions by independent, impartial and competent verifiers who are

[122] Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions amending Commission Regulation (EU) No 601/2012

[123] Commission Implementing Regulation (EU) 2018/2067 on the verification of data and on the accreditation of verifiers

[124] Evaluation of the EU ETS Directive, Ecologic and SQ Consult, 2015, https://www.ecologic.eu/sites/files/publication/2015/2614-04-review-of-eu-ets-evaluation.pdf

[125] Evaluation of the EU ETS Directive, Ecologic and SQ Consult, 2015, https://www.ecologic.eu/sites/files/publication/2015/2614-04-review-of-eu-ets-evaluation.pdf

accredited by a national accreditation body and the use of a verification template designed to improve the quality of verification.[126] For those options where the road transport and buildings sectors would integrate the current ETS system, the current verification system would be applicable to them, requiring appropriate capacity of verifiers. The recently adopted guidance document by the Commission on EU ETS inspections aiming to remedy the problems of capacity of the authorities to check the verified reports might need to be adapted. For those options where the sectors would integrate a separated ETS, similar rules and guidance documents would need to be tailored ensuring a level playing field with the sectors under the current ETS.

In addition, under the ETS Directive 2003/87/EC, the breach of the obligation to surrender an equivalent number of emission allowances, every year by 30 April, entails the activation of a compliance system by which competent authorities impose effective, proportionate and dissuasive penalties to operators not complying with the rules. The current ETS Directive under its Article 16(3) requires 100 € (+inflation) penalty to be paid for each $tCO_2(e)$ emissions for which no allowance has been surrendered (without waiving the requirement to surrender the allowances). This penalty system ensures environmental integrity (i.e. effectiveness of the cap) and transparency by the publication of the name of the installations and aircraft operators which have failed to surrender sufficient allowances for covering their verified emissions (Article 16(2)). Other penalties “effective, proportionate and dissuasive” are left to the Member States discretion including in relation to obligations not stated in the ETS Directive but in the EU legislation regulating MRVA.

The regulatory criteria to assess the different options would require that similar rules are applicable to the new sectors integrating the ETS or a separated system.

The implementation of other legal acts might also have an impact on the compliance and enforcement of the ETS. For example, any obligations linked to monitoring and reporting under the ETS might benefit from exiting tools like smart metering already introduced in buildings to support the implementation of the EED.

While the adoption of EEOS is specifically mandated within Article 7 of the EED, Member States may choose to implement alternative measures or a combination of both. Some measures of the designed EEOS in the 15 countries that are using them, set incentive measures, including subsidies, to achieve energy savings in certain sectors such as vulnerable or low-income households or community-based initiatives. Those measures could promote compliance and implementation of the ETS. Some promote information on efficient energy use, how to reduce the energy bill or how to read smart meters. They promote also the use of other funding instruments to support the necessary investments such as cohesion funds or innovative funding mechanisms. Others promote skill development programmes and training experts. Those measures could interact with the implementation of the ETS covering all fossil fuels by supporting regulated entities to fulfil their obligations for monitoring emissions or training verifiers.

The ETS price might trigger the implementation of energy efficiency measures (e.g. retrofitting existing buildings, as mentioned in section 4.2). However, as energy savings planned under the EEOS have to be additional to those which are expected from existing EU efficiency policies, the objectives in the new designed EEOS will need to take into account the mandatory reduction of emissions under the ETS.

[126] Ibid.

4.2 Question 3.2: Point of regulation

4.2.1 General Principles

The point of regulation for an ETS of greenhouse gas emissions from the building and transport sector is a key design element of an emissions trading scheme. Emissions from the two sectors are combustion emissions from fossil fuels, which limits the scope of regulation to the fuel supply chain, i.e. to a segment of the chain between producer/importer and consumer. We limit our analysis to mid- and upstream approaches for regulation. The possibility of a pure downstream regulation, as in the existing EU ETS, seems to be a less efficient option due to high transaction costs caused by the large number of regulated entities and the fact that in this case many private persons would also be regulated. A brief excursion on this topic is given in section 4.4.3.

There are two aspects to be considered when deciding on the point of regulation. First, the further upstream the regulation, the smaller the number of regulated entities and the lower the administrative burden. Moreover, a smaller number of entities means that they are generally larger and their share of transaction costs in the costs of emissions trading tends to be lower than for small entities. Second, the further down the supply chain the regulation, the more precisely the delivered fuels can be matched to their intended use and the more likely a price signal is passed on to the end consumer. In the first literature on upstream emissions trading systems, such as in Bader (2000), it is recommended to regulate emissions as far upstream as possible. This has the advantage of few actors and a simple registration of all energy quantities. However, such an approach seems to make sense only in the case of a Greenfield implementation, which has the objective of covering all emissions from the combustion of fossil fuels. In the present case, however, due to the existing EU ETS and other existing climate policy instruments, the implementation is a brownfield implementation, which should only include the road transport sector and the building sector and requires to separate fuels that are being used in already regulated entities. More downstream regulation seems to be preferable, as it must be possible to ensure that only energy flows for road transport and buildings are regulated. Double counting of fuels regulated in the EU ETS and upstream ETS must also be prevented, because it contradicts the intention of an ETS to use market mechanisms to reduce emissions at the lowest economic cost. Double counting would therefore be permissible below certain de minimis limits, for example, if the administrative effort required to prevent double counting is greater than the resulting burden. In this case, ex-post compensation would have to take place. It should be noted that very high upstream in the supply chain it is often not known yet what the fuels are used for. This is especially true for primary and intermediate products such as crude oil or naphtha, but also for end products such as petroleum or diesel, which can be used for combustion. Also, the transit of products from abroad to other countries outside the EU must be taken into account. As the end-use of the fuels plays a role in a hybrid system as the one analysed here it has to be considered whether the cost of tracking fuels over several parts of the supply chain, or whether a higher number of regulated entities is more efficient.

Table 61 gives an overview of the necessary information on the final consumer of the fuel that the regulated entity must have depending on the design option. In all design options, except Option 0, the regulated entities must be able to identify fuels used in buildings and/or fuels used in road transport. Options 1c and 3b raise particular challenges, as in these two cases only freight transport and only commercial buildings are covered, which could require additional information.

Table 61. Design options and necessary knowledge about the end user

Design Options	Necessary knowledge about the end user
Option 0	MS individual
Option 1a	Need to identify the use in road transport or in buildings
Option 1b	Need to identify the use in road transport or in buildings
Option 1c	Need to identify use in freight road transport or commercial buildings
Option 2a	Need to identify use in road transport
Option 2b	Need to identify use in buildings
Option 3a	Need to identify the use in road transport or in buildings
Option 3b	Need to identify use in freight road transport or commercial buildings

Regulation at the point of excise duty

In principle, regulation at the point of the excise duty seems possible. For petroleum products, this could be done by regulating tax warehouses, which are places where excise goods under duty suspension arrangements are produced, processed, held, received or dispatched by an authorised warehouse keeper. In the case of petroleum products, excise duty is levied in tax warehouses in the Member States. This means that the point of levying the tax on petroleum products is the same in all Member States. As the tax rates e.g. for the use of gas oil in transport or for heating in buildings differ in most Member States, tax warehouse operators usually know the final use (but not necessarily the end user) of the products they supply.

Of the three main fossil fuels, a harmonized tax warehouse system in all Member States exists only for petroleum products. In contrast, the excise duty on coal and gas in the Member States does not necessarily target the same point in the supply chain. The *Taxes in Europe Database v3*[127] on the website of the EU Commission provides an overview of the taxpayers of excise duty in the individual Member States. However, it is not complete for all Member States. According to the data available in the data base, in the majority of Member States the excise duty on coal and gas is levied at the level of the supplier to the final customer. For the excise duty on gas this is the case in e.g. Austria, Belgium, the Czech Republic, Germany, Ireland, Italy, Croatia, the Netherlands, Romania and Slovakia. However, there are also some exceptions where the excise duty point is not the supplier to the final consumer, such as in Hungary, where in addition to traders, users or producers may also be taxable persons. Since in the European gas market gas is almost completely supplied via pipelines, nearly all gas passes through an excise duty point, even if it is tax-exempt (only Hungary has a tax exemption for heating buildings with gas[128]). So, in principle, the excise duty point could also be chosen as the point of regulation for emissions trading. However, this would mean that not only end-user suppliers, but in certain cases and Member States other market participants would also be covered by emissions trading. This is not

[127] https://ec.europa.eu/taxation_customs/tedb/splSearchForm.html

[128] https://ec.europa.eu/taxation_customs/sites/taxation/files/resources/documents/taxation/excise_duties/energy_products/rates/excise_duties-part_ii_energy_products_en.pdf

preferable from a transaction cost perspective, as this would lead to an incalculable number of additional actors to be regulated in particular from countries where excise duty is levied from the consumer. Furthermore, it would have to be ensured that the gas traded is only regulated once, which is difficult to monitor if it is regulated at different levels of the supply chain and, in addition, in some cases, at consumer level. As gas plays a major role in heating buildings (see 3.1.1) and gas is traded a lot between the Member States, the transaction costs of an approach that always uses the excise duty point as the point of regulation must therefore be considered quite high. However, the fact that almost all Member States levy excise duty from the supplier to the end customer strengthens the argument that that point of regulation makes sense from a transaction cost perspective.

The market for coal products is more complex. In most Member States, as in the gas market, the seller to the final customer is the tax payer. However, there are exceptions to that. For example in Belgium the tax is levied when the coal is delivered to the retailer and in the Netherlands the tax is levied on producers and warehouse operators. In the coal market, which is much less regulated in terms of monitoring by the State in almost all Member States, not all coal products necessarily pass through an excise duty point. Nevertheless, in such a case, the excise duty point could also be a regulatory point for a new ETS, but it would need to be ensured that all coal for use in the building sector is passing through an excise duty point. Based on section 3.1.1, in seven Member States (Poland, Hungary, Ireland, the Czech Republic, Slovakia, Lithuania and Bulgaria) coal accounts for a significant share of fuels for heating in buildings. In Hungary and Slovakia, the use of coal in private households is exempt from excise duty[129], which is why coal for heating in buildings does not necessarily pass through an excise duty point in these countries. Even if these tax exemptions would not exist and it could be ensured that all coal used for heating in buildings is passing through an excise duty point, the same problem would arise for coal as for gas if excise duty point would to be set as point of regulation for an ETS: different parts of the supply chain would be regulated in the individual Member States which could lead to high regulatory costs for ensuring that coal is priced once, but only once under the EU ETS.

4.2.2 Defining entities to be regulated

Four aspects are crucial for choosing the most efficient regulatory point for the use of fossil fuels in the case of emissions trading: (I) is regulation at this point feasible at all? (II) Does the point of regulation allow for incentives to reduce emissions to be passed on to the consumer? (III) Are the transaction costs proportional to the reduction effect? And, (IV) very few regulated entities, or a few very large and many very small regulated entities, on the other hand, pose a problem of market power and should be avoided in emissions trading. The first aspect restricts the choice for the point of regulation, since only those points of regulation that can be practically implemented represent a sensible solution. For the aspects (II), (III) and (IV) it is more important to weigh up which advantages and disadvantages dominate. It is particularly important for the incentive effect that the consumer is aware of the price signal and that the regulated entities pass it on, because only consumers can significantly reduce emissions. It can be assumed that if the short-term price elasticity of demand is low, it is easier for companies to pass on the price. This is the case when consumers are unable to reduce or only slightly reduce their demand in the short term, such as for heating buildings. In these cases, GHG emission reductions can

---

129 https://ec.europa.eu/taxation_customs/sites/taxation/files/resources/documents/taxation/excise_duties/energy_products/rates/excise_duties-part_ii_energy_products_en.pdf

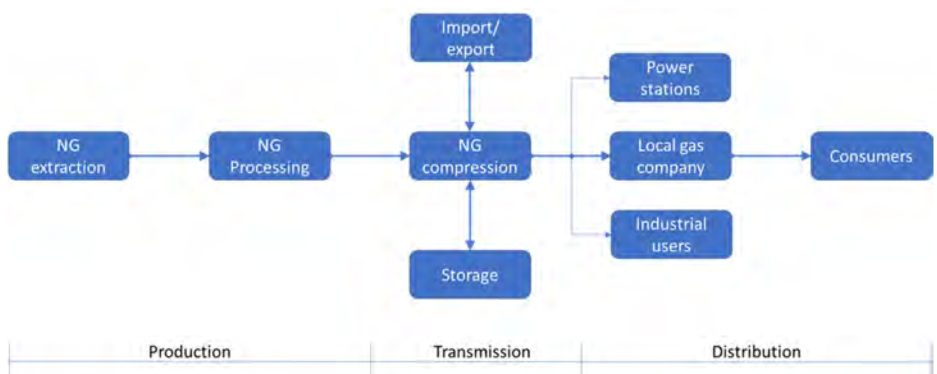
hardly be achieved in the short term, but only in the longer term. With regard to transaction costs, the number of entities to be regulated and the monitoring and reporting efforts are of particular importance. Transaction costs are generally incurred by the entities, but also by the public sector.

The following section gives an overview of the three main fuels for the two sectors buildings and road transport and discusses the advantages and disadvantages of regulation for all levels of the supply chain. The use of low-emission technologies such as electric vehicles, heat pumps or heating with biomass is not considered here, as electricity use is already regulated under the EU ETS, whereas biomass is considered a renewable energy source and therefore not covered by emissions trading.

4.2.2.1 Gas products

As Task 2.1 has shown, that gas is the most important fuel in the building sector with about 80 Mtoe resulting in a share of 32% of energy consumption in 2017 in residential sector and with about 37.5 Mtoe and a share of 28% of energy consumption in the commercial sector, but plays only a very small role in road transport with about 2.7 Mtoe and a share of 1% in energy consumption in 2018.

Figure 88. Supply chain of the gas market



- **Feasibility**

Figure 88 gives an overview of the supply chain in the gas market, which is explained in detail in section 2.1. At the top of the supply chain is the gas production, which includes extraction and processing. Extraction and processing are considered together, as this often happens in combination and is carried out by the same companies. Importers who import gas into Europe and gas storage are also classified at this level. Importers who import gas to Europe, and gas storage facilities are somewhat between Level 1 and Level 2, but since they feed gas into the transmission network, they are classified as level 1 in the following of this section. On the second level of the supply chain are the Transmission System Operators (TSO), who transmit the gas from central transfer points to regional and local distributors, to large power plants or industrial customers. At the third level on the supply chain are the regional and local distributors, since larger industrial plants and power stations are often supplied directly by the TSOs, this means that not all gas is delivered to the final consumer via the regional and local gas companies.

As mentioned above, an important factor in deciding which entities should be regulated is that it must be possible for the regulated entities to know the final use of the fuels. This is not possible at the first level, where it cannot be identified whether the supplied gas is used in the building or transport sector) or for other sectors. As large quantities of gas are supplied to industrial plants and power stations, regulation at this level of the supply chain seems not practical.

At TSO level, in contrast, a significant amount of gas is already sold directly to end customers. According to information from the Agency for the Cooperation of Energy Regulators (ACER), TSOs typically only know the off-takers, which are usually the local gas companies[130] or large energy consumers such as power plants, fertilizer plants, glass, cement, ceramics, metallurgy or large district heating systems. As there is already a significant amount of gas taken off at TSO level which is not intended for the building or road transport sector, it may be appropriate to regulate at TSO level and thus regulate all gas going to DSOs/ local gas companies. Then, in turn, compensation would have to be made for the industrial companies and power stations supplied by the DSOs. One argument against regulation at TSO level is unbundling, i.e. the separation of the owner of the gas and the transporter. TSOs are not the owners of the gas, but only transport it. However, regulating a company for a product that the company only transports but does not own seems problematic. The owners of the gas at TSO level are usually gas trading companies that sign long-term contracts with the producers and sell the gas to the regional distributors. There is also spot trading, which is usually done via the European Energy Exchange (EEX) in Leipzig and the National Balancing Point (NBP) in Great Britain. Due to the spot market, regulation at a level above regional distribution does not seem possible, as ownership rights in the spot market are not necessarily sold down the supply chain. The fact that not only gas trading companies participate in the spot market, but also regional distribution or specialised energy trading companies[131] complicates regulation at this level and would affect a large number of companies, more than if only regional distribution would be regulated.

At the DSO/ local gas company level, the end customers are known and it is easy to distinguish between the supply to buildings and other users. Even for the design options that only include the commercial building sector, regulation at this level seems feasible. Big customers have their individual consumption profile depending on type of operation (continuous, seasonal, day/night, etc.). Residential customers will also be individually known to local gas companies (for billing / metering), but they are not much different from each other – consumer profile would generally be the same with slight variations depending on size of dwelling, type of construction/insulation of the building and number of residents in the dwelling. Building heating systems are typically not connected to the TSO network, as this requires other pressure regulating stations (PRS), as the gas flows through the pipes at a completely different pressure. Large consumers who off-take gas directly from the TSO would have a PRS that takes the gas at line pressure (35-70 bar) and gets it on to the facility at 4-12 bar. DSOs have other PRS in their system, first from about 12 bar to about 4 bar, then even lower, all the way to 0.2 bar for residential customers. It can therefore be assumed that almost all building heating systems are supplied by DSOs and therefore no significant amount of gas for building heating is not covered by regulation at this level. However, if larger consumers, such as hospitals, hotels or petrol stations, have a direct connection to the TSO network, they would have to be included as specific cases under the regulation. The first step would be to check how many such exceptions actually exist. Two solutions would seem to be possible. Since it can be assumed that these exceptions are very large companies that purchase large quantities of gas, a downstream regulation of these companies would be possible, as is already possible today via Article 24. Another possibility would be that the gas is supplied by the TSO

[130] In some MS, due to unbundling, distribution system operators (DSOs) and local gas companies selling gas to final customers have been separated, so that the seller is not the same as the supplier.

[131] https://www.eex.com/de/handel/teilnehmerliste#/teilnehmerliste

but sold by a local gas company. These local gas companies would be the point of regulation in this case, which would mean that the gas sold would be regulated. In this case, the last step in the distribution supply chain would be bypassed, but not in the owner supply chain. In some countries, a distinction must also be made at the DSO level between the seller of the gas and the distributor of the gas, as they are partly separated due to competitive regulation. As mentioned above, regulation on the side of the owners, i.e. the sellers of the gas, seems preferable.

Incentives

As mentioned above, in addition to feasibility, the incentives for emission reductions, as well as the transaction costs, play a major role in choosing the point of regulation. Given the very low short-term price elasticities shown in Section 2.2.1, it should be possible to pass through the price at least in the short term. However, gas companies are increasingly having to compete with district heating, heat pumps and wood pellet heating. Against this background, natural gas suppliers could face the challenge that passing on the price signal would lead to a competitive disadvantage in one of their main consumer markets. However, this disadvantage compared to renewable energies would only in the medium- to long-term result in a reduction of sales as investments into new heating devices or new automobiles are needed. It is unlikely, that a significantly earlier replacement would take place due to the price increase for gas from the introduction of an emissions trading system. On the other hand, increasing competition in some member states due to unbundling and other competition-enhancing measures on the part of the distribution companies suggests that profit margins are rather low and additional costs must therefore be passed on to the consumer in the long term. However, it is important to note that competition at this level varies considerably from one Member State to another and that monopolistic structures in some Member States may hinder the passing on of the price signal. It may also be possible that the price signal could be distorted, for example if private customers or the commercial sector have more market power than the other sector. Given the structures and competition with renewable energies and district heating, it cannot be completely ruled out that the price signal in the gas market is not passed on to the consumer. To ensure that end consumers are also informed about and aware of the CO_2 price signal, the CO_2 price may have to be shown separately on the bill. Assuming that the price signal is fully passed on and given a carbon price of 20€ or 100€ per ton of CO_2 and a consumption of about 20,000 kWh per year, owners of gas heating systems must expect additional costs of about 81€ to 405€ per year.

Transaction costs

The additional transaction costs on the gas market resulting from the implementation of emissions trading would be moderate, as volumes are already metered at almost all levels of the supply chain, due to billing and supply, but also due to the strong regulation of the market. However, tracking the flow of gas to the consumer at levels in the supply chain above regional distribution would require significant effort. On the other hand, the number of entities is highest at the level of regional distribution. There would be 433 extractors and importers and 56 processors at the first level, 58 TSOs at the second level and 2,329 entities at the regional distribution level. Since the transaction costs in a company are not linear to its emissions, but small companies have relatively higher transaction costs than large companies (Heindl 2017) and since the administrative burden of the public sector also increases with the number of regulated entities, regulation at the TSO level would thus make sense from this perspective. However, it is not clear whether regulation of TSOs is possible, as they are not the owners of the gas. For ownership regulation at TSO level to be feasible and economically meaningful, it would need to be possible to identify ownership, to regulate who is responsible for the gas being transferred from the TSO grid to the DSO grid and the number of owners should not exceed the number of local gas companies (2,329). However, due to the spot market, it can be assumed that the ownership structure is not easily apparent, nor can it be precisely tracked whose gas is fed from the TSO grid into the DSO grid. Furthermore, many local gas companies also participate in the spot market, so it can be assumed that the number of players to be regulated should not be significantly lower when regulating the owners at TSO level than when regulating local gas companies.

Market structure

The European gas market is a highly regulated market due to its grid structure. Thus grid operators often have regional monopolies, which is mainly the case for the TSO. At the level of *gas producers and importers*, there are quite a number of players with 433 companies, but according to Eurostat only 67 of them have a market share of more than 5% in their home country.[132] The market share of the biggest players varies from 66% in Belgium, where 4 companies share this proportion, to 100% in Estonia or Finland, where there is only one producer on the market. The producer market in the Member States is therefore dominated by a few large companies. The situation is quite similar on the market for *gas retailers* on which 2,329 companies are operating, but only 110 have a market share of more than 5% in their home country. In Ireland (6 companies), Lithuania (2) and Luxembourg (4) the largest retailers deliver almost 100% of the gas sold in these countries. In Germany, which has the lowest market concentration, around 73% of gas is sold by smaller companies. Although market concentration is regionally very high at all levels of the supply chain, which is why the gas market is also one of the most regulated energy markets, these structures have little influence in terms of market power in emissions trading. Based on emissions using the figures in 2.1c, it appears that natural gas with emissions of about 289 $MtCO_2$ accounts for less than a quarter of total emissions from the building and road transport sectors. This means that even large gas companies would not have much market power in an emissions trading scheme that only includes road transport and buildings (Design Options 3a and 3b). If integrated into the existing EU ETS, which in 2018 showed about 1.67 Gt CO_2 emissions, there would also be no market power problem.

Conclusion gas market

Table 62 provides an overview of the main criteria for evaluating the point of regulation. Given the relatively inelastic nature of retail demand, the price signal is likely to be passed on through all levels. In theory, regulation at the production level would be feasible, but its practical implementation seems difficult. On the one hand, very high transaction costs would be incurred for tracking the gas to the point of use or for ex-post compensation of parties not belonging to the building and transport sector. Furthermore, the number of entities to be regulated is not particularly low and a few big players dominate the market. Regulation at the level of TSOs is difficult due to the situation described above regarding ownership rights and it is unclear whether regulation of TSOs or the owners of the gas is feasible at all. However, one advantage of regulating TSOs would be the small number of entities. Regulation at the distributor level has the disadvantage of more than 2,000 companies to be regulated, but the costs of identifying supply streams to buildings and filling stations are expected to be by far the lowest. A further distinction between residential and commercial buildings

[132] https://ec.europa.eu/eurostat/statistics-explained/index.php/Natural_gas_market_indicators#Natural_gas_market_-_import_.26_production_.28IMPRO.29

would also probably be feasible with the lowest costs at this level. Therefore, given the above mentioned market characteristics and the fact that excise duty is also levied at this level in most Member States, regulation at the level of regional distributors appears most appropriate. This applies to all design options considered in this section, since the gas flow to buildings or filling stations should be traceable for all design options (see Table 56). Also, the argument of market power, which is particularly relevant for the design options 3a and 3b, does not present a problem at the regional distributor level. As described above, TSOs are not the owners of the gas, but if a legal review shows that it is unproblematic to regulate a transporter of a good although he is not the owner, then TSOs would also be an option for the point of regulation.

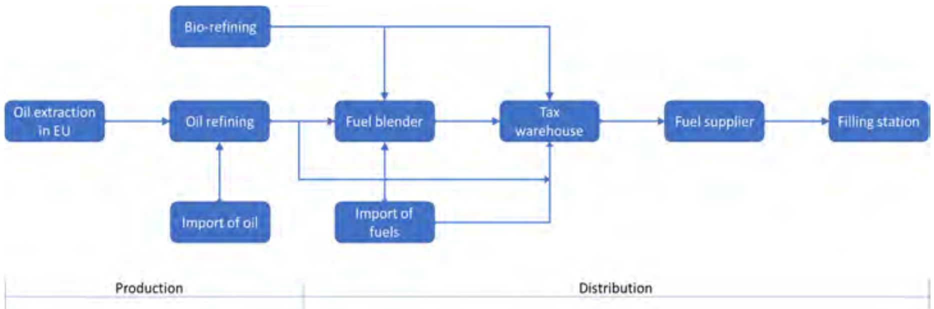
Table 62. Overview of the findings

Level	**Feasibility and MRV costs**	**Number of entities**	**Market structure**	**Passing on the price signal**
Production	High feasibility unclear	433 (extr./imp.) 56 (proc.)	Few large and many small companies	Likely
Transmission	High feasibility unclear	58	Regional monopoles	Likely
Distribution	Low feasible	2,329	large differences between member states	Likely

4.2.2.2 Mineral oil products

Unlike the fuels coal and gas, both of which only play a major role in the building sector, petroleum products are widely used both in road transport and the building sector. Furthermore, oil is used the chemical industry but also for electricity generation. Based on Section 2.1, in Europe about 30 Mtoe of heating oil were consumed in buildings in 2017. In road transport about 180 Mtoe diesel, about 68 Mtoe gasoline and about 5.5 Mtoe LPG were used.

The supply chain for oil has been summarized to consist of four entities in production (oil extractors, oil refineries, bio-refineries, and oil importers) as well as five in distributions (fuel blender, fuel importer, tax warehouses, fuel supplier, filling stations).



Feasibility

Within the production part of the supply chain the final use of the oil products is not clear for oil extractors and oil importers. They could be used outside of transport and heating. Accordingly, it is not meaningful to choose them as regulated entity. Bio-refineries convert biomass into fuels and chemicals. Since their products stem from biomass, they do not contribute to fossil fuel carbon emissions and should not be directly regulated.

The last part of the production side are oil refineries. They convert oil into oil products, such as gasoline, diesel, jet fuel, heating oil, and others. Thus, it is possible to distinguish between the specific end uses and a possible choice for regulated entity. They are more upstream than other parts of the supply chain and their number is quite low with only 87 active oil refineries in Europe. There are two draw-backs to regulate refineries.

- Some oil products are traded within as well as to and from outside the EU and thus any regulation has to include im- or exports as well:
  - Exported oil could be regulated, but oil importers would not be regulated. For imports from other EU Member States, this could be solved. However, this could lead to cheap oil product imports from outside the EU without carbon price.
  - Exported oil could not be regulated but then imported oil would need to be regulated. This has the disadvantage that imported oil products could also include biomass oil products whose carbon content would need to be excluded from regulation. But this should be possible as the biofuel content should typically be known. In this case, imports from outside the EU or other Member States would be treated alike.
- Some oil products are already included in the downstream ETS. Jet fuel for domestic flights (regulated under the EU ETS), for example, - as well as for international flights although those are not yet regulated - would need to be excluded from regulation (easily possible), but use in industry is more difficult to track as the oil refinery do not control the purchase of the individual product. The same holds for use of oil products in navigation and shipping, which is not yet regulated downstream, but which is also not included in the present analysis.

Thus, oil refineries are a feasible choice for regulation with some overlap with the existing downstream ETS.

The most upstream entities in the supply chain, fuel blenders and fuel importers cannot be regulated separately as they interact with each other and both deliver oil products to tax warehouses. The total number of fuel blenders (500 – 2,000) and fuel importers (100 – 1,000) is somewhat smaller than the number of tax warehouses (approx. 7,000). Yet, tax warehouses would be the preferred most up-stream option within oil distribution as regulation without interaction of entities is easier for this case. Tax warehouses as regulated entity have several advantages. First, all liquid transport and heating fuels pass the tax warehouses. Second, tax warehouse keepers are already strictly monitored (for tax reasons) and relevant data for monitoring would be directly available at the tax warehouses. Third, they have good knowledge about the share of biofuels. According to (CE Delft 2014), tax warehouses monitor biofuels in many member states. The latter is relevant as biofuels can be expected to be treated separately in an ETS as their burning is carbon neutral and their share in energy consumption is regulated within the renewable energy directive (RED). However, similar to oil refineries, tax warehouses do not know the final user of their products and a double counting of emissions from upstream and downstream ETS is possible and need to be solved. But this is a general problem that needs to be addressed.

One option to distinguish different uses of oil products is by the different taxation of fuels in transport and heating applications. Many tax warehouses also act as excise duty points. Many Member States have different tariffs for oil products in transport, e.g.

- Petrol,
- Gas oil in Industrial/Commercial use,
- Gas Oil as Propellant or for heating,
- gas oil in special sectors (agricultural, horticultural or piscicultural works, and in forestry as compared to use in railways),
- And others.

However, not all member states have different tariffs for different uses. For example, the following countries have the same tariffs for specific fuels and purposes (cf. EC 2020)[133]

- The same tariff for Gas oil as propellant and for heating: BG, EE, EL, HU, NL, RO, SK

- Gas oil in Industrial/Commercial use are not distinguished among use in (a) stationary motors, in (b) plant and machinery used in construction, civil engineering and public works, and in (c) vehicles intended for use off the public roadway or which have not been granted authorisation for use mainly on the public roadway: BE, BG, CZ, partly DE, DK, EE, partly EL, ES, FI, FR, partly HU, IE, partly IT, LT, LU LV, NL, PL, partly PT, RO, SI, SK, UK;

- Gas oil use in specific sectors are not fully distinguished among use (a) as motor fuel for agricultural, horticultural or piscicultural works, and in forestry, (b) for agricultural, horticultural or piscicultural works, and in forestry, and (c) for railways: BE, CZ, FI, FR, partly IE, IT, LV, LU, NL, LT, LU, PL, PT, RO, SI, SE, SK, UK

- Countries that do not distinguish in tariffs between kerosene in transport and heating: AT, BG, EE, EL, FI, HU, IT, LT, NL, PT, SK,

- Heavy fuel oil can be used for transport in shipping but also for heating or electricity generation but member states do not distinguish these uses in taxation (except for partly BE).

In summary, there are many instances where taxes cannot be used to distinguish between oil product use in transport and heating.

---

[133] EC (2020): EXCISE DUTY TABLES Part II Energy products and Electricity. In accordance with the Energy Directive (Council Directive 2003/96/EC) INCLUDING Natural Gas, Coal and Electricity http://ec.europa.eu/taxation_customs/index_en.htm

Further downstream, there are over 10,000 liquid fuel suppliers and approx. 107,000 fuel stations in Europe. Fuel stations are too far downstream and their number is quite large. Additionally, booking the share of bio fuels sold seems more complex for fuel stations, as biofuels are commonly blended into conventional fuels and the specific type and source of biofuel is less easy to track for fuel stations than other potential regularity entities.

Incentives

With a carbon price of 20€ or 100€ per ton of CO_2, oil heating system owners must calculate with additional costs of about 107€ to 535€ per year. Given the underlying CO_2 prices, car drivers would have to calculate additional costs of about 38€ to 239€ per year for a distance driven of about 13,000 kilometres and a consumption of about 7 litres per 100 kilometres.

The market for petroleum products is, even though there are regional price differences, transparent, in particular for final customers in terms of consumer prices. Petrol, diesel or heating oil prices can be compared online, thus creating strong competition among petrol station operators or among fuel distributors for heating oil.

For heating, the elasticity of demand is relatively low in the short term, because apart from changes in behaviour, the end consumer has little opportunity to reduce consumption. Furthermore, the past has shown that even a very high world market price for crude oil had a rather moderate effect on demand in these sectors. Since the world market prices for crude oil have to a large extend so far been passed on to the end consumer, it can be assumed that this would happen with a price signal from an ETS. However, the price signal could be distorted by the fact that large customers in the commercial building sector may have more market power than private customers, so that private customers may have to pay more than commercial customers.

Since tax warehouses have a rather administrative function and have no contact with end consumers, it is unlikely that they will play an active role in providing information about the carbon price. A way to reduce the problem of awareness is to list the CO_2 price separately on the bills for end consumers. This option could be delegated to the Member States.

Transaction costs

In the section above, possible points of regulation were discussed, with oil refineries and tax warehouses being identified as the most appropriate regulatory points. In terms of transaction costs, the regulation of tax warehouses has the advantage that an administrative quantity metering system for monitoring and reporting already exists which is used for the excise duty. If this point would also be chosen for emissions trading, then monitoring, reporting and verification (MRV) costs could be reduced, since only the quantities would have to be converted into emissions using emission factors. On the other hand, the advantage of regulating oil refineries is the low number of regulated organisations with only 87 oil refineries (plus 100 – 1,000 fuel importers) in Europe compared to approx. 7,000 tax warehouses. The export and import of fuel requires some extra care when oil refineries are regulated.

Additional transaction costs could arise in the differentiation between fuels for heating and fuels for road transport, or in the design variant when only commercial buildings and freight transport are included. Due to the large number of tax warehouses, the costs for the public sector would be rather high.

Conclusion oil market

Table 63 provides an overview of the main criteria for evaluating the point of regulation. **Tax warehouses and oil refineries appear to be the most**

appropriate entity for regulation. Both have knowledge about the sectoral use (transport or heating), the share of biofuels is known, and they are more upstream than other entities. The number of regulated organisations is much lower for refineries but import/export needs to be treated separately (with approx. 100 – 1,000 fuel importers in Europe). For tax warehouses, strict monitoring is already available and imported fuels are directly included, but the number of tax warehouses is much larger than the number of refineries (87) and fuel importers (100 – 1,000). Potential double counting of upstream and downstream ETS needs to be avoided for both options.

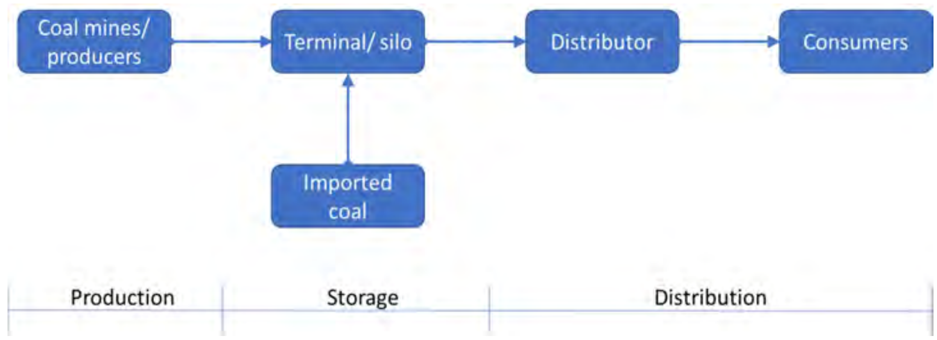
Table 63. Overview of the findings

Level	Feasibility and MRV costs	Number of entities	Market structure	Passing on the price signal
Oil extractors	Not feasible	247	No knowledge about end use	little likely
Oil refiner	Feasible, low cost	87	end use known, some products exported, import/export treated separately	Likely
Oil importer	Not feasible	40	No knowledge about end use	Likely
Bio refiner	Not meaningful	213	Carbon neutral products	-
Fuel blender	partly feasible, medium cost	500 – 2,000	End use known	Likely
Fuel importer	partly feasible, medium cost	100 – 1,000	End use known	Likely
Tax warehouse	feasible, low cost	Approx. 7,000	End use known, monitoring system existing	Very likely
Fuel supplier	Feasible, medium cost	10,000	Many SME, no monitoring system, strong competition	Very likely
Fuel station	partly feasible, high cost	107,500	Many SME, no monitoring system, strong competition	Very likely

4.2.2.3 Coal

Task 2.1 has shown, that coal only plays a minor role in the building sector with about 10 Mtoe in 2017 in residential buildings and 1 Mtoe in 2017 in commercial buildings, although coal still plays a significant role in some Member States (e.g. Poland, Czech Republic or Ireland). In the residential building sector, the use of coal has been relatively stable since 2000, whereas in the commercial building sector it has declined slightly. Despite these figures, it can be assumed that coal will continue to play a minor role in the building sector in the future, and this role is likely to decline rather than increase, especially in the commercial building sector. Coal is not used in the transport sector.

Figure 89. Supply chain of the coal market



Feasibility

Figure 89 gives an overview of the supply chain in the coal market. At the top of the chain are the coal mines, who extract the raw material and process coal products. On the second level are importers who import coal from outside the EU and the coal terminals which represent a transhipment and a storage point for coal. Below that, in third level, are companies for distribution to end consumers in the building sector. Unlike the market for mineral oil, there are no tax warehouses for coal, which therefore cannot be used as a regulatory point. According to the association EURACOAL, although most producers know the users of a large part of their coal, this only includes power stations or industrial customers. The use of coal for heating in houses, on the other hand, is currently not known by the producers. Nevertheless, upstream regulation may be feasible if all large consumers are known by the producers, so that double counting with the EU ETS can be avoided. Coal that is not purchased by large industrial plants and power stations would then be regulated. It remains to be analysed what share of the regulated coal is used to heat buildings and whether smaller industrial companies would also be regulated, which would then have to be compensated. Since the market for coal is far less regulated and monitored than the markets for gas or mineral oil products, in this case clever coal suppliers could drive to large power plant operators and try to buy coal there, which would not have been regulated upstream. This is something that would hardly be possible in the other two markets due to the strong monitoring, but is doable in the coal market. This would in turn require the monitoring of coal deliveries to all plants excluded upstream, which would lead to an increase in transaction costs.

One problem with such upstream regulation, however, is that the market for coal is less regulated and monitored than the markets for gas or mineral oil, so tracking through the levels of the supply chain would be a major challenge especially if only the heating of commercial buildings is regulated. Trading of intermediate products, final products even within one segment of the supply chain and also coal blenders complicate monitoring and make tracking difficult to put into practice. A regulation point, which makes it possible to identify the supply streams to buildings, is at the level of distribution to end consumers. With a little more effort, it also seems possible to distinguish between the commercial and private building sectors there.

The second level of the coal supply chain appears to be the most difficult point of regulation. Storage is an important step in the coal supply chain. However, the only type of storage that is traceable are the large terminals that mainly supply coal to industry and power plants. The household distribution network sources its coal and charcoal products from producers, importers, wholesalers or (if vertically integrated) from its own production lines, which means that at the production and distribution points there are storage depots of varying sizes, but for which the precise numbers are completely unclear, making them impractical as regulated entities.

Incentives

With regard to the final consumers of coal, it can be assumed that demand from the final consumer is relatively inelastic in the short term and that, accordingly, the price signal can be passed on to the final consumer relatively undistorted in the short term. This is because distributors and retailers operate on a relatively limited regional market and transporting smaller quantities of coal over longer distances is not financially attractive and short-term adjustment processes are rather limited. Since it is likely that the price signal will be transmitted at the last level of the supply chain, it can be assumed that the price signal could also be transmitted at the higher levels. Another point in favour of passing on the price signal in the supply chain for coal for heating is that the end product is not a strategically important product for companies at any stage of the supply chain, but rather a niche product that plays only a minor role, making strategic pricing unlikely. Distributors of coal have direct contact with the final consumer and could inform the final consumer about carbon costs. A way to increase awareness is to list the CO_2 price separately on the bills for end consumers. Assuming that the price signal is fully passed on and given a carbon price of 20€ or 100€ per ton of CO_2 and a consumption of 20,000 kWh owners of coal-fired heating systems have to calculate additional costs of about 138€ to 690€ per year.

Transaction costs

In comparison to the markets for mineral oil or gas, it is to be expected that the market for coal for heating will incur significantly higher transaction costs, since it can be assumed that many smaller players, which have hardly been regulated up to now, will be involved, and that they would have to establish monitoring and reporting systems. This means that investments must be made, in particular in precise volume monitoring. For the government, it means more efforts in terms of participant identification, supervision and enforcement. In order to keep transaction costs within reasonable limits, as in the existing EU ETS, the size (quantity of fuels sold or emissions) of an entity could be used to determine whether or not it is included in emissions trading. This case would probably only be relevant for the coal market, since all petroleum products flow through tax warehouses and natural gas is not sold apart from the existing pipeline network. However, it must be taken into account that such an approach provides incentives to split up companies to avoid regulation, making a minimum quantity sold a difficult benchmark. Furthermore, the level playing field between small and large suppliers would of course also be distorted, which would be problematic in terms of fair competition.

Based on the figures from 2.1c, only 40 Mt of CO_2 emissions result from the combustion of coal in the building sector, this represents about 3% of emissions from the two sectors buildings and road transport. The coal sector is therefore not expected to dominate the emissions market. Furthermore, due to the limited demand for coal from the building sector, this sector is of little relevance to producers, so that little strategic activity can be expected on the supply markets and a dominant position of few players is unlikely.

Conclusion coal market

Table 64 provides an overview of the main criteria for evaluating the point of regulation. Similar to the gas market, the demand for heating coal is also expected to react relatively little to a price increase in the short term, making it very likely that the price signal would be passed through all levels of the supply chain. In addition, for very few players in the supply chain, heating coal represents a relevant revenue share, which makes it more likely that the price signal will be passed on. With regulation at the level of production, MRV costs are very high, as either certain market players such as industry would have to be compensated or the flow of coal to the buildings would have to be monitored. The risk of fraud also appears to be high at the upper levels of the supply chain, as non-regulated coal could be purchased from power plants. On the other hand, the rather small number of entities to be regulated compared to distributors argues in favour of regulation on producers. Regulation at the level of storage operators does not seem feasible, or only at extremely high cost, as the number of operators is only known for the larger storage facilities, which usually supply industry only, while the smaller storage facilities for supplying households are not known. Due to the very high MRV costs associated with regulation at the upper levels of the supply chain, regulation of distributors appears appropriate despite the comparatively high number of entities to be regulated and the many different emission factors that may apply due to the many different end products. A distinction between commercial buildings and residential buildings also appears to be the least costly at distributor level. This recommendation applies to all design options, with the exception of option 2a, which does not include the buildings sector, making coal regulation unnecessary. Also, the market power argument relevant to options 3a and 3b does not present a problem for coal due to the low penetration of coal heating.

Table 64. Overview of the findings

Level	Feasibility and MRV costs	Number of entities	Market structure	Passing on the price signal
Production	High	118 (mines) 198 (producers)	Little relevance of the end product	very likely
Storage	High	28 (terminals) 500 (importers)	Little relevance of the end product	very likely
Distribution	Middle	3,000	Strong competition	very likely

4.2.3 Downstream regulation for buildings and road transport

In general, also concepts exist that foresee a downstream regulation for household and transport emissions. Most prominently the approach was developed and discussed in the UK under the term "personal carbon trading" in the 1990s and 2000s (see Duscha 2014). The general idea is to regulate all adult citizens and young adults (children would normally be regulated via their parents), as well as in some cases also firms and the state. In addition to paying their energy bills and transport fuels, they would also have to submit an amount of allowances equal to the amount of CO_2 emitted in the process of using those fuels. For transactions of allowances, each adult citizen would need a carbon account as well as a CO_2 card similar to a credit or debit card, that allows him/her to transfer allowances for compliance, but also to buy additional allowances once the allocated amount (normally it is assumed in those systems that most citizens would receive a certain amount of allowances for free initially) has been used up and addition allowance are needed.

The main advantage of such a form of downstream regulation is raising awareness among the general public. By formulating a common target and giving every adult a direct way of contributing to reach that target they hope for more specific engagement and identification with the targets and necessary measures.

However, downstream regulation of that kind also has several disadvantages compared to a more upstream-oriented regulation. One key point is the high number of regulated entities (for the EU this would be around 430m people if all citizens from age 14 would be regulated separately) and the related relatively high transaction costs, particularly compared to the contribution each individual is able to make. Another aspect is choosing a design that has particularly high acceptance in the general public. Only if the population accepts such a system, citizens will also try to actively engage in reducing emissions. A third point is to design the system in a way that also allows easy compliance for people who are either not interested in actively participating in emission reduction efforts or who are - e.g. due to their age or health - not able to actively participate. In those cases, easy ways for complying with the regulation are needed to not exclude them from social life.

Even when restricting a downstream regulation to the commercial parts of the two sectors, the number of regulated entities would still be enormous. For freight road transport, Eurostat reports the number of transportation companies up to the year 2012. Only 11 out of the 27 Member States are reporting figures (see …). Still, the total of companies within those 11 Member States is more than 200,000. Main reason for that is the large number of very small companies (1-5 employees), which account for more than 80% of total companies in that sector.

Member State	Total	Companies with 1-5 employees
Bulgaria	9,874	Na
Estonia	2,445	1,079
Italy	73,030	63,580
Cyprus	998	723
Latvia	2,776	Na
Hungary	6,760	4,774
Austria	6,587	4,548
Poland	81,893	78,466
Slovenia	4,846	4,121
Slovakia	12,176	11,350
Finland	10,496	8,936
Total	211,811	177,577

Source: Eurostat, road_ec_entemp

Similarly, the restriction to commercial buildings, although it reduces the number of regulated entities compared to a downstream approach covering all citizens, still results in a very high number. Only the retail sector reported 3,295,208 companies for the EU 27, so the number of regulated entities for all commercial buildings would be significantly higher than that.

4.3 Question 3.3: Emissions cap

Cap setting in an emissions trading system is always a sensitive topic. The cap defines to a large extent the price signal forming on the markets and hence the financial burden being established by the system. Therefore, discussions on the cap are normally highly political. A sound scientific basis for the definition of a cap can help to a large extent to justify a cap in the political process. In the following, we use different approaches for cap setting to derive figures on the overall cap and linear reduction factors for the different design options. The overall GHG target is a relevant figure for this exercise. Building on the current political debate, we apply three different overall GHG targets: a reduction of 40% below 1990 levels by 2030 as currently implemented under the 2030 climate and energy framework, a reduction of 50% below 1990 levels by 2030 and a reduction of 55% below 1990 levels by 2030. The two later cases build upon the current discussions on increasing the overall GHG target of the EU for the year 2030.

Depending on the design options, we need to define one or two caps (design options 3a and 3b). For the definition of the target(s) we take into account existing or newly defined overall GHG targets as described above, but also abatement potential and costs to allow the definition of ambitious, but realistic targets. Prices should present a price signal needed for action but not result in too high pressure for regulated entities. At the same time, definition of the target(s) for the ETS(s) also needs to take into account what the remaining burden would be for the (remaining) ESR sectors.

For calculation of the cap different approaches could be applied:

- Stick to current targets proportionally to today's definition of 2030 targets
- Cap 2: Define new targets based on cost-effectiveness criteria
- Cap 3: Define new targets based on equal reductions for ETS and ESD sectors

In all cases, the target is set as an absolute cap, relative target setting options are not further considered as they do not allow for reaching overall GHG targets with the sufficient amount of certainty.

4.3.1 Current target setting and what can be learned from it

Target setting as currently applied under the EU ETS follows certain specifications:

- A target is being defined for a specific target year (currently up to 2030)
- The definition of the target is based on a historic base year (currently 2005), for which emissions data is available from the EU ETS already. Using a historic base year has the advantage, that figures are fixed and verified and uncertainty on the calculation of the overall amount of emissions is as small as possible.
- For the definition of the annual overall amount of allowances, a linear trajectory is being used. The linear reduction factor (LRF) gives the annual reduction in allowances in percentage of the amount of allowances in 2010. Again, as the overall amount of allowances in 2010 is a fixed figure, a unchangeable data provide the basis for the calculation of the annual overall amount of allowances under the EU ETS.

Using a historic base year for the definition of the target and a fixed reference point for the definition of the LRF provides a sound data base for the calculation of the annual overall amount of allowances under the EU ETS. This approach should be adopted for other sectors as far as possible in an extended or newly created ETS as was done for the aviation sector.

A key challenge that occurs for the inclusion of new sectors is the availability of a sound data base for historic emissions. For the definition of the target for aviation, different data sets were being combined (from the European Organisation for the Safety of Air Navigation (Eurocontrol), fuel consumption information from individual aircraft operators covering about 93% of emissions and calculations for fuel consumption from the use of Auxiliary Power Units). While aviation is a highly controlled sector in the EU, it is likely more difficult to provide a data base for the sectors road transport and buildings of a similar quality than was possible for aviation. While EU GHG inventory data provide information on those two sectors (and subsectors), the calculation of the data follows a much more top-down approach than desirable for the definition of the cap under an ETS. Another possibility for data collection is the energy tax. It should be assessed to what extent energy tax data can be used in the Member States for a bottom-up estimation of the emissions of the two sectors.

If no sound data base is available for the definition of a LRF, instead the definition of a fixed amount of annual reductions could be defined.

The use of a linear trajectory is not a precondition. Several analyses have investigated non-linear trajectories for the definition of annual overall amounts of allowances. A convex curve requires higher reductions in the beginning and lower reductions later, taking into account that reduction potential may become smaller over time. In contrast, a concave curve provides more flexibility in the beginning, but requires higher reductions later. In both cases, a clear mathematical definition of the non-linear curve would be needed to provide a sound basis for the calculation of the annual overall amount of allowances. As the degree of freedom for the definition of a non-linear curve is high, it can be more problematic to negotiate a non-linear reduction pathway compared to a linear one. A way to circumvent this problem is to use linear trajectories, but use shorter time periods for the definition of the LRF. In case of the EU ETS, the LRF is currently fixed for the period 2021 to 2030 but can be revised after 5 years. Splitting up a longer period into two or more shorter periods allows to provide a certain flexibility for the definition of the trajectory without complicating the calculations and negotiations too much.

4.3.2 A 40% GHG reduction target and current target setting rules

As a starting point for the analysis, we stick to the target setting currently defined in the 2030 climate and energy framework. That is, the EU ETS sectors have to reduce emissions by 43% below 2005 levels and the ESR sectors have to reduce emissions by 30% below 2005 levels, resulting in overall GHG emission reductions of 40% below 1990 levels. Depending on whether a design option foresees that the sectors transport and buildings remain regulated under the ESR or become part of the EU ETS and leave the ESD, we define the target accordingly (see Table 65). For example: in Option 1a, when road transport as well as buildings become part of the EU ETS, more ambitious targets of 43% below 2005 levels are introduced for those two sectors. Hence, the overall ambition level under the EU ETS remains 43% below 2005 levels.

Table 65. Targets based on current target setting rules under the 2030 climate and energy framework [% below 2005]

	EU ETS	"new" ETS	ESD
Option 0	43%	---	30%
Option 1a	43%	---	30%

	EU ETS	"new" ETS	ESD
Option 1b	43%	---	30%
Option 1c	43%	---	30%
Option 2a	43%	---	30%
Option 2b	43%	---	30%
Option 3a	43%	30%	30%
Option 3b	43%	30%	30%
Option 3c	43%	30%/30%	30%

Source: Own definition

This target setting approach ensures that the EU's current 40% target is met in all cases. However, in some of the design options analysed ETS+ESD emission reductions are higher than the 40% overall target when ESD sectors become part of the EU ETS and hence face a higher reduction obligation. Table 66 gives GHG levels for ETS + ESD and emission reductions below 1990 in the analysed scenarios. Design option 1a results in a GHG emission reduction for ETS + ESD of 44% below 1990 levels due to the high amount of emissions becoming part of the EU ETS and thus facing a higher emission reduction target. In the remaining scenarios, the increase in GHG emission reductions for ETS + ESD is small. In scenario 1b, the resulting GHG emission level is uncertain due to the double regulation of part of the emissions under the ESD and the EU ETS. However, the application of the ESD target for all current ESD sectors and the additional - and more ambitious - definition of the EU ETS target also being applied to the ESD sectors transport and buildings ensures that the GHG target for ETS + ESD is being met.

Table 66. Resulting GHG levels [Mt CO2e] and reductions below 1990 levels

	GHG levels	Reduction below 1990
Option 0	2,898	40%
Option 1a	2,722	44%
Option 1b	At most 2,898	At least 40%
Option 1c	2,837	42%
Option 2a	2,795	42%
Option 2b	2,824	42%
Option 3a	2,898	40%
Option 3b	2,898	40%
Option 3c	2,898	40%

Source: Own calculations

A slightly different approach, taking into account that the target split of 43% for the ETS sectors and 30% reduction for the ESD sectors is based on cost-effectiveness considerations, is to integrate the different current reduction levels for the definition of new targets under the EU ETS and the ESD. That is, we assume that all sectors stick to their current target setting rules. In case of ESD sectors becoming part of the EU ETS, we assume, that the new EU ETS target is calculated based on current EU ETS sectors' EU ETS target of 43% and current ESD sectors' ESD target of 30% below 2005 levels. Table 67 gives the resulting targets for the EU ETS, the "new ETS" and the ESR under the different design options. In all scenarios, in which the current EU

ETS is being extended to include new sectors, the target value under the new EU ETS decreases. However, the figure still remains significantly above the target for the ESD sectors with 38 to 41% below 2005 levels.

Table 67. Resulting EU ETS, "new ETS" and ESR targets by applying sectors-specific targets [% below 2005 levels]

	EU ETS	"new ETS"	ESD
Option 0	43%	---	30%
Option 1a	38%	---	30%
Option 1b	38%	---	30%
Option 1c	41%	---	30%
Option 2a	39%	---	30%
Option 2b	40%	---	30%
Option 3a	43%	30%	30%
Option 3b	43%	30%	30%
Option 3c	43%	30%/30%	30%

Source: Fraunhofer ISI

4.3.3 Keeping current proportionality for higher ambition levels

A simple approach to transfer the current proportionality to higher ambition levels is to keep the share of emission reductions between EU ETS and ESD constant. According figures are provided in Table 68. Emission reductions under the EU ETS would need to increase to 55% below 2005 in case of an overall emission reduction target of 50% below 1990 levels and to 62% below 2005 in case of an overall emission reduction target of 55% below 1990 levels. Targets under the ESR and for Options 3a-3c in the newly created ETS systems would increase to 39% and 43% respectively.

Table 68. Targets based on emission reductions proportional to the 2030 climate and energy framework [% below 2005] for higher ambition levels of 50/55%

	50%			55%		
	EU ETS	**"new" ETS**	**ESD**	**EU ETS**	**"new" ETS**	**ESD**
Option 0 - 2b	55%	---	39%	62%	---	43%
Option 3a-3c	55%	39%/39%	39%	62%	43%/43%	43%

Source: Fraunhofer ISI, own calculation

Table 69 analogous to Table 67 shows resulting 2030 targets for the EU ETS, the new ETS and the ESR for an integration of the new sectors into the EU ETS.

Table 69. Resulting EU ETS, "new ETS" and ESR targets by applying sectors-specific targets as defined in Table 68 for higher ambition levels [% below 2005 levels]

	50%			55%		
	EU ETS	**"new ETS"**	**ESD**	**EU ETS**	**"new ETS"**	**ESD**
Option 0	55%	---	39%	62%	---	43%
Option 1a	49%	---	39%	54%	---	44%
Option 1b	49%	---	39%	54%	---	43%
Option 1c	52%	---	39%	59%	---	43%
Option 2a	51%	---	39%	57%	---	43%
Option 2b	52%	---	39%	58%	---	43%
Option 3a	55%	39%	39%	62%	43%	43%
Option 3b	55%	39%	39%	62%	43%	43%
Option 3c	55%	39%/39%	39%	62%	43%/43%	43%

Source: Fraunhofer ISI, own calculation

4.3.4 Similar emission reduction requirements compared to todays' GHG levels

Instead of using abatement costs as the underlying principle for splitting emission reductions between sectors, it could also be assumed that all sectors' contributions to emission reductions should be similar. In the long run, meeting the targets of the Paris Agreement requires close to zero emissions in all sectors, in particular for emissions from the burning of fossil fuels. Similar emission reduction requirements would depict this final target, while admittedly leaving out current cost considerations. As a similar contribution at the absolute level only makes sense if the size of the sectors is comparable, we interpret similar contribution as similar with regards to relative emission reductions. In that case, the choice of the base year also plays an important role when determining the resulting emission levels and emission reduction requirements. More recent base years neglect to a certain extent if sectors have made significant contributions in the past (early action), which can be taken into account when using more historic base years. Table 70 provides target splits for the different design options for two base years: 2005 (as currently used for measuring reduction targets in the EU climate and energy framework) and 2017 as the most recent historic base year available.

Table 70. Resulting emission reductions [below 2005 levels] for more ambitious overall GHG reduction targets of 50 and 55% below 1990 levels applying similar relative emission reduction requirements for different base years (2005 and 2017)

	50%			55%		
	EU ETS	"new ETS"	ESD	EU ETS	"new ETS"	ESD
2017 base year						
Option 0	51%	---	42%	56%	---	48%

Option 1a	48%	---	42%	53%	---	48%
Option 1b	48%	---	42%	53%	---	48%
Option 1c	49%	---	42%	55%	---	48%
Option 2a	48%	---	44%	53%	---	50%
Option 2b	51%	---	40%	56%	---	46%
Option 3a	51%	42%	42%	56%	48%	48%
Option 3b	51%	41%	42%	56%	47%	48%
Option 3c	51%	38%/48%	42%	56%	44%/53%	48%
2005 base year						
Option 0 - 3b	46%	46%	46%	52%	52%	52%

Source: Fraunhofer ISI

Using most recent GHG emissions as base year for splitting the target results - in all design options - in significantly higher relative reduction figures for the EU ETS sectors compared to the ESD sectors. This reflects that - in relative terms compared to 2005 - less progress has been made in the ESD sectors compared to the EU ETS sectors. This is consistent with the 2020 targets set for ETS and ESD sectors as well as with current 2030 targets. The large EU ETS options (design options 1a and 1b) show slightly lower relative ambition levels for the EU ETS sectors compared to the other sectors as a large part of the sectors with limited reductions in the past moves to the EU ETS. Effects for the ESD, however, are limited.

Comparing reduction levels for different overall ambition levels shows that, while in general the above described effects hold for both overall ambition levels - moving to a higher overall ambition level also requires higher relative emission reduction levels from the ESD compared to the EU ETS sectors. The difference in percentage points between the sectors becomes slightly lower.

When choosing 2005 as a base year, i.e. early action is partly rewarded by lower ambition levels for 2030, this differentiation disappears. Relative ambition levels for the EU ETS are slightly lower and relative ambition levels for the ESD sectors increase slightly. This is in the order of magnitude of 4 to 5 percentage points for all ambition levels and all design options.

In the past two years, emissions in the EU ETS have significantly fallen from 1590 to 1385 Mt CO_2e. This drop would significantly affect reduction targets when apply similar emission reductions compared to most recent emission levels if emissions in the ESD sectors have not fallen to a similar extent. As no 2019 data are available for the ESD sectors, a similar calculation using 2019 as a base year is currently not possible. For an indication of the effect, Table 72 provides a similar calculation to Table 71, using 2019 data for the EU ETS sectors and keeping 2017 data for the remaining sectors (i.e. assuming that emissions in the ESD sectors have not significantly changed between 2017 and 2019). As can be seen, the recent drop in emissions in the EU ETS would result in a significant increase in the EU ETS target in particular in Option 0 by 4 percentage-points compared to 2005 levels, accompanied by a drop in the target for the ESD sectors by 3 percentage-points. This effect is softend in the other Options when current EU ETS and ESD sectors are combined in a common market.

Table 71. Resulting emission reductions [below 2005 levels] for more ambitious overall GHG reduction targets of 50 and 55% below 1990 levels applying similar relative emission reduction requirements for mixed base years (2019 for EU ETS and 2017 for other sectors)

	50%			**55%**		
	EU ETS	"new ETS"	ESD	EU ETS	"new ETS"	ESD
Mixed 2019/17 base year						
Option 0	55%	---	39%	60%	---	45%
Option 1a	49%	---	39%	54%	---	45%
Option 1b	49%	---	39%	54%	---	45%
Option 1c	52%	---	39%	57%	---	45%
Option 2a	49%	---	41%	53%	---	47%
Option 2b	53%	---	37%	58%	---	43%
Option 3a	55%	39%	39%	60%	45%	45%
Option 3b	55%	38%	39%	60%	44%	45%
Option 3c	55%	34%/45%	39%	60%	41%/51%	45%

Source: Fraunhofer ISI

4.4 Question 3.4: Risk of Leakage, slippage or double counting (particular in the buildings sector)

4.4.1 Context

At the margin, the introduction of a carbon price to housing and/or transport, through an extension of the EU ETS or through another mechanism, could distort the functioning of the carbon market and the price signal. This can either happen by pricing the same emissions twice, or through loopholes that allow emissions to go unpriced. Such inconsistencies are problematic for different reasons: they impose an undue and unfair burden on emitters that pay double, and they create an incentive to game the system in order to exploit loopholes. They are therefore problematic from an equity and fairness perspective, but also reduce the overall efficiency of the system and undermine its capacity to reduce emissions at least cost. In addition, such inconsistencies pose a problem for emission data, as the emissions reported by the liable entities could diverge from the actual emissions, if some emissions are counted twice or are not counted at all.

There are different possible causes of inconsistencies:

- **Carbon leakage** occurs wherever some emitters face a carbon price, whereas their competitors do not. This allows customers to avoid the carbon price by switching to alternative products or services that are not covered by the pricing instrument. The term is typically used for transboundary carbon leakage – where a domestic carbon price increases the price of a domestically produced product or service vis-à-vis the imported substitute, and hence makes it more attractive to purchase the imported alternative. Likewise, the domestic carbon price also increases the price of domestically produced goods that are exported, and thus makes them less competitive on export markets. In addition to transboundary carbon leakage, there can also be cases of leakage across sector boundaries: these occur where only some sectors, products or services are covered by a carbon price, but commercial substitutes do not. The result could be leakage across sectoral boundaries, increasing demand for the non-covered substitute. For instance, in a setting where electricity generation is covered with a carbon price, whereas the combustion of diesel fuels is not, one result could be leakage from (electricity-powered) rail to road transport, or from electrically powered rail to diesel-powered rail.

- **Carbon Slippage**, unlike carbon leakage, is not a well-defined term. For the intents of this study, it is understood to relate to situations where emissions "slip" from the coverage of the pricing tool as fuels are repurposed away from their originally intended use, thereby evading the carbon price. Such cases may arise since identical (or equivalent) fuels can be used in different sectors – e.g. natural gas or heating oil that can be used both for heating buildings and for power production, or heating oil that could be used as a transport fuel. A typical case of carbon slippage could occur in a mixed upstream-downstream system, if fuels that were intended for combustion in the downstream part of the system (and hence do not incur a carbon price at the point of sale) are instead combusted in the upstream part of the system.
- **Double counting** is the opposite case of carbon slippage (as defined above), and occurs if a fuel that already incurred a carbon price at the point of sale is then combusted in an installation that is part of a downstream ETS, and hence incurs a carbon price for the reported downstream emissions. In this case, the carbon price would be levied twice – once at the point of sale, when the fuel is purchased, and once after the fuel has been combusted, when the buyer has to account for the emissions.

4.4.2 Carbon Leakage

Of the different channels described above, the main concern is transboundary leakage, specifically in the transport sector. Cross-sectoral leakage is generally not a concern – if anything, establishing a carbon price in transport and housing will contribute to levelling the playing field and avoiding distortions. It will thus eliminate (or at least meliorate) situations where up until now, cross-sectoral leakage may have been a concern, such as the case of electricity-powered rail transport vs. road transport.

Likewise, transboundary leakage is less problematic in the housing sector. It could only arise in cases where heat for district heating is supplied across an EU border. Since district heating systems operate within urban areas, the risk would be limited to cases where a conurbation extends across an EU border. Due to the lack of infrastructure and the limited spatial scale of district heating systems, this is a very limited risk.[134]

Transboundary leakage risks are a more realistic and relevant possibility, however, in the case of transport. The introduction of an EU-wide carbon price for transport could exacerbate existing differences between EU countries and neighbouring non-EU countries, and thus strengthen the incentive to exploit these differences. This would potentially lead to two types of inefficiencies: first, arbitrage by individuals to take advantage of price differentials (better known as fuel tourism), which not only partly

[134] The only (anecdotal) incidence of such a case that could be identified is the Swiss municipality of Basel. Basel features one of the most extensive district heating networks in all of Switzerland. The network is physically linked to Germany, and supplies a number of households in the German settlement of Stetten-Süd, just across the border. Since Switzerland operates its own ETS, which in due course will be linked to the EU ETS, and since Basel itself has ambitious climate goals, the risk of leakage is non-existent, as there is virtually no difference of climate ambition between the EU and Basel. In addition, the extent of the problem is limited by the infrastructure – the community in question has about 13,000 inhabitants, and the rate of connection to district heating in the city of Lörrach is at about 5%.

mutes the carbon price signal, but also induces additional trips and hence additional emissions. The second variety of this phenomenon occurs where long-distance transport operators plan their refuelling stops to take advantage of price differentials, particularly in transit countries with lower fuel prices. This, too, besides muting the price signal and leading to downward competition, can lead to additional emissions if drivers plan detours or install larger (and therefore heavier) tanks to take advantage of fuel price differentials. However, both for fuel tourism and for refuelling stops, the additional time required for these activities constrains the problem – particularly where it involves crossing the outer border of the EU. For the decision to install more or larger tanks on freight trucks, an additional trade-off is that the increased fuel weight reduces the available payload.

It should also be noted that the introduction of a carbon price for transport would merely exacerbate differences which already exist, not only between the EU and its neighbours, but also within the EU. The following tables show the ten inner-EU (land) borders with the largest price differences for petroleum (Super-95), ranging from 50 cents per leader between Greece and Bulgaria to 21 cents at the between Portugal and Spain. While a uniform EU carbon price would of course not increase the inner-EU difference, the absolute value of the cost increase would likely be lower than the differences that already exist.

Table 72. Ten largest price differentials for petroleum between neighbouring EU countries

Country A	Petroleum price (Super-95)	Country B	Petroleum price (Super-95)	Difference (Euro / litre)
GR	1,32	BG	0,82	0,50
IT	1,36	AT	0,99	0,37
IT	1,36	SL	1,00	0,36
DE	1,20	PL	0,87	0,33
NL	1,48	BE	1,17	0,31
NL	1,48	DE	1,20	0,28
DE	1,20	CZ	0,93	0,27
FR	1,24	LU	0,98	0,26
DE	1,20	LU	0,98	0,22
PT	1,29	ES	1,08	0,21

Source: European Commission, EU Oil Bulletin. Prices are national averages for 18 May 2020

For diesel, the differences between Member States are less pronounced. Here, the starkest difference can be observed between Belgium and Luxemburg and between France and Luxemburg, with a difference of 31 / 30 cents, respectively. For most neighbouring countries across the EU, however, the difference is less than 15 cents.

Table 73. Ten largest price differentials for Diesel between neighbouring EU countries

Country A	Diesel price (Euro per litre)	Country B	Diesel price (Euro per litre)	Difference (Euro / litre)
BE	1,17	LU	0,86	0,31
FR	1,16	LU	0,86	0,30
GR	1,09	BG	0,81	0,28
IT	1,25	AT	0,98	0,27
IT	1,25	SL	1,00	0,25
DE	1,05	LU	0,86	0,19
FR	1,16	ES	0,99	0,17
DE	1,05	PL	0,89	0,16
SE	1,26	DK	1,10	0,16
PT	1,14	ES	0,99	0,15

Source: European Commission, EU Oil Bulletin. Prices are national averages for 18 May 2020

However, for the assessment of potential leakage risks by planning refuelling stops, what matters is price differential to neighbouring non-EU countries. Here, it should first be noted that several of these countries are actually at the higher end when it comes to fuel (diesel) prices: as could be expected, this applies to Switzerland (1.30 Euro per litre of diesel), Norway (1.30) and the UK (1.25), but notably also to countries like Albania (1.36) and Serbia (1.12). This means that, for instance, between the UK and Ireland, between Switzerland and France, Germany and Austria, between Albania and Greece and between Serbia and all its EU neighbours, the fuel price is higher in the non-EU countries – from a few cent between UK and Ireland or Greece and Albania, to 30 cent or more between Switzerland and Austria or between Serbia and Bulgaria. If a carbon price of 20-25 Euro per ton would increase the EU fuel prices by 5-6 cent per litre, this would not change the situation significantly: An estimated fuel price increase in the EU would not drive refuelling and tank tourism out of the EU – if anything, it would counteract existing refuelling and tank tourism *into* the EU.

There are, however, also several relations where the prices are markedly lower in the non-EU neighbouring countries, particularly along the Eastern EU border, but also in some of the other Balkan countries (Northern Macedonia and Bosnia and Herzegovina).

Table 74. Ten largest price differentials for Diesel between EU countries and neighbouring non-EU countries

EU country	Diesel price (Euro per litre)	Non-EU country	Diesel price (Euro per litre)	Difference (Euro / litre)
FI	1,16	Russia	0,60	0,56

EU country	Diesel price (Euro per litre)	Non-EU country	Diesel price (Euro per litre)	Difference (Euro / litre)
EE	1,00	Russia	0,60	0,40
SK	1,07	Ukraine	0,73	0,34
LV	0,90	Russia	0,60	0,30
GR	1,09	Northern Macedonia	0,80	0,29
LT	0,97	Belarus	0,68	0,29
LV	0,90	Belarus	0,68	0,22
PL	0,89	Belarus	0,68	0,21
HR	1,04	BiH	0,84	0,20
PL	0,89	Ukraine	0,73	0,16

Source: for EU countries – European Commission, EU Oil Bulletin. Prices are national averages for 18 May 2020. For non-EU countries: globalpetrolprices.com, Data for 25 May 2020

In these instances, the introduction of an EU-wide carbon price for transport fuels would indeed exacerbate the already existing differences, and strengthen the incentive to relocate refuelling stops to outside the EU border. Assuming a carbon price of 25 Euro per ton, which corresponds to 6 cents per litre of diesel, the situation would change as follows: For a truck entering from Ukraine into Poland, filling up an 800-litre tank before the border would currently deliver a saving of 128 Euro. With a carbon price in place, this would increase to 176 Euro. Likewise, for a truck from Russia to Estonia, the saving would increase from currently 320 Euro to 368 Euro. In these instances, however, it is safe to assume that the hauling companies would already exploit the existing fuel price differentials, and that the additional fuel price increase from the carbon price would not change the situation in any significant way.

4.4.3 Slippage

Carbon slippage can emerge where fuels are treated differently, depending on which sector they are used in, opening up the possibility of evading the carbon price. In this way, carbon slippage is of particular concern for a hybrid system with a mix of upstream and downstream coverage. In such systems, fuel suppliers will need to differentiate their sales, depending on the ETS obligation of their customer: for fuels that are sold to customers who have a downstream obligation, the supplier would not need to surrender allowances (and hence would not include the carbon price in the cost of the fuel). For fuels sold to customers with no such obligation – i.e. fuels sold to consumers from the upstream sectors – the supplier would need to surrender allowances, and hence include the carbon price in the price of his product. This situation would easily be resolved if different fuels were used in the different sectors and uses – however in reality identical (or equivalent) fuels can be used in different sectors, e.g. diesel or heating oil that or natural gas can be used for transport, heating and for power generation. However, in practice this is not the case – the higher up one moves in the supply chain, the more difficult it becomes to ascertain what the fuels will be used for, particularly for intermediate products such as crude oil or naphtha (see above).

This may give rise to situation where emissions "slip" from the coverage of the pricing tool as fuels are repurposed away from their originally intended use. Thus, fuels that were intended for combustion in the downstream part of the system (and hence do not carry a carbon price) may instead end up being used in the upstream part – and thus "slip" from the coverage. Such slippage may occur by accident, but can also be the result of fraudulent intent, as it amounts to tax evasion.

Avoiding slippage (as well as double counting) therefore requires that suppliers are able to discriminate between different fuels, depending on their intended use and destination, and particularly whether the fuels will incur a compliance obligation when combusted. The following section describes these for the most relevant fuel types, i.e. gas products, mineral oil products and coal.

4.4.3.1 Gas products

As elaborated above in section 4.2.2.1, the structure of the gas grid is only partly aligned with the type of customers to which gas is delivered. Large installations will often be connected directly to the transmission grid. This includes installations that have an existing obligation under the EU ETS (such as large energy and industry installations), but also other large consumers in the building sector (hospitals, hotels, universities, large residential units etc.), which are nonetheless below the threshold for inclusion in the downstream EU ETS. This means that the operators of the transmission grid will not have reliable information about the ETS status of their customers, nor to which sector they belong. This image is clearer at the level of regional and local fuel distributors: at this level, the end users (and the uses) of the gas are well known. Hence it is also possible for the supplier to establish whether the fuels will end up in the transport or buildings sector, and whether or not they will incur a compliance obligation in the EU ETS, and to differentiate them accordingly.

What is important is that gas sold from the gas grid to the consumer – whether from the TSO grid or from the local grid – is delivered to the place where it will be used. Installations do not have the possibility to feed gas back into the grid; in fact, most consumers do not even have the option of storing a significant amount of gas. The risk of re-sale or re-purposing of fuels is therefore limited. The quantity of gas that is delivered through other channels than the gas grid (e.g. bottled gas) is marginal; in particular, it can safely be assumed that gas sold through these channels will only be used in non-ETS uses (above in the residential and construction sector).

4.4.3.2 Mineral oil products

Carbon slippage is potentially more problematic in the case of mineral oil products. As elaborated in section 4.2.2.2, the lowest feasible point of regulation would be the finished products leaving refineries – further up the supply chain, it is not possible to establish in which sectors and activities the fuels will be used – or not even to which final products the mineral oil inputs will be converted. If the point of obligation is set at the level of final products leaving the refinery, or at the level of tax warehouses, it is possible to establish the destination and intended use of the fuels, and hence their treatment under upstream or downstream ETS.

There are, however, several instances where fraud risks may emerge, as fuels that are otherwise identical (or very similar) are used for different purposes, or benefit from special treatment.

- One source of slippage / fraud risk concerns the domestic use of mineral oil products that were destined for export. To avoid distortions and competitive disadvantages, it is likely that products destined for export could be exempted from the coverage of the carbon pricing system. If, instead of being exported, they would be used domestically, this would constitute a risk of fraud or abuse. As fuels are covered tightly in terms of the taxation regime, this would however appear to be a minor risk. The risk could be further reduced if compensation is only granted ex-post, if the fuel exporter fuels can demonstrate that the respective quantity of fuels has indeed been exported.

- Another potential fraud risk arises if chemically similar or identical fuels are used in different sectors. Thus, for instance, heating oil / light fuel oil and diesel mostly differ through some additives that are added to the fuels, but are otherwise largely identical. As a result, there have been numerous cases of "fuel fraud", whereby heating oil is used or sold as diesel fuel. To some extent, this can be mitigated by adding markers / colourants to diesel to make it discernible from heating oil. This (existing) fraud risk could be exacerbated if the fuel types are treated differently in a carbon pricing system – if, for instance, light fuel oil destined for a downstream industrial installation (and thus not carrying a carbon price) is instead used as heating oil.
- Finally, fraud risk is already a concern wherever identical or equivalent fuels are taxed differently for other reasons. For instance, several Member States grant a tax rebate or exemption for diesel used by famers for farming activity (or more generally for off-road uses). In these instances, slippage may occur if farmers use the subsidised diesel for non-farming activities, e.g. for fuelling their private car. Such risks would be exacerbated if a general carbon pricing regime was applied to all fuels of a certain type (e.g. all transport fuels), but exempting certain uses (e.g. off-road uses).

In conclusion, in the case of mineral oil fuels, the risk of carbon slippage that would arise from a different treatment of fuels destined for upstream or downstream sectors is real. However, it mostly amounts to exacerbating existing risks of tax fraud. In response to the existing risks, the system for monitoring fuel uses and their taxation has already been set up rather meticulously, and incidents of fuel tax fraud remain isolated.

4.4.3.3 Coal

As noted in section 4.2.2.3, the risk of carbon slippage in the case of coal is limited by the fact that coal has no role in transport, and only a very small (and shrinking) role in home heating, or in small industry installations that are below the threshold for participation in the EU ETS. In Germany, for instance, coal use in private households and in services accounted for 0.75 million tons of coal equivalent (tce) in 2018, or 0.75% of the total coal use in Germany in that year.[135]

At the same time, however, the situation is less clear since the coal market has fewer regulations and less monitoring than that for gas and mineral oil products. Thus, the evasion scenario – that coal shipments destined for a downstream use are instead sold on to be used in a sector that would be covered by an upstream carbon price – is more likely for coal than it is for other fossil fuels.

As elaborated below, this risk could be mitigated by prohibiting direct trades of coal from entities covered downstream, requiring instead that trades can only be made via designated fuel suppliers (which would then obviously incur an upstream compliance obligation). Alternatively, it would need to be stipulated that any entity that sells coal assumes the function and the legal obligations of a fuel supplier, including the obligation to surrender allowances for coal sold to installations and uses under the upstream coverage.

[135] Arbeitsgemeinschaft Energiebilanzen (2018). Energieflussbild 2018, https://ag-energiebilanzen.de/9-0-Energieflussbilder.html

4.4.3.4 Addressing carbon slippage

To address the risk of carbon slippage, different routes would be available in principle (and have been applied in similar instances).

- One option is to **legally classify fuels** that are destined for different categories of customers and uses (i.e. those covered by a downstream obligation, and those without) **as different products**. This would also require that the different fuels would need to be distinguished and tracked separately all the way down the supply chain. This distinction can be supported if the fuels are also physically distinguishable, by adding chemical markers or colourants, in the same way as already applied for diesel, offroad diesel and heating oil.
- A different option would be to **generally treat all fuels as if destined for a customer / use that is not covered by a downstream obligation**, and to allow those customers / uses that have such an obligation to **apply for a refund**. As a result, all fuels sold would initially lead to a surrender obligation for the fuel supplier, and would hence include the carbon price. If the fuel customer proves – as part of their annual reporting duties that already exist under the EU ETS – that the fuel was combusted and resulted in a surrender obligation, this would qualify for a refund. In this case, the surrender obligation of the supplier would need to be adjusted downward accordingly.
- A variety of the latter would be an **opt-in option**. Like the former, this would generally treat all fuels as destined for an upstream customer, but to allow customers the choice whether they want to remain in the system as a downstream installation (and thus a full participant in the ETS with all rights and obligations), or whether they prefer to enter as an upstream customer – in which case they would, for instance, no longer need to monitor and report their emissions. This would be reminiscent of a feature in the New Zealand ETS, in which fuel customers can voluntarily opt into the ETS and thereby become downstream participants, including all reporting obligations.

The first option – different legal status for different fuel types depending on their end use – creates some administrative burden, particularly for fuel suppliers, tax warehouses and fuel traders / distributors, as well as the tax and customs authorities that are in charge of overseeing these rules. In addition, it gives rise to some legal issues that need to be addressed:

- The **liability risk** between supplier and customer will need to be addressed: in general, the supplier would need to ascertain the ETS status of their customer, i.e. whether the fuel is intended for combustion in an installation covered by the (downstream) ETS. If would be the customer's responsibility to ensure that this information is correct. Yet if the information is indeed incorrect, it would mean that the supplier has not complied with his / her surrender obligation. Liability would thus need to be addressed in the delivery contract between supplier and customer.
- Inconsistencies may also arise in the case of **bilateral trading or exchanges between covered entities** (unless such transactions are prohibited): this may occur if an installation that is covered under the downstream ETS – and would hence acquire its fuels without a carbon cost element – should sell or transfer fuels to another installation, company or business unit that has no such obligation. In this case, it would need to be clarified for whom this transaction creates a surrender obligation: for instance, it could be regulated that any entity selling fuels thereby becomes a fuel supplier, with corresponding obligation. An alternative would be to prohibit such bilateral transactions, and to require that trades would need to be made via a registered fuel trading company (which would obviously be covered by the upstream obligation).

The second option – to generally apply the carbon price to all fuels and allow for a refund – would address the above issues, and largely eliminate the potential for fraud, but at the cost of significant drawbacks:

- If firms need to incur the cost first, and receive the refunded later, it could be a strain on their liquidity – particularly if the refund occurs annually. Which would be the most straightforward option, if the refund should be tied to the MRV procedures under the EU ETS.
- The need to apply for a refund would create an additional administrative burden – which would appear particularly disproportionate for incumbent installations under the EU ETS.
- The refund would logically be connected to a downward adjustment of the supplier's surrender obligation. As a result, the refund would either be paid directly by the fuel supplier – or from the public budget, and later recovered from the fuel supplier. In either case, provisions would need to be made to prepare for contingencies (e.g. bankruptcy of the supplier).
- A fundamental issue is to establish which costs should actually be refunded. Since the carbon price fluctuates, it would be necessary to establish which carbon cost was indeed passed on at the time of the sale (or the contract). Suppliers are assumed to pass on the cost, but would not normally document which part of their product price is due to the carbon price. Even if such a requirement was introduced, it would create an additional risk – since the supplier would have an incentive to report a pass-on that is as low as possible.
- Should downstream customers choose not to apply for a refund, or fail to do so for other reasons, the result would be double counting of their emissions.

Weighing these different options, it appears that while a refund could work as a recourse for limited, special situations (see following section), it would not seem feasible or proportionate as the default procedure.

4.4.4 Double counting

A combination of an upstream and a downstream ETS leads to challenges, especially in the monitoring of energy flows of fossil fuels. In a hybrid upstream-downstream system, double counting of emissions may arise where fuels that were destined for the upstream sector (and which therefore carry a carbon price) instead end up being combusted in an installation that has a downstream obligation. In this case, the same ton of emissions would lead to a compliance obligation both for the fuel supplier and for the final customer. This situation is less problematic for environmental integrity – as the cap is not breached – but rather in terms of fairness and efficiency, as the emission source in question effectively pays double for their emissions, creating an undue burden and undermining the goal of the instrument to reduce emissions at least cost. Also, compared to the issue of slippage, double counting is generally less of a concern since it runs against the economic interest of the operator – the fact that the carbon price has to be paid twice provides a disincentive to accept situations of double counting, or the incentive to look for a solution.

This risk of double counting affects those installations already covered in the EU ETS as downstream emitters, i.e. industrial and energy installations (electricity and heating), as well as air transport. The transport (except air transport) and buildings sectors are not currently regulated by the EU ETS and therefore double counting may occur only in exceptional cases.

There are two principle options to avoid double counting: either the downstream-regulated entity or the upstream-regulated entity must be exempted.

If the **upstream-regulated entity is exempted**, this means that this entity would not need to surrender allowances for those fuels that are delivered to installations and used in activities that are part of the downstream ETS. The quantities of such fuels could be reported, but would not incur a compliance obligation for the supplier. This would also mean that such fuels would be traded at a lower price, as there would be no reason to include a carbon price.

If the **downstream entity is exempted**, this means that the entity would not incur a compliance obligation for the share of emissions that stems from combusting fuels intended for the upstream sector. As already practiced in the case of biofuels, the use of such fuels would be reported, but would be calculated with an emission factor of zero, as the emissions are already covered elsewhere. In this case, the carbon price would remain included in the price of the fuel sold from the upstream supplier to the downstream customer: as the downstream emitter does not face a surrender obligation and hence a carbon price on the direct emissions, they would instead pay the carbon price indirectly.

Furthermore, there are two distinct possibilities in terms of the timing of the process:

In the case of an **ex-ante exemption**, fuel that is delivered from an upstream-regulated fuel supplier to a downstream-regulated installation would not incur a compliance obligation for the supplier. Thus, the quantities of fuel in question would either not be reported at all, or they would be reported but deducted from the overall fuel delivered by the fuel supplier, so that they would not be included in the compliance obligation of the fuel supplier.

In the case of **an ex-post exemption**, the downstream-regulated installation can apply to be compensated afterwards if it can demonstrate that the emissions have been counted twice. The compensation would logically be paid to the downstream regulated installation, as it can be assumed (and corresponds to the intention of the system) that the upstream regulated fuel supplier would include the allowance costs in his sale price and thereby passes them on to the downstream regulated customer. In this case, an additional technical question concerns the issue whether compensation is handled in the form of allowances, or in monetary form. The latter would raise the question which carbon price and pass-through rate should be assumed for the compensation; in the former case, the value of the compensation might deviate from the cost incurred if the carbon price has changed in the meantime.

An ex-ante exemption appears to be a viable approach for some design options and for certain supply streams, as some fossil fuel supply streams are already covered by energy taxes, with differential tax rates applying to different uses of the fuels. For this reason, many suppliers already know their customers and the intended use of the fuels.

As noted, there may be instances where there is no practicable solution to avoid double counting, since keeping and separating different stocks of fuels would incur higher administrative effort than the cost of paying twice. These are instances where refund solutions could make sense: This would mean that the fuel customer would need to clearly demonstrate that the purchased fuels did not end up being combusted in a non-ETS use, but were used in an ETS installation and covered by a surrender obligation. In these instances, the customer would be able to apply for a refund – which, in the logic of the system, would lower the compliance obligation of the fuel supplier. Hence, the monetary refund would also need to be paid (directly or indirectly) by the fuel supplier.

4.5 Question 3.5: Monitoring, reporting and verification of emissions

Accurate monitoring, reporting and verification (MRV) of emissions is needed for the effective functioning of the ETS. A robust compliance regime is the backbone of the ETS and a precondition for its credibility.

Currently, the Monitoring and Reporting Regulation (EU) No 601/2012 supplemented with the Accreditation and Verification Commission Implementing Regulation (EU) 600/2012 set the framework applicable to the ETS sectors. The legislation has been amended and from January 2021 the Commission Implementing Regulation (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions will enter into force. Another revision of these regulations is expected in 2020. Furthermore, the Monitoring Mechanism Regulation (EU) No 525/2013 (MMR) has established an annual reporting system based on a compliance cycle requiring an annual review of Member States' GHG emission inventories to ensure compliance with the Effort Sharing legislation.

The general principles for establishing an emissions monitoring and reporting system, as stated in the MMR in the framework of the national GHG inventories, and also stated in the MRR in the framework of the EU ETS, must comply with the TACCC principles:

Transparency of the data that the regulated entities obtain, record, compile, analyse and document.

Accuracy of the emission determination.

Consistency and comparability of the methodologies used and data sets over time.

Completeness of the sources of emissions covered under the regulation.

An inclusion of the road transport and/or the buildings sector in an ETS will require that an accurate, reliable and cost efficient MRV system can be established also for these sectors.

Eight design options have been discussed in section 4.1, regarding the extension of the current EU ETS for sectors or sub-sectors, or the creation of separated ETS.

MRV requirements depend on the point of regulation, that is to say the nature of the regulated entities chosen also regarding the design options proposed for the inclusion of the CO2 emissions from the combustion of fossil fuels in the road transport and the building sectors in an ETS.

The analysis of the supply chains for the use of fossil fuels in particular in the road transport and the buildings sector conducted in Question 2.1b provides the following overview.

Figure 90. Estimation of the number of entities in the fuel supply chains in the EU (excluding UK), and the end-users

Natural Gas supply chain

Stage	Sub-stage	No. of entities
Production	Extraction/ import	433
	Processing	58
Transmission	Transmission system operators	58
Distribution	Local gas companies	2 329

CONSUMERS

- Industrial users, power stations, steam generation plants
- Buildings:
  - Residential
  - Services,

  End-use: heating spaces and water, cooking, electricity

  Road transport:
  - Cars and motorcycles
  - Buses
  - Trucks and light-duty vehicles

Solid fuels supply chain

Stage	Sub-stage	No. of entities
Production	Coal mines	118
	Coal producers	198
Storage	Coal terminals	28
	Importers of coal	500
Distribution	Coal distributors	3000

CONSUMERS

- Industrial users, power stations, steam generation plants
- Buildings:
  - Residential
  - Services,

  End-use: heating spaces and water, cooking, electricity

Oil supply chain

Stage	Sub-stage	No. of entities
Production	Oil extraction in EU	247
	Oil refining	87
	Biorefineries	213
	Oil importers	40
Distribution	Fuel blender	500-2000
	Fuel importers	100-1000
	Tax warehouses	7000
	Fuel supplier	10,000
	Filling station	107,545

CONSUMERS

- Industrial users, power stations steam generation plants
- Buildings:
  - Residential
  - Services,

  End-use: heating spaces and water, cooking, electricity

  Road transport:
  - Cars and motorcycles
  - Buses
  - Trucks and light-duty vehicles

Legend:

Currently (partly or totally) in the EU ETS, when achieving the criteria of Annex I of Directive 2003/87/EC amended (green shading)

Not currently in the EU ETS (no shading)

Source: Task 2 and Citepa

Following the supply chains, upstream and downstream approaches have been discussed in section 4.2 regarding options on the point of regulation (i.e. the regulated entities) for the inclusion of the CO2 emissions from the combustion of fossil fuels in the road transport and the buildings sectors in an ETS. The results of the discussion show that an upstream approach is preferred while the downstream approach presents several disadvantages compared to a more upstream-oriented regulation.

In the upstream approach, decisions on the regulated entities are made by type of fuel rather than final output sector. As stated in section 4.2.2, options for the definition of the regulated entities are proposed for the following types of fuels: gas products, oil products, and solid products. The Table 75 below provides a combined overview of the design options proposed, the related MRV enforcement measures, the necessary knowledge about the end user and the proposed regulated entities, based on the results of previous tasks.

Table 75. Design options, related MRV enforcement measures, necessary knowledge about the end user and proposed regulated entities

				Gas products	**Oil products**		**Solid products**
Option ID	**Scope**	**Implementation, compliance and enforcement measures**	**Necessary knowledge about the end user**	**Distributors**	**Oil refineries** (supply)	**Tax warehouse**	**Distributors**
Option 0	**Baseline** *No EU-wide extension of the EU ETS, potential opt-in by individual MS*		MS individual				
Option 1a	**Full scope extension** *Full EU-wide scope extension of the EU ETS to include road transport + buildings. Sectors no longer part of the ESR.*	Current MRV rules apply – feasibility depends on the regulated entities	Need to identify the user in road transport or in buildings	X (road transport and buildings)	X (road transport and buildings)	X (road transport and buildings)	X (buildings)
Option 1b	**Full scope extension under existing ESR** *Full EU-wide scope extension of the EU ETS to include road transport + buildings. Sectors also part of the ESR.*	Current MRV rules apply – feasibility depends on the regulated entities and the links with enforcement under ESR	Need to identify the user in road transport or in buildings	X (road transport and buildings)	X (road transport and buildings)	X (road transport and buildings)	X (buildings)
Option 1c	**Scope extension for freight transport and commercial buildings** *EU-wide scope extension of the EU ETS to include freight transport + commercial buildings*	Current MRV rules apply – feasibility depends on the regulated entities	Need to identify user in freight road transport or commercial buildings	X (freight transport and commercial buildings)	X (freight transport and commercial buildings)	X (freight transport and commercial buildings)	X (commercial buildings)

				Gas products	Oil products		Solid products
Option ID	**Scope**	**Implementation, compliance and enforcement measures**	**Necessary knowledge about the end user**	**Distributors**	**Oil refineries** (supply)	**Tax warehouse**	**Distributors**
	Sectors no longer part of the ESR.						
Option 2a	**Scope extension for road transport** *EU-wide scope extension of the EU ETS to include road transport* *Road transport no longer part of the ESR.*	Current MRV rules apply to transport– feasibility depends on the regulated entities	Need to identify user in road transport	X (road transport)	X (road transport)	X (road transport)	

				Gas products	Oil products		Solid products
Option ID	**Scope**	**Implementation, compliance and enforcement measures**	**Necessary knowledge about the end user**	**Distributors**	**Oil refineries** (supply)	**Tax warehouse**	**Distributors**
Option 2b	**Scope extension for buildings** *EU-wide scope extension of the EU ETS to include buildings* *Buildings sector no longer part of the ESR.*	Current MRV rules apply to buildings– feasibility depends on the regulated entities	Need to identify user in buildings	X (buildings)	X (buildings)	X (buildings)	X (buildings)
Option 3a	**One separate ETS for [road transport + buildings] with limited linking to the EU ETS: new ETS market** *Separate ETS schemes for road transport + buildings* *Sectors also part of the ESR.*	New MRV and enforcement rules to be designed – feasibility according to regulated entities and further option details	Need to identify the user in road transport or in buildings	X (road transport and buildings)	X (road transport and buildings)	X (road transport and buildings)	X (buildings)
Option 3b	**One separate ETS for [freight transport + commercial buildings] with limited linking to the EU ETS: new ETS market** *Separate ETS schemes for freight transport + commercial buildings* *Sectors also part of the ESR.*	New MRV and enforcement rules to be designed – feasibility according to regulated entities and further option details	Need to identify user in freight road transport or commercial buildings	X (freight transport and commercial buildings)	X (freight transport and commercial buildings)	X (freight transport and commercial buildings)	X (commercial buildings)

				Gas products	Oil products		Solid products
Option ID	**Scope**	**Implementation, compliance and enforcement measures**	**Necessary knowledge about the end user**	**Distributors**	**Oil refineries** (supply)	**Tax warehouse**	**Distributors**
Option 3c	**Two separate ETS: one for [road transport] + one for [buildings], with limited flexibilities with the EU ETS** *2 new ETS markets. Sectors also part of the ESR.*	New MRV and enforcement rules to be designed – feasibility according to regulated entities and further option details	Need to identify the user in road transport or in buildings	X (road transport) (buildings)	X (road transport) (buildings)	X (road transport) (buildings)	X (buildings)

Source: Questions 3.1 and 3.3

Detailed characteristics on the regulated entities proposed are specified below, based on the section 4.2.

Table 76. Overview of MRV characteristics regarding the three main fuels for the two sectors discussed in Question 3.3

Type of fuel concerned: Natural gas	
Type of potential regulated entities, point of the supply chain	Distribution level -> Regional distributors (ex: local gas companies) Supply streams to buildings and filling stations Most important role for the building sector
Number of potential regulated entities, size, market concentration	2 329
Incentives created for emissions reductions and innovation	Assuming that the price signal is fully passed on and given a carbon price of 20€ or 100€ per tonne of CO_2 and a consumption of about 20,000 kWh per year, owners of gas heating systems must expect additional costs of about 81€ to 405€ per year. End users would then be encouraged in the medium term to switch to other systems: biomass heating, heat pumps or heat networks
Administrative burden and possible impact on SMEs	Administration: costs of identifying building and service station supply flows are expected to be by far the lowest. However, this will require monitoring over 2,000 installations. Impacts on SMEs: weak
Upstream / downstream / mix?	Upstream
De minimis rules and gradual approaches to ETS extension	*tbd*

Type of fuel concerned: Mineral oil products	
Type of potential regulated entities, point of the supply chain	Production level -> refineries End use known, some products exported, import/export treated separately Important role for both road transport and building sectors
Number of potential regulated entities, size, market concentration	87
Incentives created for emissions reductions and innovation	With a carbon price of 20€ or 100€ per tonne of CO_2, oil heating system owners must calculate with additional costs of about 107€ to 535€ per year. Given the underlying CO_2 prices, car drivers would have to calculate additional costs of about 38€ to 239€ per year for a distance driven of about 13,000 kilometres and a consumption of about 7 litres per 100 kilometres.
Administrative burden and possible impact on SMEs	Oil refineries and tax warehouses being identified as the most appropriate regulatory points. The advantage of regulating oil refineries is the low number of regulated organisations with only 87 oil refineries (plus 100 – 1,000 fuel importers) in Europe compared to approx. 7,000 tax warehouses.
Upstream / downstream / mix?	Upstream
De minimis rules and gradual approaches to ETS extension	*tbd*

Type of fuel concerned: Mineral oil products	
Type of potential regulated entities, point of the supply chain	Distribution level ->Tax warehouse End use known, monitoring system existing Important role for both road transport and building sectors
Number of potential regulated entities, size, market concentration	Approx. 7,000
Incentives created for emissions reductions and innovation	With a carbon price of 20€ or 100€ per tonne of CO_2, oil heating system owners must calculate with additional costs of about 107€ to 535€ per year. Given the underlying CO_2 prices, car drivers would have to calculate additional costs of about 38€ to 239€ per year for a distance driven of about 13,000 kilometres and a consumption of about 7 litres per 100 kilometres.
Administrative burden and possible impact on SMEs	Oil refineries and tax warehouses being identified as the most appropriate regulatory points. In terms of transaction costs, the regulation of tax warehouses has the advantage that an administrative quantity metering system for monitoring and reporting already exists which is used for the excise duty. Due to the large number of tax warehouses, the costs for the public sector would be rather high.
Upstream / downstream / mix?	Upstream
De minimis rules and gradual approaches to ETS extension	*tbd*

Type of fuel concerned: Coal	
Type of potential regulated entities, point of the supply chain	Distribution level -> Distributors 3000 entities Role only for buildings
Number of potential regulated entities, size, market concentration	3 000
Incentives created for emissions reductions and innovation	Assuming that the price signal is fully passed on and given a carbon price of 20€ or 100€ per tonne of CO_2 and a consumption of 20,000 kWh owners of coal-fired heating systems have to calculate additional costs of about 138€ to 690€ per year.
Administrative burden and possible impact on SMEs	In comparison to the markets for mineral oil or gas, it is to be expected that the market for coal for heating will incur significantly higher transaction costs, since it can be assumed that many smaller players, which have hardly been regulated up to now, will be involved, and that they would have to establish monitoring and reporting systems. This means that investments must be made, in particular in precise volume, net calorific value, carbon content monitoring. For the government, it means more efforts in terms of participant identification, supervision and enforcement.
Upstream / downstream / mix?	Upstream
De minimis rules and gradual approaches to ETS extension	*tbd*

Source: Question 3.3

Based on the above information on the supply chain, the design options and regulated entities proposed, the following MRV challenges have been analysed:

1. The extent to which an MRV system can rely on the current EU ETS system of fuel emission factors per energy and on the current national GHG inventory reporting system to monitor progress.
2. The possibility for the regulated entity to ensure an accurate monitoring and reporting of CO2 emissions. The possibility for the regulated entity to identify the end-user of the supplied fuel and distinguish fuels that will result in emissions in the transport and building sectors.
3. The complexities involved in combining and delimiting upstream and downstream approaches for different sectors.
4. The resulting cost and administrative burden for the regulated entity and the relevant administrative bodies and agencies.
5. The possibility for fraud of the regulated entity's monitoring and reporting system.

4.5.1 Currently applicable framework

Industrial installations and aircraft operators currently covered by the EU ETS are required to report their annual CO2 emissions, which have been monitored based on a monitoring plan. The monitoring plan is submitted to the national competent authorities together with the application for an operating permit and is approved as part of the permitting process. This approved monitoring plan shall be used by the operator to monitor CO_2 emissions during the year.

Operators report on their emissions once a year through the submission of a verified emissions report. On the basis of this report, an operator will surrender an equivalent number of emission allowances, every year by 30 April.

As introduces previously, the MRV system under the EU ETS is regulated in two main legal instruments, which are currently subject to review as part of the revision for phase 4 of the EU ETS, which will start in 2021:

The Monitoring and Reporting Regulation (MRR)[136], and

The Accreditation and Verification Regulation (AVR)[137].

In addition to these two main legal instruments, the Commission has prepared detailed guidance documents and templates for the reporting.

Monitoring and reporting

The MRR sets out detailed requirements for the monitoring and reporting of CO_2 emissions by operators, such as on the accuracy of data monitored and reported, consistency and comparability across years for the same activities, integrity of the methodology and transparency of parameters used, including assumptions, references, activity data, emission factors, oxidation factors and conversion factors, in a manner that enables the reproduction of the determination of emissions by the

[136] COMMISSION REGULATION (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council

[137] COMMISSION IMPLEMENTING REGULATION (EU) 2018/2067 of 19 December 2018 on the verification of data and on the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council

verifier and the competent authority.[138] The MRR explicitly requires operators and aircraft operators, in its Article 7, to ensure that emission determination is neither systematically nor knowingly inaccurate and to identify and reduce any source of inaccuracies as far as possible. Specific requirements for the monitoring plan and accompanying documentation are set out in Chapter II of the MRR. The MRR also regulates the situation in which an operator argues that the application of a certain monitoring methodology would not be technically feasible or would entail unreasonable costs.[139]

In addition to these overarching requirements relating to the monitoring and reporting of CO2 emissions by operators, the MRR contains detailed monitoring, measurement and calculation requirements and parameters for both types of operators currently covered by the EU ETS. Applying these detailed requirements, set out in Chapter III of the MRR, an operator of an industrial installation is required to monitor all GHG emissions for all emission sources and source streams belonging to activities carried out at the installation and listed in Annex I to the EU ETS Directive, and any opt-in activities included by Member States.[140] Aircraft operators are required to monitor emissions for the flights included in this same Annex I to the ETS Directive performed by the aircraft operator during the reporting period, in accordance with the detailed requirements set out in Chapter IV.[141]

To this end, the Article 52 of the MRR requires them to multiply the annual consumption of each fuel expressed in tonnes by the representative emissions factor. Each aircraft operator has to determine the fuel consumption for each flight and for each fuel, using the methods specified in the MRR. As stated in article 21 of the MRR, a calculation-based methodology shall consist in determining emissions from source streams on the basis of activity data obtained by means of measurement systems and additional parameters from laboratory analyses or default values.

The MRR explicitly requires the operator to choose the method which provides for the most complete and timely data combined with the lowest uncertainty without incurring unreasonable costs. For the fuel uplift, the operator shall choose between the measurement by the fuel supplier as in the delivery note for each flight or the data from the onboard measurement systems, recorded in the aircraft transaction log and transmitted electronically to the aircraft operators.

In the current EU ETS, the more a regulated entity emits per year, the more accurately it must estimate the CO_2 annual emissions. This is the core of the Tier approach, summarised in Table 77.

[138] Article 6 MMR.

[139] Articles 17 and 18 MMR.

[140] Article 20 and following MMR.

[141] Article 50 and following MMR.

Table 77. The Tier approach in the current EU ETS

Tier Level	Activity Data		Emission Factor	Biomass Fraction	Oxidation Factor
	Maximum uncertainty in fuel amount	Net Calorific Value			
Tier 4	± 1.5%	Factors determined by analysis	Factors determined by analysis	Factors determined by analysis	Factors determined by analysis
Tier 3	± 2.5%				
Tier 2	± 5%	Country specific factors / value from fuel invoices	Country specific factors / proxy values from analysis		Country specific factors
Tier 1	± 7.5%	Standard factors from Annex VI of the MRR	Standard factors from Annex VI of the MRR	Standard factors	1

Source: EU ETS handbook, European Commission, 2015

The different Tiers must be applied by the operator for each source stream of the plant, regarding the combination of the classification of the source stream and the category of the installation (article 19 of the MRR).

Table 78. Categories of installations in the current EU ETS

Small emitters	A	B	C
Annual emissions			
E < 25 000 t CO_2e	E < 50 000 t CO_2e	50 000 t CO_2e < E < 500 000 t CO_2e	E > 500 000 t CO_2e

Sources streams are classified as follows (article 19 of the MRR):

(a) minor source streams, where the source streams selected by the operator jointly account for less than 5 000 tonnes of fossil CO2 per year or less than 10 %, up to a total maximum of 100 000 tonnes of fossil CO2 per year, whichever is greater in terms of absolute value;

(b) de minimis source streams, where the source streams selected by the operator jointly account for less than 1 000 tonnes of fossil CO2 per year or less than 2 %, up to a total maximum of 20 000 tonnes of fossil CO2 per year, whichever is greater in terms of absolute value;

(c) major source streams, where the source streams do not fall within the categories referred to in points (a) and (b).

The MRR requirements aim at ensuring that the verifier and by extension the competent authority, is in a position to verify and assess the emissions reported by an operator and hence reduce the risk of misrepresentation in CO_2 emissions monitored and reported. Overall, the requirements in the MRR are considered to accurately capture the information required for the effective functioning of the EU ETS for both sectors, in particular following recently introduced modifications.

The analysis of national responses under Article 21 of the EU ETS Directive (Application of the European union emissions trading directive in 2018, European Commission, 2019) includes various feedback and areas of improvement which could be useful when assessing and designing the inclusion of road transport and buildings in the ETS.

Considering the application of the Tier approach, it is useful to look at the proportion between installations derogating from the highest tier approach and the total number of installations to be able to evaluate possible improvements in the MRV system. In 2017, 21.3% of category B installations derogated from the highest tiers approach for the years, and 13.7% of category C installations (EC, Article 21 responses analysis, 2019). Even if this percentage has decreased since 2013, it shows that one fifth of category B installations demonstrated that the required monitoring rules were technically infeasible or incurred unreasonable costs. The current MRR authorizes these derogations, if the competent authority approves them, but it highlights that some operators do not manage to reach the high level of accuracy required by the regulation. A further analysis on the reasons and the demonstration of the derogations could be considered to propose adapted MRV rules for the potential new ETS sectors. For instance, we can assume that the monitoring of combustion-related CO2 emissions of fuel distributed to the road transport and the buildings sectors would not be the most complex method to implement, compared to process emissions monitored in complex sectors such as petroleum production, iron and steel or chemical industries. Nevertheless, the monitoring of the calculation parameters (for instance by using measurements from samplings at a high frequency for determining the specific carbon content or biomass content of a fuel), or the activity data at a required uncertainty, which could in theory be applicable to the potential proposed regulated entities, can lead to unreasonable costs or be technically unfeasible. Such feedback should be considered when establishing MRV rules on new regulated entities.

A 2015 evaluation of the EU ETS Directive showed that the fact that the MRR contains minimum requirements for the monitoring plan, and the Commission's publication of electronic templates, have led to a strong improvement of monitoring plan quality.[142] In particular the requirements to list all the metering instruments and monitoring approaches, as well as the requirement to outline the data flows and implemented control procedures in place have resulted in a better basis for competent authorities to approve monitoring plans.[143] The evaluation concludes that the current MRVA system is reasonably mature, and robust, as demonstrated by the low number of non-compliance cases found.[144]

Verification

The Accreditation and Verification Regulation (AVR), which has been adopted and applies in parallel to the MRR, regulates the verification of annual emission reports and the accreditation of verifiers authorised to carry out this process. The AVR contains a general requirement for a verified emissions report to be reliable for users and to represent the emissions faithfully. In its Article 6, it requires "the process of verifying an operator's or aircraft operator's report to be an effective and reliable tool in support of quality assurance and quality control procedures, providing information upon which an operator or aircraft operator can act to improve performance in monitoring and reporting emissions or data relevant for free allocation." The verifier is required to

[142] Evaluation of the EU ETS Directive, Ecologic and SQ Consult, 2015, https://www.ecologic.eu/sites/files/publication/2015/2614-04-review-of-eu-ets-evaluation.pdf

[143] Ibid.

[144] Ibid.

conclude with reasonable assurance that the operator's report is free from material misstatements, to do so with an attitude of professional scepticism, and to work in the public interest.[145] Similarly to monitoring and reporting, the Commission has developed guidance documents to assist the verifiers in their task and to ensure a degree of harmonisation across Member States.

4.5.2 Consistency challenges between the EU ETS MRV rules and the GHG inventory reporting system

Comparison of the current EU ETS system of fuel combustion emission factors (per unit of energy) and the current inventory reporting system

The Commission implementing regulation (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC contains the rules for the monitoring and reporting of greenhouse gas emissions and activity data under Directive 2003/87/EC for the fourth trading period of the EU ETS. A second revision of the MRR is expected in 2020.

The currently regulated entities in the EU ETS must report the minimum information defined in the Annex X of the above-mentioned Regulation in their annual emissions report, especially:

- the total emissions expressed as t CO_2.
- the activity data:
    - in the case of fuels, the amount of fuel (expressed as tonnes or Nm3) and the net calorific value (GJ/t or GJ/ Nm^3) reported separately.
    - (...)
- the emission factors, expressed in accordance with the requirements set out in Article 36(2); biomass fraction, oxidation and conversion factors, expressed as dimensionless fractions.
- where emission factors for fuels are related to mass or volume instead of energy, values determined pursuant to Article 26(5) for the net calorific value of the respective source stream.

The article 36(2) details that "emission factors of fuels, including those used as process input, shall be expressed as t CO_2/TJ. The competent authority may allow the operator to use an emission factor for a fuel expressed as t CO_2/t or t CO_2/Nm^3 for combustion emissions, where the use of an emission factor expressed as t CO_2/TJ incurs unreasonable costs or where at least equivalent accuracy of the calculated emissions can be achieved by using such an emission factor."

The article 26(5) indicates that "where the competent authority has allowed the use of emission factors expressed as t CO_2/t or t CO_2/Nm^3 for fuels, (...), the net calorific value may be monitored using a conservative estimate instead of using tiers, unless a defined tier is achievable without additional effort."

Under certain circumstances such as great effort of calculation or the results are equivalent due to standards, emission factors referring to the mass of fuel can also be applied. However, this is only allowed in individual cases by the competent authority.

According to the MRR, for combustion emissions from fuels, the CO_2 emission factor is expressed in relation to the energy content (NCV) of the fuel rather than in mass or

[145] Article 7 AVR.

volume. The Annex VI of the MRR provides standard emission factors in t CO_2/TJ for the following fuels (Tier 1 method, i.e. the lowest certain estimate):

Table 79. Default CO2 fuel emission factors related to net calorific value (NCV) and net calorific values per mass of fuel under the EU ETS

Reference values for calculation factors (Article 31(1)(a))

1. FUEL EMISSION FACTORS RELATED TO NET CALORIFIC VALUES (NCV)

Table 1

Fuel emission factors related to net calorific value (NCV) and net calorific values per mass of fuel

Fuel type description	Emission factor (t CO_2/TJ)	Net calorific value (TJ/Gg)	Source
Crude oil	73,3	42,3	IPCC 2006 GL
Orimulsion	77,0	27,5	IPCC 2006 GL
Natural gas liquids	64,2	44,2	IPCC 2006 GL
Motor gasoline	69,3	44,3	IPCC 2006 GL
Kerosene (other than jet kerosene)	71,9	43,8	IPCC 2006 GL
Shale oil	73,3	38,1	IPCC 2006 GL
Gas/Diesel oil	74,1	43,0	IPCC 2006 GL
Residual fuel oil	77,4	40,4	IPCC 2006 GL
Liquefied petroleum gases	63,1	47,3	IPCC 2006 GL
Ethane	61,6	46,4	IPCC 2006 GL
Naphtha	73,3	44,5	IPCC 2006 GL
Bitumen	80,7	40,2	IPCC 2006 GL
Lubricants	73,3	40,2	IPCC 2006 GL
Petroleum coke	97,5	32,5	IPCC 2006 GL
Refinery feedstocks	73,3	43,0	IPCC 2006 GL
Refinery gas	57,6	49,5	IPCC 2006 GL
Paraffin waxes	73,3	40,2	IPCC 2006 GL
White spirit and SBP	73,3	40,2	IPCC 2006 GL
Other petroleum products	73,3	40,2	IPCC 2006 GL
Anthracite	98,3	26,7	IPCC 2006 GL
Coking coal	94,6	28,2	IPCC 2006 GL
Other bituminous coal	94,6	25,8	IPCC 2006 GL
Sub-bituminous coal	96,1	18,9	IPCC 2006 GL
Lignite	101,0	11,9	IPCC 2006 GL
Oil shale and tar sands	107,0	8,9	IPCC 2006 GL
Patent fuel	97,5	20,7	IPCC 2006 GL
Coke oven coke and lignite coke	107,0	28,2	IPCC 2006 GL

Fuel type description	Emission factor (t CO_2/TJ)	Net calorific value (TJ/Gg)	Source
Gas coke	107,0	28,2	IPCC 2006 GL
Coal tar	80,7	28,0	IPCC 2006 GL
Gas works gas	44,4	38,7	IPCC 2006 GL
Coke oven gas	44,4	38,7	IPCC 2006 GL
Blast furnace gas	260	2,47	IPCC 2006 GL
Oxygen steel furnace gas	182	7,06	IPCC 2006 GL
Natural gas	56,1	48,0	IPCC 2006 GL
Industrial wastes	143	n.a.	IPCC 2006 GL
Waste oils	73,3	40,2	IPCC 2006 GL
Peat	106,0	9,76	IPCC 2006 GL
Wood/wood waste	—	15,6	IPCC 2006 GL
Other primary solid biomass	—	11,6	IPCC 2006 GL (only NCV)
Charcoal	—	29,5	IPCC 2006 GL (only NCV)
Biogasoline	—	27,0	IPCC 2006 GL (only NCV)
Biodiesels	—	27,0	IPCC 2006 GL (only NCV)
Other liquid biofuels	—	27,4	IPCC 2006 GL (only NCV)
Landfill gas	—	50,4	IPCC 2006 GL (only NCV)
Sludge gas	—	50,4	IPCC 2006 GL (only NCV)
Other biogas	—	50,4	IPCC 2006 GL (only NCV)
Waste tyres	85,0 (1)	n.a.	WBCSD CSI
Carbon monoxide	155,2 (2)	10,1	J. Falbe and M. Regitz, Römpp Chemie Lexikon, Stuttgart, 1995
Methane	54,9 (3)	50,0	J. Falbe and M. Regitz, Römpp Chemie Lexikon, Stuttgart, 1995

(1) This value is the preliminary emission factor, i.e. before application of a biomass fraction, if applicable.
(2) Based on NCV of 10,12 TJ/t
(3) Based on NCV of 50,01 TJ/t

Regarding GHG national greenhouse gas inventories, Member States must follow the monitoring and reporting rules included in the Mechanism for monitoring and reporting regulation (MMR). Under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, the monitoring and reporting rules lean on the IPCC Guidelines for National Greenhouse Gas Inventories. The 2006 version is the latest version currently used by Member States, while the 2019 refinement, which brings updates and supplements to the 2006 IPCC Guidelines, were adopted and approved in May 2019. Guidelines on the CO2 emissions estimates from the road transport (Volume 2-Energy, Chapter 3-Mobile combustion) and from combustion in buildings (Volume 2-Energy, Chapter 2-Stationary combustion) are not part of the refinement. The 2019 refinement are not applied yet for the elaboration of the GHG inventories under the UNFCCC.

For standardised fuels such as diesel, heating oil or petrol, reporting an emission factor in t CO_2/mass can be expected to be relatively accurate, while for less standardised fuels such as coal, a mass-based emission factor can lead to larger inaccuracies, considering the various compositions of the different coals used in the

EU. This will be relevant for a limited share of heating of buildings in certain Eastern European countries.

Road transport sector

To explore the feasibility for including the road transport sector in the EU ETS, based on the current inventory reporting system, an analysis of data reported by MS in the framework of their GHG inventory was performed. The reported data for the year 2018, referring to Common Reporting Format (CRF) and National Inventory Reports (NIR) (available at https://unfccc.int/ghg-inventories-annex-i-parties/2020) were analyzed. According to the 2006 IPCC Guidelines and the CRF requirements, activity data for Energy purpose are required in energy unit (TJ). As CO2 emissions are reported in mass (Gg), therefore the implied emission factor is automatically calculated in t CO2/TJ in the CRF Tables, even if Member states do not use directly the EF in t CO2/TJ for the CO2 emissions calculation, but use an EF in t CO2/t or in t CO2/m^3.

One of the aspects considered in the analysis for the inclusion on the road transport in the EU ETS is the consistency of the expression of the emission factor for fuels, i.e. units either in terms of mass (*t CO2/t fuel)*) or expressed as energy (*t CO2/ TJ fuel)*.

As expected, all Member States' report implied emissions factors (IEF) in their CRF tables in tonnes of CO2 per TJ. However, some of the IEFs reported in the CRFs may be the result of an automatic calculation of the CRF Reporter tool and used for reporting requirements only. For instance, as stated by Slovenia (NIR, p. 90): *"The CO2 emissions have to be reported in kt. In the CRF Tables, the fuel consumption has to be presented as energy (in TJ), not in mass (in tonnes). Implied CO2 emission factors, expressed in t CO2/ TJ fuel, are calculated automatically by CRF Reporter and used for reporting requirements only.".*

In order to bring to light the preference of the expression for the EF, as well as the availability of country-specific net calorific value (NCV), a detailed review of the reported data (CRF Tables & NIR) from MS was carried out (Table 80). The aim of this review is to explore the feasibility of using emission factors from combustion in road transportation expressed in tonne of CO2 per tonne of fuel (or per m3) which would be probably more appropriate for the EU ETS framework, and easier to monitor for the regulated entities.

Table 80. Summary of use of CO2 EF units and provision of specific NCV by Member states.

Member State	Emission factor for a fuel expressed as t CO2/t		Country-specific net calorific values (NCV) provided	
Austria	Partially	All Implied Emission Factors are given in t/TJ. Except for alternative fuel biodiesel = CO2-EF for fossil FAME[146] [kt CO2/kt FAME] (2020 NIR p. 155)	YES	The selected net calorific values of each fuel are shown in Annex 4.5– "Net Calorific Values" provided by Statistik Austria (IEA JQ 2019).
Belgium	NO	No comment	NO	No precise validated information about the carbon content and net calorific values of fuels in Belgium is currently available from the fuel suppliers. The Fund for the Analysis of Petroleum Products by 'Fapetro' cannot provide country-specific values and

[146] FAME: Fatty Acid Methyl Esters

Member State	Emission factor for a fuel expressed as t CO2/t		Country-specific net calorific values (NCV) provided	
				they will not provide it unless it becomes a European obligation (2020 NIR p. 111)
Bulgaria	NO	No comment	YES	Fuel consumption (liquid, gaseous and biofuels) is obtained from the Energy balance and converted into energy units using the country-specific NCV (as recommended by the ERT (FCCC/ARR/2013/BGR). (2020 NIR p, 122)
Croatia	NO	No comment	YES	The inventory team used country-specific fuel net calorific values for emission estimates. Calorific values from energy balance were compared with data from the IPCC Guidelines. Results of this comparison showed that there is no significant difference between these two sets of data. The natural units are transformed to energy units using appropriate national net calorific values (Table 3.1-3) (2020 NIR p. 63)
Cyprus	Partially	Yes, but only for the reference approach: "Table 3.27. Net calorific value (TJ/kt) and carbon emission factors (t CO2/kt) of fuels consumed in Cyprus used for the reference approach" (2020 NIR p.92)	Partially	The calorific value used to convert mass to energy unit are according to the national energy balance, i.e. Diesel 43.0 TJ/kt, Gasoline 44.3 TJ/kt and Biodiesel 37.0 TJ/kt. For LPG, fuel consumption obtained from the Statistical Service is in kt, and converted to TJ using the default NCV proposed by the 2006 IPCC Guidelines, i.e. 47.3 TJ/Gg (2020 NIR p. 82)
Czech Republic	NO	Other sectors operate with emission factors in [g.kg-1] of fuel, not in [g.TJ-1] of energy, because the country-specific measured data of every greenhouse gas in the internal database are in this unit. (2020 NIR p. 102)	YES	Tab. 3-11 Net calorific values (NCV), CO2 emission factors and oxidation factors used in the Czech GHG inventory – 2018 (2020 NIR p.68) Implied EFs are additionally dependent on calorific value of fuel (kg/TJ) - actualized every year from the Czech Oil Questionnaire for EEA, and country-specific H:C and O:C ratios (Černý, 2018). (2020 NIR p. 109)
Denmark	NO	For liquefied petroleum gas (LPG), the emission factor source is based on COPERT[147] default value (2020 NIR p. 202)	YES	Net calorific values (NCV) are fuel-specific constants. The country-specific values from the Danish Energy Agency (DEA) are used for all inventory years. (2020 NIR p. 246)
Estonia	NO	No comment	YES	The NCVs for the fuels used in road transport are the following: diesel – 42.3 GJ/kg, LPG – 45.5 GJ/kg and gasoline 44.0 GJ/kg (2020 NIR p.107)
Finland	Partially	The CO2 emission factors for biogenic components of gasoline and diesel oil are based on the stoichiometric C-contents of 52% for bioethanol (C2H5OH) and 85% for biodiesel (C18H38); these give	YES	Country-specific net calorific values and CO2 emission factors are shown in Table 3.2-4 (2020 NIR). The table includes separate data for fossil and biogenic shares of blended liquid fuels (p. 111). Emission factors per TJ in Table 3.2-4 have been calculated using

[147] COPERT: COmputer Program to calculate Emissions from Road Transport

Member State	Emission factor for a fuel expressed as t CO2/t		Country-specific net calorific values (NCV) provided	
		respectively 1.913 t CO2/t of bioethanol and 3.12 t CO2/ t of biodiesel. Emission factor for bioethanol (per mass unit) has been used for all types of bioadditives in gasoline, and correspondingly EF for biodiesel have been used for different types of biodiesel (HVO[148] and FAME).		NCVs and shares of different biocomponents in gasoline and diesel oil. For biogas used in transport, the same CO2 EF (56.1 t/TJ) has been used as for other uses of biogas. (2020 NIR p. 101)
France	YES	2020 NIR page 225	YES	National net calorific values which are used in the national emission inventories when no other information is available are shown in 2020 NIR p. 133.
Germany	Partially	Only for gasoline (2020 NIR p. 863)	YES	Since TREMÖD calculates energy consumption in tonnes, the results first have to be converted into TJ. This is done with the net calorific values provided by the Working Group on Energy Balances (AGEB) (cf. Table 574, 2020 NIR p. 888). In the interest of consistency, an energy-related CÖ2 emission factor has been calculated from the calculated weight-based emission factor and the lower net calorific value listed in the Energy Balance. (2020 NIR p. 863)
Greece	NO	No comment	YES	No comment
Hungary	Partially	Only for emission factor for gasoline (fossil part) (2020 NIR p.79)	Partially	Only for emission factor for gasoline (fossil part): energy conversions were executed following the values given in the EMEP/EEA air pollutant emission inventory guidebook 2019. Default density and calorific values of primary fuels determined using the EMEP/EEA air pollutant emission inventory guidebook 2019 (p. 76). For the years starting in 2016, the refinery provided the carbon content and calorific value of the fossil part of diesel from which the country-specific values could be derived (2020 NIR p. 79).
Ireland	NO	No comment	YES	All CO2 emission factors for fuel combustion, except in the case of biomass, are country-specific values, regardless of methodological tier used, which are determined directly from information on the carbon contents and net calorific values of the fuels used in stationary and mobile sources. Information on CO2 emission factors and net calorific values are available for liquid, solid and gaseous fossil fuels in Table 4.C of Annex 4. (2020 NIR p. 64)
Italy	YES	CO2 emission factors, expressed as kg carbon per tonne of fuel, are based on the H/C and O/C ratios of	YES	2020 NIR Page 477.

[148] HVO: Hydrotreated vegetable oils

Member State	Emission factor for a fuel expressed as t CO2/t		Country-specific net calorific values (NCV) provided	
		the fuel. (2020 NIR p. 95 and p. 477)		
Latvia	NO	No comment	YES	In 2012 Ministry of Environmental Protection and Regional development funded research “Research on carbon content in transport fuels”. The research on C content in fuels carried out in 2012 quantified C and H content in gasoline. For gasoline the C content is 84.7%, furthermore, the NCV for gasoline was calculated (43.97 MJ/kg) and the CO2 emission factor was estimated in accordance with requirements from the 2006 IPCC Guidelines. For diesel oil the C content is 86.68%, the NCV was calculated for diesel oil (42.49 MJ/kg) and the CO2 emission factor was estimated in accordance with the requirements from the 2006 IPCC Guidelines. Based on the results of this research, CO2 EF of gasoline has been calculated - 71.18 kg/GJ and diesel oil 74.75 kg/GJ (oxidation factor is 1) (2020 NIR p. 148)
Lithuania	Partially	Only for fossil origin CO2 (kt) (2020 NIR p. 128)	YES	For fuels in common circulation, the carbon content of the fuel and net calorific values were obtained from fuel suppliers in accordance with the 2006 IPCC Guidelines (2020 NIR p.113). Net calorific values (NCVs) used to convert fuel consumption in natural units into energy units are provided in the Table 3-37: Specific net calorific values for Road transportation (conversion factors) (Statistics Lithuania) (2020 NIR p. 120)
Luxembourg	NO	No comment	YES	Table 3-16 – Fuel Properties (2020 NIR p. 201)
Malta	NO	No comment	NO	From Table 3-4 Summary of UNFCCC provisional views on the issues raised in the previous review report (2017): "Obtain data on the NCVs and carbon content from the fuel suppliers in order to develop and use a more accurate EF when estimating CO2 emissions from gasoline; if such data are not available, use the default CO2 EF from the 2006 IPCC Guidelines that is applicable to European gasoline passenger cars. (Addressing)” (2020 NIR p.83)
Netherlands	YES	Annex 7 Geilenkirchen et al. (2020) Methods for calculating the emissions of transport in NL_tables.xls	YES	Country-specific heating values and CO2 EFs are used. They were derived from two measurement programmes, the most recent being performed in 2016 and 2017. The methodology is described in detail in the 2018 inventory report. A detailed description of the methodology that is currently used for calculating GHG emissions for road transport is provided in chapter 2 of Geilenkirchen et al. (2020). The EFs that were used are provided in Geleienkirchen (2020) in Table 2.8 (CO2 EFs). (2020 NIR p. 111)

Member State	Emission factor for a fuel expressed as t CO_2/t		Country-specific net calorific values (NCV) provided	
Poland	NO	No comment	NO	No comment
Portugal	NO	No comment	NO	No comment
Romania	NO	No comment	YES	For liquid fuels country specific NCVs values, derived for the corresponding liquid fuels from the EU ETS reporting, are used. For gaseous fuels the amount in TJ as reported by the energy balances was used directly. Since the reported values are Gross Calorific Values, all numbers were multiplied by 90% in order to compute the NCV. (2020 NIR p. 201)
Slovakia	NO	No comment	YES	The NCVs of the fuels were obtained from the Statistical Office of the Slovak Republic and are shown in the Table 3.24 for the years 1990 – 2018. (2020 NIR p. 86)
Slovenia	YES	The CO_2 emission factors (g CO_2/ kg fuel) used for the emission calculation are comparable with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2020 NIR p.90)	YES	The differences between CO_2 emissions factors (t CO_2/ TJ) presented in CRF Tables and those stated in the 2006 IPCC Guidelines arise from differences in applied net calorific values (2020 NIR p. 90).
Spain	YES	CO_2 emission factors: 3,170 kg de CO_2/kg for gasolina, and 3,155 kg de CO_2/kg for diesel oil (2020 NIR p. 212)	YES	Tabla 3.8.7. Fuels specifications in the road transport (2020 NIR p. 212)
Sweden	NO	No comment	YES	Annex 2, Emissions of CO_2 from combustion of gasoline and diesel are based on the fuel consumption, country-specific thermal values and emission factors provided by the Energy Agency and the Swedish Petroleum and Biofuel Institute (SPBI) (2020 NIR p. 164)

Source: National Inventory Reports for greenhouse gases (NIR), 2020.

It should be noted that road transportation is a key source for CO_2 emissions in all MS. According to the 2006 IPCC Guidelines, country-specific NCV and EF should be used when implementing a Tier 2 method. As shown in the previous table, with only a few exemptions (Belgium, Malta, Poland and Portugal), most Member States explicitly reported in their NIRs the application of country-specific net-calorific values (NCV) for fuels. This is in line with the Tier 2 requirements from the IPCC. The net calorific values (NCV), which are used for converting mass or volume units of the fuel quantities into energy units [TJ], were obtained either from fuel suppliers, Statistical Offices, Energy Agencies or directly from measurements of the characteristics of the fuels (in laboratories).

With regards to the CO_2 EF units, only France, Italy, Netherlands, Slovenia and Spain used EFs in t CO_2/t for all fuels. Other MS, such as Austria, Cyprus, Finland, Germany, Hungary, Lithuania appear to partially use emission factors in terms of mass, only for certain fuels.

It is very important to clarify that, with the exception of the points listed below, almost no information was found in relation to the preference for the chosen EF expression (either in mass or in energy). Little or no comment has been made in this regard in the NIRs. It has been found that countries seem only to adhere to the obligations for the CRF, which requires the reporting of activity for road transport (consumption data) in energy and emissions in tonnes.

The preference of the CO2 EF per unit of energy or mass could come from the need to homogenize different fuels, notably blended fuels with non-fossil fuels. According to the TNO report[149], the different metrics of reporting carbon content are aimed at different ways of reporting GES emissions:

1. [g/g] carbon content is used to report the CO2 emissions based on the fuel sold in weight units, typically at the production level and for trading,
2. [g/liter] usually to report CO2 emissions based on customer data collected at fuel stations, and
3. [g/MJ] carbon content used to compare different types of fuels and handle biofuels and blended fuels with non-fossil fuels in a uniform manner.

The same report provided data to update the fuel-based CO2 emission factors in the Netherlands based on a comprehensive analysis for relevant physical-chemical properties of oil and diesel, i.e. calorific value, density and carbon content, among other parameters. The authors underline the importance of reporting CO2 EF in g/MJ, especially in the context of bio-admixture: “The total bio-admixture as specified in the Renewable Energy Directive and monitoring requirements in the Fuel Quality Directive is based the replacement of fuels according to the energy they supply, as different fuels have different heating values per litre or kilogram. In particular, ethanol has a 38% lower heating value (per litre). Therefore, the CO2 reduction of adding 5% ethanol reduces the CO2 emission by about 3% maximum. The relevant unit for such reporting is the CO2 emissions in g/MJ”.

Regarding the impacts of NCV changes on CO2 EF, emission factors depend upon net calorific value (NCV) of the fuel and emission coefficients. The relevance of country-specific NCV values in context of the consideration of the extension of the EU ETS to the road transport must be considered for accurate estimation of CO2. As stated before, NCV, which is used to convert fuel consumption in natural units into energy units of fuels, should be country-specific values for key sources. Except for the points cited below, no relevant information was found regarding the impact of chosen NCVs on road transport emissions, i.e. increases or decreases in total CO2 emissions due to the application of new NCVs. Nonetheless, some relevant information is founded in the MS NIR regarding this issue and are summarized below.

“There are several reasons why there is a difference between the results of the reference approach and the national inventory at global level in CO2 emissions. These differences and their potential reasons have been already discussed in previous National Inventory Reports of Belgium”. (…) Reason number 2: the effect of calorific values and emission factors of liquid fuels in the reference approach is important for countries with high import of crude oil. Half of the resulting CO2 emissions from the use of liquid fuels calculated in the reference approach for Belgium results from the import, export and stock changes of crude oil. A small variation in the average net calorific value used (which is difficult to determine), has a large influence on the total CO2-emissions following the reference approach. Belgium uses a value of 42.19 GJ/tonne in the reference approach (for the year 2017). If this value is about 5%

[149] Ligterink, N.E., TNO 2016 R10700. Dutch market fuel composition for GHG emissions. 2016

lower (40 GJ/tonne) the reference approach would be 5 478 kt CO2 lower. Belgium, 2020 NIR p. 72

“The differences between CO2 emissions factors (t CO2/ TJ) presented in CRF Tables and those stated in the 2006 IPCC Guidelines arise from differences in applied net calorific values**.** In the period 2006-2018 additional deviations occurred due to the use of biofuels. The decreasing trend of the CO2 IEF for gasoline from 1986 to 2018 is attributed to the introduction of unleaded gasoline in the country, which has lower carbon content than leaded gasoline. Leaded and unleaded gasoline has different H:C and O:C ratios. The value for H:C ratio in unleaded gasoline compared to the leaded one is 1.89 vs. 1.92. The value for O:C ratio in unleaded gasoline compared to the leaded one is 0.016 vs. 0. CO2 IEF for diesel was fluctuating after the year 2006 due to introduction of biofuel in road transportation fuel. Biodiesel has been used as a mixture within fossil fuel in the period 2006-2018.” Slovenia, 2020 NIR page 90

“The IEF of LPG for the period 2004-2006 is varying as a result of fluctuations in NCV provided by national statistics. Up to 2006 Bulgaria used the NCVs for liquid fuels provided by the producers/importers. In order to harmonize Bulgarian and EU statistics (IEA/Eurostat uses average NCVs for all liquid fuels) the preferred EU approach has been adopted since 2007. In this regard, discussions with Lukouil Neftochim revealed that NCVs had never been measured by laboratory tests, since the process was too costly. Instead, other relevant characteristics were monitored to ensure compliance with international standards. This is the key reason to use the average European NCVs for the years after 2007. The NCV methodology adopted adjusts the annual mileage in order to have an exact match with the reported fuel consumption in natural units (Gg) and the calculated fuel consumption by the COPERT model (COmputer Program to calculate Emissions from Road Transport). It is considered that the NCV difference does not influence emission estimates, but only reflects the IEF”. Bulgaria, 2020 NIR p. 127.

“The activity data calculated for the CRF Reporter in TJ are affected by country-specific calorific value (which is variable in different years) of a particular fuel. The fuel consumption entering to the CRF Reporter must be converted from weight to energy units (using the calorific value). So, the time series of IEF depends partially on the trend of calorific values and mostly on EF in [g/kg].” “Small fluctuation (in the emissions of CO2 from road transportation) can be caused by the fact that EFs are calculated on the basis of a slightly variable calorific value of a particular fuel.” Czech Republic, 2020 NIR, p.102 and 110.

“We have also slightly deviated from the NCVs reported in the IEA/Eurostat Annual Questionnaire. Originally, the net calorific value applied in the Hungarian energy statistics was usually 42 TJ/kt for both fuels (gasoline and diesel). However, there were indications that the real calorific value might be different. For example, the default NCVs are 43.8 TJ/kt for gasoline and 42.7 TJ/kt for diesel in COPERT. In the 2006 IPCC Guidelines, we can find even higher values: 44.3 TJ/kt and 43 TJ/kt for gasoline and diesel, respectively. And we have also one measurement from the refinery for diesel oil: that is 43.04 MJ/kg. So, in the 2017 submission the calorific values were changed to 44 TJ/kt and 43 TJ/kt for (fossil) gasoline and diesel oil, respectively. (Meanwhile, NCVs have been revised upwards also in the energy statistics.). Hungary, 2020 NIR p.79.

“In order to ensure consistency between LIPASTO transport submodels, greenhouse gas inventory and Energy Statistics, Statistics Finland supply the information on the total diesel oil and gasoline consumption, the share of biofuels and on the properties of fuels (bio additives change the density and NCV of fuels). Only small differences (for the most recent years 0.1%, for years 2006 to 2013 approximately 1%) in total diesel oil and gasoline consumption data taken as a sum from the LIPASTO transport submodels compared with total fuel sales data taken from the Energy Statistics have been identified. These differences are caused by disaggregation, conversions between quantity units and roundings in different stages of the process, and the share of biofuels (bio additives change the density and NCV of fuels). Also, in some cases total fuel consumption figures are updated during the inventory process. These differences are taken into account in the ILMARI system in road transport, which is the largest subcategory of diesel oil and gasoline consumption, to ensure full consistency between the Energy Statistics and the GHG inventory. The corresponding CO2 emissions are updated as well; both updates in activity data and bioshares of fuels affect the final CO2 emissions". Finland, 2020 NIR, p. 100

"According to the previous ERT recommendation, the country specific H/C ratio and NCVs were used in model calculation. Delivering actual and most recent data on fuels´ composition is crucial for correct country-specific EFs estimation. The H/C and O/C ratio of the fuels was analyzed by the Research Institute for Crude oil and Hydrocarbon Gases (VÚRUP) in 2018 (Tables 3.22 and 3.23)." Slovakia, 2020 NIR p. 85

To summarize, we can say that the Member States are aware of the impact of selecting one NCV over another. Although no analysis comparing resulting CO2 emissions based on different NVCs was found (from the NIR review), everything seems to indicate that impacts tend to be slight. The only exception would be Belgium which states that a small change in the average net calorific value could have a large impact on CO2 emissions.

Regarding the literature, the TNO study (Ligterink N.E., 2016), which was based on fuels samples across the Netherlands at the fuel stations in 2015, showed that the variation of the fossil component could differ substantially not only between years (Table 81 below), but also between summer and winter (Table 82 below). Due to the variability of fuel properties, and to study the effectiveness of blending non-fossil fuels, one recommendation was to continue to monitor oil properties on a regular basis. This can be used to update emission factors in the future and can provide input to future fuel quality requirements. Therefore, monitoring and research focusing on estimating carbon content from fuels sold within the MS must be done on a regular basis.

TNO established that the energy density (i.e. NCV) exhibited the largest variation of all the relevant fuel properties affecting the CO2 emissions. Indeed, the largest variability in the fuel was the heating value (and not the density or weight fraction of carbon), especially the heating value (i.e. NCV) of petrol (i.e. gasoline), particularly in the summer (Table 82).

Table 81. Summary of the findings based on a 50%/50% summer and winter fuel combination (2015), compared with the Statistics Netherlands (CBS) values from 2013.

market fuels with bio-admixture		**heating value [MJ/kg]**	**carbon content [g/MJ]**
petrol	Statistics Netherlands 2013	43.20	69.8
	TNO study	41.65	74.0
diesel	Statistics Netherlands	42.50	72.2

market fuels with bio-admixture	heating value [MJ/kg]	carbon content [g/MJ]
2013 TNO study	43.01	72.5

Table 82. Fuel parameter variations

	petrol				diesel			
	winter	variation	summer	variation	winter	variation	summer	variation
density [g/ml]	730.4	0.7%	745.5	0.6%	835.4	0.4%	833.6	0.5%
heating value [MJ/kg]	42.34	1.2%	40.96	5.5%	42.98	0.8%	43.05	0.4%
carbon content [%]	83.88	1.1%	84.23	0.7%	85.19	1.1%	84.98	0.6%

CO2 [g/g]	3.076	3.088	3.124	3.116
CO2 [g/MJ]	72.64	75.39	72.68	72.38
CO2 [g/l]	2246	2302	2609	2597
fossil only	excluding 4.69% ethanol		excluding 3.18% FAME	
CO2 [g/g]	3.133	3.146	3.133	3.125
CO2 [g/MJ]	72.69	75.52	72.59	72.27
heating value [MJ/kg]	43.10	41.66	43.17	43.24

The results above are from the TNO study test program, with the variations therein defined as the standard deviation divided by the average. This includes the bio-admixtures, the fossil components are determined from subtracting the average admixtures. The study states that the carbon content is somewhat lower than would be expected on the basis of the commonly used data from the literature. This lowers the CO2 emissions based in fuel sold, in weight units, somewhat.

CO2 reporting in inventory and the potential future extension to road transport – Tier approach

The potential inclusion of the road transport in the EU ETS will raise a consistency question related to another MRV system: the EU GHG emissions inventory system and its specific format.

Following the 2006 IPCC Guidelines, activity data for the road transportation CO2 estimates are based on fuel sales within the MS. Indeed, the definition of consumption of fuel at the country level is based on fuel sales. These include gasoline, diesel, liquefied petroleum gas (LPG), compressed natural gas (CNG) and biofuels. Most countries apply the COPERT methodology (the EU standard vehicle emissions calculator) to ensure that the statistical energy consumption matches the calculated energy consumption, by adjusting the blend type and share and the annual distance travelled (mean activity). In other words, the calculated fuel consumption in COPERT (or a chosen model or software) must equal the national statistical fuel sale totals reported according to the UNFCCC and UNECE emissions reporting format. The statistical fuel sales for road transport (data on motor fuel consumption) are usually provided by an entity at a national level, i.e. National Energy Authorities, National Statistics Offices, etc. In most cases fuel sales data are well known.

There are a few countries for which national fuel sales correspond well with the fuel used in the country, i.e. Finland (2020 NIR p.108). Moreover, there are some cases where the percentage of fuel bought within the MS but consumed outside has been precisely monitored. For instance, in Ireland 5.1% of automotive fuels sales were used in the UK in 2018 (2020 NIR p. 95). On the one hand, some MS have created their own tailored models to divide the Energy Balance data over the different CRF categories, i.e. Netherlands (2020 NIR p. 111). On the other hand, the majority of MS are in general estimating the proportion of emissions by vehicle category type using mainly COPERT model (or HBEFA (Handbook Emission Factors for Road Transport).

Regarding the CO2 emission factor, as stated by the 2006 IPCC Guidelines (Volume2, Chapter 3-Mobile combustion), the CO2 emission factors are based on the carbon content of the fuel and should represent 100 percent oxidation of the fuel carbon. Also, the IPCC states that it is good practice to use country-specific net-calorific values (NCV) and CO2 emission factor data if possible, particularly for key source emissions. (higher Tiers than Tier 1, which refers to the use of default values). It is known in Europe that the Tier 1 default CO2 EF for gasoline is lower than all CS EF determined based on measurements.

In most of European countries, road transport and commercial/residential buildings being key categories in GHG inventories, MS have to apply Tier 2 or Tier 3 methodologies to estimate CO2 emissions. This means that they need to apply country specific (CS) emission factors based on C content measurement in the fuel used. After several rounds of reviews of national inventories in the framework of the Effort Sharing Decision and UNFCCC leading to recommendations on this issue, most of the European countries have developed CS CO2 EF for most current fuels. A few countries remain with default EF (Tier 1 methodology).

The following are some of the issues that were encountered from the NIR review regarding the estimation of country-specific emission factors.

"It should be noticed that no country specific carbon content or country specific CO2 emission factors are available in Belgium. Belgian Petrol Federation cannot provide country-specific values for fuels consumed in the transport sector and they will not provide it unless it becomes a European obligation", Belgium (2020 NIR p. 111).

"Regarding the recommendation to use a Tier 2 approach, Lukoil Neftochim was approached in order to obtain country-specific values for the carbon content of the liquid fuels produced. However, it was established that the fuel producer did not measure this fuel feature properly. On a related note, Bulgaria imports significant amounts of diesel and gasoline from neighbouring countries, which makes the estimate of a country-specific emission factor highly uncertain". "The default fuel parameters, provided in the EMEP/EEA emission inventory guidebook and subsequently used by the COPERT model are much more certain and relevant nationally (considering the fact that liquid fuels are following common European standards), than a potential approach for deriving a country-specific emission factor, which is based on a limited number of laboratory measurements and some hard to obtain parameters of imported fuels. We plan to update the calculation methodology for CO2 emissions when country-specific CO2 emission factors are available (if provided by the Lukoil Neftochim – the national refinery). Discussions with Lukouil Neftochim revealed that NCVs had never been measured by laboratory tests, since the process was too costly". Bulgaria (2020 NIR p. 126-128).

Countries such as Luxembourg estimate the CO2 FE based on the countries from which it imports fuel. "Luxembourg decided to revise its CO2 emission factor for motor gasoline, based on the CO2 emission factor of the two other neighbouring countries from which motor gasoline is imported." Luxembourg (2020 NIR p. 205).

The examples above show that even at plant level, specific parameters are not yet measured or well measured according the current regulations in place.

Finally, for fuel sales to the road transport, another issue which can exist in some countries, and which can be highlighted here regarding the inclusion of the road transport in an ETS is the fuel smuggling. According to the 2020 Greece NIR (p.147 and 162): "It is a fact that we take into account all fuel sold and we compare calculated fuel consumption to the corresponding statistical fuel consumption. However, in the previous year's calculations, the fuel consumption cross check could not result in very small differences as statistical fuel consumption data were influenced from illegal activities in the fuel market (e.g. the use of the cheaper heating diesel for vehicles). This is why, in general there was a very good agreement between statistical and calculated gas consumption data, whereas for diesel we had an overestimation with COPERT, as a result of the above-mentioned illegal uses. However, as was already mentioned in previous years NIR (2016, 2017), the problem with emissions calculation cross-check using statistical data for energy consumption due to fuel smuggling and other illegal uses, was tackled by Greek government with specific legal measures. Hence, for 2014 and on, we consider that such a comparison is possible, and we have performed the cross-check. This is further reflected to the good comparison of calculated versus statistically given fuel consumptions". This raises the issue of consistency between different data sources for the sales or the distribution of fuels to the road transport in the different frameworks such as the GHG inventory and the potential extension of EU ETS to the road transport.

Another situation when considering the distributors or the tax warehouses as regulated entities for the road transport is the tank tourism. Luxembourg states that: "Fuel quantities sold at Luxembourg's petrol stations, after having been converted into GHG volumes, are, according to IPCC reporting rules, totally included in the GHG balance, although around 71% of the emissions cannot be assigned to vehicles registered in Luxembourg and are actually emitted mostly abroad" (NIR p. 139). In the framework of the EU ETS, as Luxembourg neighbour countries are also part of the EU ETS, we can consider that this is not an issue.

Off-road vehicles fuel consumption consideration

Off-road vehicles consume the following fuels: motor gasoline, non-road diesel oil, and biofuels. These mobile machines are usually fuelled with standard fuels, but if the transport sector is included upstream in the EU ETS, this fuel would be regulated under the EU ETS, which would also lead to regulation of these small sectors, which are not yet distinguished in the transport inventories. Indeed, it appears that none or very few countries have the capacity to accurately distinguish fuel consumption between road transport and off-road. Fuel consumptions by mobile machineries in the different economic sectors are generally not reported separately in the MS Energy Balance.

The following issues must be considered:

- Off-road vehicles are currently excluded from the EU ETS. Would they be included together with "road transport"? If not, as they are currently excluded from the EU ETS, it seems difficult to distinguish the consumption for off-road vehicles from the fuel sold by refineries or distributed by tax warehouse (proposed points of regulation at upstream level for oil products).
- In the GHG inventory, according to 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 (Energy), chapter 3 (Mobile combustion), the CO2 emissions from off-road vehicles are reported either:

- in the road transport sector: CRF 1.A.3.e.ii Road transportation/Off-road (Combustion emissions from Other Transportation excluding Pipeline Transport),
- in the Commercial/institutional sector: CRF 1.A.4.a,
- in the Residential sector: CRF 1.A.4.b
- in the Agriculture / Forestry/ Fishing / Fish farms sector: CRF 1.A.4.c.ii (Emissions from fuels combusted in traction vehicles on farmland and in forests),
- in part of other sectors, such as the "Industries and construction sector" (CRF 1.A.2.g Other) when off-road vehicles are used in Industrial processes plants, or construction sectors,
- in the specific industrial sectors where these off-roach machineries operate.

2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 (Energy), chapter 1 (Introduction) states that in some industries it might occur that fuels are partly used for stationary equipment (combustion unit or process unit) and partly for mobile equipment. This could for example occur in agriculture, forestry, construction industry etc. When this occurs and a split between mobile and stationary is not feasible, the emissions could be reported in the source category that is expected to have the largest part of the emissions, that is to say in the respective industrial process sector. For example, off-road vehicles emissions occurring in glass production plants will be allocated in the CRF sector 1.A.2.f Non-metallic minerals.

The allocation of these CO2 emissions in the CRF sectors highly depends on the structure of the Energy balance in the country and the ability for inventory compilers to distinguish "off-road vehicles" consumptions from other combustion equipment onsite.

The crucial question to avoid double counting of emissions is the identification of the end-user of the fuel distributed. If the end-user of the fuel is already covered by the current EU ETS, then the emissions from the consumption of the fuel are already monitored in compliance with the MRR, according to the monitoring plan developed by the operator, except the fuel used for the off-road vehicles. Indeed, off-road vehicles are currently completely excluded from the EU ETS, so that their consumptions do not need to be monitored, nor the CO2 emissions reported by the plant operator. Furthermore, these consumptions are often difficult to track at plant level because they represent very less consumption compared with fuel used in the combustion units or in the process.

Consideration of biofuels

Another issue to be taken into account is the share of biofuels in the fuels consumed as bio CO_2 is treated differently in the framework of the EU ETS and in the GHG inventories.

The increased use of biomass products in the future is an intended effect of the possible inclusion of transport in the EU ETS. A review of MS reported data under GHG inventories (CRF) is analyzed in order to identify the potential difficulties to clearly separate fuels that are used in all road transport, namely biomass and other fossil fuels[150]. Special attention is paid to the proper allocation of these fuels into the sub-

[150] UNFCCC requires to report only biomass activity and related emissions. But it is known that biofuels are not 100% bio. A little part of biofuels is fossil fuel (residual part of input product: for example to produce FAME we need seeds and methanol, which give by esterification FAME and glycerin. In FAME there is a little part of methanol ~5%).

sectors of the road transportation sector. Indeed, the design options regarding scope of the new system and legal implementation in the context of the existing EU ETS establishes the need to differentiate activity within the road transport sector, by distinguishing the freight transport according to design options 1c and 3b (section 4.1.1.2).

As seen above, the implementation of options 1c and 3b would require disaggregated data at least for the freight transport, which is classify within the CFR code 1.A.3.b.iii. Heavy duty trucks and buses. The objective is to explore the possibilities to accurately monitor CO2 emission data for freight transport, regarding biomass and other fossil fuels. As stated in section 3.1.2, cars and motorcycles represent 57% of the road transport CO2 emissions in 2018 in the EU-27, followed by trucks and light duty vehicles (41%) and buses (2%). Biofuels gained +5.5% in the energy mix consumption in the road transport sector from 2000 to 2018.

Table 83. Biomass and Other fossil fuels allocation, MS CRFs Table 1.A(a)s3, 2020

CRF 1.A.3.b Road transportation	Reported activity in CRF tables, 2018		Reported activity in CRF tables, 2018	
	Biomass	Other fossil fuels	Biomass	Other fossil fuels
	Austria		**Italy**	
i. Cars	Y	Y	Y	Y
ii. Light duty trucks	Y	Y	Y	Y
iii. Heavy duty trucks and buses	Y	Y	Y	Y
iv. Motorcycles	Y	NO	Y	NO
	Belgium		**Latvia**	
i. Cars	Y	IE	Y	Y
ii. Light duty trucks	Y	IE	Y	IE
iii. Heavy duty trucks and buses	Y	IE	Y	IE
iv. Motorcycles	Y	IE	Y	NO
	Bulgaria		**Lithuania**	
i. Cars	Y	Y	Y	NO
ii. Light duty trucks	Y	Y	included in 1A3bi	NO
iii. Heavy duty trucks and buses	Y	Y	included in 1A3bi	NO
iv. Motorcycles	Y	NO	included in 1A3bi	NO

CRF 1.A.3.b Road transportation	Reported activity in CRF tables, 2018		Reported activity in CRF tables, 2018	
	Biomass	Other fossil fuels	Biomass	Other fossil fuels
	Croatia		**Luxembourg**	
i. Cars	Y	IE	Y	Y
ii. Light duty trucks	Y	IE	Y	Y
iii. Heavy duty trucks and buses	Y	IE	Y	Y
iv. Motorcycles	Y	IE	Y	NO
	Cyprus		**Malta**	
i. Cars	Y	NO	Y	NO
ii. Light duty trucks	Y	NO	Y	NO
iii. Heavy duty trucks and buses	Y	NO	NO	NO
iv. Motorcycles	N	NO	NO	NO
	Czech Republic		**Netherlands**	
i. Cars	Y	NO	Y	Y
ii. Light duty trucks	Y	NO	Y	Y
iii. Heavy duty trucks and buses	Y	NO	Y	Y
iv. Motorcycles	Y	NO	Y	Y
	Denmark		**Poland**	
i. Cars	Y	Y	Y	Y
ii. Light duty trucks	Y	Y	Y	Y
iii. Heavy duty trucks and buses	Y	Y	Y	Y
iv. Motorcycles	Y	NO	Y	NO
	Estonia		**Portugal**	

CRF 1.A.3.b Road transportation	Reported activity in CRF tables, 2018		Reported activity in CRF tables, 2018	
	Biomass	Other fossil fuels	Biomass	Other fossil fuels
i. Cars	Y	IE	Y	Y
ii. Light duty trucks	NO	NO	Y	Y
iii. Heavy duty trucks and buses	NO	NO	Y	Y
iv. Motorcycles	NO	NO	Y	NO
	Finland		**Romania**	
i. Cars	Y	NA	NO	NO
ii. Light duty trucks	IE	NA	NO	NO
iii. Heavy duty trucks and buses	IE	NA	NO	NO
iv. Motorcycles	IE	NA	NO	NO
	France		**Slovakia**	
i. Cars	Y	Y	Y	NO
ii. Light duty trucks	Y	Y	Y	NO
iii. Heavy duty trucks and buses	Y	Y	Y	NO
iv. Motorcycles	Y	Y	Y	NO
	Germany		**Slovenia**	
i. Cars	Y	IE	Y	Y
ii. Light duty trucks	Y	IE	IE	NO
iii. Heavy duty trucks and buses	Y	IE	IE	NO
iv. Motorcycles	Y	IE	IE	NO
	Greece		**Spain**	
i. Cars	Y	NO	Y	Y
ii. Light duty trucks	Y	NO	Y	Y
iii. Heavy duty trucks and buses	Y	NO	Y	Y
iv. Motorcycles	NO		Y	NO
	Hungary		**Sweden**	

CRF 1.A.3.b Road transportation	Reported activity in CRF tables, 2018		Reported activity in CRF tables, 2018	
	Biomass	Other fossil fuels	Biomass	Other fossil fuels
i. Cars	Y	NO	Y	
ii. Light duty trucks	Y	NO	Y	
iii. Heavy duty trucks and buses	Y	NO	Y	
iv. Motorcycles	Y	NO	Y	
	Ireland			
i. Cars	Y	Y		
ii. Light duty trucks	Y	Y		
iii. Heavy duty trucks and buses	Y	Y		
iv. Motorcycles	Y	NO		

Based on this review, MS seem to accurately monitor and report under the current CRF system the activity from biomass and other biofuels. **This means that at least in principle it is possible to exempt or include only certain subsectors such as the freight transport**.

The only exemptions are shown below:

- MS including biomass consumption from 1.A.3.b.iii in 1.A.3.b.i (Cars):
- Estonia;
- Finland;
- Lithuania and
- Slovenia.
- MS including biomass consumption from 1.A.3.b.iii either into 1.A.3.b.i or 1.A.3.b.ii (or both):
- Malta.

As seen in the above table, Romania is the only MS not reporting biomass use in each road transport subcategories. However, emissions attributable to this fuel have been reported elsewhere as an information item only. As stated on page 201 from the NIR: "*In order to estimate the emissions from biomass combustion activities in road transport, data on energetic quantities provided through the Energy Balance were used. Liquid biomass used comprise biogasoline, biodiesel and other bioliquids. All these types are combusted to produce heat and/or power. However, CO2 emissions released from these processes are reported as an information item, as the CO2 is naturally captured from the air*".

It is known that increasing the amount of biofuel will be an important mean to reach GHG emissions reductions. However, it is difficult to estimate the expected emission reduction that may result from the increase use of these biofuels. The importance of the correct allocation of biomass lies in the increasingly use of these fuels in the future. In addition, the Renewable Energy Directive (RED) requires the development of verification systems that enable verification of the sustainability criteria set and requires economic operators to trace biomass content through the use of mass balances (CE Deflt, 2014). The RED, which regulates the share of renewable energy in the total energy consumption of transport, required that 10% of the energy consumed in transport comes from renewable sources by 2020.

It is also important to mention that the CO_2 emission factor of biomass and other biofuels are set at zero if they comply with the sustainability criteria under the current ETS system. Indeed, the definition of biomass in the MRR (recital (4)) should be consistent with the definitions of 'biomass', 'bioliquids' and 'biofuels' in Article 2 of Directive 2009/28/EC of the European Parliament and of the Council[151].

It should be noticed that the carbon content of the blending of biofuels is uncertain. For biofuels such as biogasoline, biodiesels, and other liquid biofuels, the MRR Guidance document N°3 on biomass issues (27 November 2017) in the current EU-ETS provides default CO_2 preliminary emission factors (i.e. including the biomass and the fossil fractions, in the mixed fuel, which could help to define the biomass fraction in a blended fuel which would be monitored). Furthermore, in the Fuel Quality Directive average default values are been used for biofuels. According to CE Delft (2014) it would be also appropriate to apply the same values for the transport ETS (section 4.5.3 provides further details on the FQD existing MRV process).

4.5.3 Ensuring an accurate monitoring and reporting of CO_2 emissions

An important criterion for the design of an ETS based on certain regulated entities is that the regulated entity needs to be able to ensure an accurate monitoring and reporting of CO_2 emissions. Including that the regulated entity is able to identify the end-user of the supplied fuel and distinguish fuels that will result in emissions in the transport and buildings sector from others.

The most accurate monitoring option for greenhouse gas emissions is monitoring the consumption of the fuels itself. Standard emission factors based on the type of fuel can be applied to estimate the greenhouse gas emissions from the fuel consumption. Other tracking mechanisms could be based on data characterizing the fuel use indirectly, such as the type of vehicle, its average fuel consumption and the distance travelled. However, such an approach is more inaccurate and also ignores certain mitigation options, e.g. a fuel-efficient way of driving. Therefore, it not considered a valuable option in the existing studies. The main question is whether there is an adequate tracking mechanism for the use of fossil fuels by type and if not, whether one could be developed.

Tracking mechanism for the use of fossil fuels by type is mostly dependant on the regulated entities. As described under section 4.2, an upstream approach is likely to be based on tax warehouse keepers or oil refineries for oil products, and fuel suppliers (distributors) for gas and coal. Tax warehouse keepers need to keep track of the fuel buyers for tax reasons, directly providing a track mechanism by user and energy product. On the contrary, fuel suppliers do not always have to track the amount of fuels with the same accuracy because gas and coal are often exempt from energy

[151] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

taxes. Nevertheless, they could in principle do so, which provides a good basis for building a tracking mechanism upon it.

For a downstream approach that regulates the emitters, there is currently no overall tracking mechanism. While in the buildings sector, the fuel supply to end-users is at least partially trackable, in particular with respect to grid-bound supply with gas, the mobility of end-users in the transport sector poses a higher hurdle to monitor their use of fossil fuels. In this context, studies have proposed a tracking mechanism for a downstream approach is to provide the emitters with an account of individual emission allowances, which is credited each time the emitter buys fossil fuels, e.g. at a fuelling station. Another approach would be to install monitoring systems in all buildings and new vehicles, which, however, may come with high transaction costs and poses additional issues in the transitioning period.

As regards to the regulated entities proposed in section 4.2, the downstream approach is not privileged in this study.

MRV aspects regarding other National Measures in the road transport and buildings sectors

According to the World Bank and ICAP (Emissions trading system in practice, WB, ICAP, 2016), the government may need to actively identify new regulated entities, as firms are established and change over time. It can be costly to monitor emissions with high levels of accuracy and precision; lower-cost approaches such as using default emission factors can provide unbiased estimates for predictable sources of emissions. Regulators should take advantage of existing local environmental, tax, legal, and market systems where relevant when establishing ETS compliance (Emissions trading system in practice, WB, ICAP, 2016).

As detailed in Question 1.2, existing tracking mechanism and MRV aspects (and their accuracy) for other measures in road transport and building sectors highlight the following aspects:

Table 84. National measures in the road transport and buildings sectors

SWEDEN		
Measure	Swedish carbon tax	
	Carbon tax	Energy tax on fuel (which is not used for the commercial aviation, commercial maritime and commercial rail transport sectors)
Sectors covered	**Transport** (except commercial aviation, commercial maritime, commercial rail transports and bio fuels) **Building** (except bio fuels)	
Regulated entities	**Transport:** energy suppliers **Building:** heat combustion plants	

<table>
<tr><th colspan="3">SWEDEN</th></tr>
<tr><td rowspan="2">Monitoring and Reporting</td><td>The "Energy Tax Act" defines which fuels are covered, the price for each, the sectors covered or exempt and to what degree.
The carbon tax is levied on all fossil fuels in proportion to their carbon content. It is therefore not necessary to measure actual emissions, which greatly simplifies the system.
€/t CO2</td><td>Based on the carbon content of different fossil fuels and excludes biofuels from its scope</td></tr>
<tr><td colspan="2">Collected by the same mechanism which eases the administrative burden for tax authorities and operators.</td></tr>
<tr><td>Performances of the system</td><td colspan="2">Transport: In 2018, the sector's GHG emissions are 15% lower than in 1990, while road traffic has increased since 2013. The share of biofuels which has greatly increased (+ 22% in 2019 compared to 1990) and the move towards efficient energy systems are the main reasons. The increase in the electric vehicle fleet also contributes to this decrease. Presumably without the Swedish carbon tax, emissions from the road sector would be 8.1% to 10.9% higher than today.

Building: The Swedish carbon tax has made the price of bio fuels more competitive than that of fossil fuels. Since the introduction of the carbon tax, consumption of fossil fuels has dropped by 85%.</td></tr>
</table>

GERMANY	
Measure	National ETS for heating and transport fuels, which operates independently of the existing EU ETS
Sectors covered	**Transport** **Building**
Regulated entities	The point of obligation (regulated entities) follows the energy tax law, i.e. the obligation arises for the same actors that are also obliged to report and pay energy taxes on fossil fuels. It covers approximately 4,000 companies that sell fuel oil, LPG, natural gas, coal, gasoline, and diesel.
Monitoring and Reporting	Throughout the year, compliance entities must monitor the fossil fuels they put on the market, report these amounts to the German authority for emissions trading. Cases of non-compliance will be penalized with a penalty of twice the price of the compensation in the respective year per missing allowance (during the package period) or 100 euros (from 2026).

GERMANY	
Performances of the system	Given that the national ETS will not enter into force until 2021, there is still no evaluation of its effects. Risk of overlap: Due to different regulatory approaches, it is inevitable that the two systems overlap at the margin, as some fuels subject to the national ETS could also be used in installations covered by the EU ETS. Thus, if the fuels intended for domestic heating (and therefore covered by the national ETS) are rather delivered to an industrial installation covered by the EU ETS, the emissions which would result therefrom would in fact be priced twice. On the other hand, if fuels which were intended for installations covered by the EU ETS - and which therefore do not create a compliance obligation for the fuel distributor - are rather used in transport or to heat buildings , this would be a loophole to completely escape pricing. The law establishing the national emissions trading system provides in this case that fuels delivered to installations covered by the EU ETS may be exempt from the obligations arising from the national ETS. In cases where such an exemption would entail disproportionate administrative efforts, it might also be possible to compensate the facilities for such double taxation. A corresponding regulation is expected to be adopted by the end of 2020.

POLAND				
Measure	Tax on energy consumption: Excise duties which apply to liquid, gaseous and solid (except when it is used to produce electricity or used to product heat and electricity or used by residential /commercial) fossil fuels, as well as to electricity (except electricity produced from renewable energy sources) (excluding biofuels and GPL)	Tax on energy consumption: Excise duties fuel, taxing gasoline, diesel, biodiesel, natural gas and liquefied petroleum gas	Fuel surcharge	White certificate system
Sectors covered	**Building**	**Road transport**	**Road transport**	**Building**
Regulated entities	Energy suppliers	Individual when buying a vehicle (except for hydrogen and electrical vehicles)	the manufacturer of fuel or gas the importer of fuel or gas a company making an intra-Community acquisition within the meaning of the provisions relating to excise duties on fuels or gas other companies that are subject to excise duty on motor fuel or gas under the excise Act	All companies selling electricity, heat or natural gas to users energy final (individual households are excluded because of the minimum threshold of 10 toe)
Monitoring and Reporting	Tax rates are differentiated by fuel type, not by carbon content €/litre of fuel, €/GJ for gas (LPG), €/GJ for solid fuels			

POLAND	
Performances of the system	No studies or reports could be found to analyse the effectiveness of the implicit national carbon pricing instruments in Poland. Trends in GHG emissions from transport and buildings over the past decades suggest that, with other policy instruments, they have not effectively curbed the growth of GHG emissions, let alone reduce them: between 1990 and 2017 , however, the country's emissions increased by 230%, the largest increase among all EU member states. The EU average is 24%. As regards heat production, small emitters, and installations (for example private individual houses) are not covered by the EU ETS, nor by excise duty, nor by the white certificate system. As far as the transport sector is concerned, there is no overlap with the EU ETS, while road transport is exclusively subject to national fiscal instruments (excise duty and fuel surcharge).

SPAIN				
Measure	Catalonia carbon tax for vehicles emitting CO2 (all vehicles that emit 95 g of CO2 / km or more will be taxed)	Hydrocarbons tax applied to liquid and gaseous fuels (including biofuels), coal tar, crude oil, used oils and gases linked to coal and coke -> exemption for energy products intended for the production of electricity or for the combined production of heat and electricity in power plants	Special coal tax, which taxes coal and coke products (excluding peat)	Special electricity tax (consumption of end users)
Sectors covered	**Road transport**: cars, vans and motorcycles (except electric vehicles)	**Transport** **Building**	**Building**	**Building**
Regulated entities	Owners		First sale or delivery of coal in the territory	End user
	To avoid overlapping, Buñuel González suggests that "emitters subject to the EU ETS should be exempt from paying the carbon tax, which is the simplest alternative for reconciling the two instruments" (2015, p. 5). Another possible option would be to allow “taxpayers to deduct the amounts paid for the purchase of EU ETS allowances”			
Monitoring and Reporting	The tax base is constituted by the CO2 emissions of the vehicle, which coincides with the official emissions stated in the certificate issued by the manufacturer or			

SPAIN				
	importer of the vehicle. EUR/gCO2/km			
Performances of the system	The Catalan government expects to raise about 150 million euros a year			

FRANCE			
Measure	Carbon tax	Bonus-malus incentive system for vehicles	A scrapping bonus (The scheme rewards consumers who replace old diesel cars with an electric or hybrid vehicle)
Sectors covered	**Transport** (except freight transport companies, domestic flights, domestic navigation, taxis and public transport) **Building** (except solid biomass used for heating) A number of exemptions are in place: for gas consumption, companies covered by the EU ETS are fully exempt from the CGE. Energy-intensive companies threatened by carbon leakage are not subject to the EU ETS pay a reduced rate of 0.08 Euro/MWh bringing their total energy tax on gas to 1.60 Euro/MWh. Both types of companies are also fully exempt from the carbon tax on oil and butane (OECD 2020, p. 49).	**Road transport** Bonus -> only electric cars, electric motorbikes and e-bikes can receive the bonus, hybrid cars are no longer eligible. Malus -> any car with CO2 emission above 110 g/km2 faces a one-time malus. The malus rises with the car's emissions, reaching 12,500 Euro for the most polluting cars	**Road transport**
Regulated entities	Upstream	Owners	Owners
Monitoring and Reporting	Besides motor fuels, the CGE also applies to natural gas, coal and heating oil, with differentiated rates reflecting the different average carbon content of the fuel types. To avoid double-taxing, the carbon tax is not levied on electricity since carbon emissions from power generation already incur a price under the EU ETS. €/t CO2		

FRANCE		
Performances of the system	For households, Gloriant (2018) has estimated the CO2 reduction due to carbon tax on transport fuels and heating oil (excluding natural gas). The results of the ex-ante assessment suggest that in 2017, the carbon tax reduced transport emissions by at least 0.6 to 1.7 Mt CO2 (a reduction of 0.6 to 1.7% compared to the baseline). Emissions from oil-based heating decreased by by 0.7 Mt CO2 (a reduction of 2% compared to the baseline for both activities), the annual reduction would rise to 3 to 5.7 Mt in 2022 if the originally planned tax trajectory were to be implemented. The study points in particular to freight transport and off-road use of gasoline as the largest exemptions with respect to the amount of emissions covered by it and in terms of lost revenue. The exemptions result in approximately 15% of energy use emissions in France facing no carbon price at all (Conseil d'analyse économique 2019, p. 6).	Both instruments appear to be complementary to the carbon tax. They are complemented by the EU fleet standards that address the supply side by forcing automakers to put ever more fuel-efficient cars on the market. The carbon tax, in turn, provides a price signal all through the use phase, thereby giving incentive to also moderate kilometres driven. It can thus help curb the rebound effect, i.e. the risk that a more efficient car would allow its owners to spend the money saved on fuel to drive more kilometres. The carbon tax does not apply to electricity and thus creates a complementary incentive for electric vehicles, as the cost per km does not increase for them.

FRANCE (*continued*)				
Measure	White certificate scheme	Zero-rate eco-loans	The Energy Transition Tax Credit	The premium for the conversion of oil or gas boilers
Sectors covered	**Building**	**Building**	**Building**	**Building**
Regulated entities	Energy suppliers	Owners	Owners	Owners
Monitoring and Reporting				
Performances of the system	Given that energy suppliers are likely to pass on at least a share of their costs for fulfilling the energy efficiency obligation to their customers, one can argue that this price premium works as an implicit carbon	All three measures support low-carbon investments and are thus complimentary to the carbon tax. Given that the funding comes from the state budget, no implicit carbon price signal results from them. However, just as the carbon price, these instruments are likely to have a regressive distributive effect. In particular, low-income households are unlikely to profit from zero-rate loans or income tax deductions		

FRANCE (*continued*)		
	price signal and therefore overlaps with the carbon price signal from the carbon tax.	

The analysis conducted on other national measures in the road transport and building sectors shows that the fuel suppliers are most of the time the regulated entities regarding carbon or energy taxes (upstream approach). When fuel suppliers are regulated, the tax is expressed in €/t CO2 (cases of Sweden and France).

In France, the carbon taxes are also expressed in €/MWh PCS (for natural gas), in €/MWh for coal and in c€/litre for gasoline, diesel, residual fuel oil and fuel oil. The regulated entities report mass, energy or volumes of fuels. Then, the carbon contents of the different fuels are defined to calculate the corresponding CO2 emissions.

Nevertheless, the information on the detailed MRV requirements, such as the references for defining the carbon contents for the different fuels leading to €/t CO2, the nature of the activity data to be reported by the regulated entities, the potential mandatory units, or the frequency of updating the carbon contents figures update is scarce.

In the case of Poland, energy suppliers are covered by a tax on energy (excise duty on fuels), which is expressed in €/litre or €/GJ. The carbon content seems to have been indirectly included when defining the amounts of the tax regarding the type of fuel.

Furthermore, regarding existing tracking mechanisms, the Directive 2009/30/EC, also called the **Fuel Quality Directive (FQD), and the Fuel Quality Monitoring System (FQMS)** deserve to be analysed in order to set out the existing monitoring systems for fuels, here for the road transport, in order to assess to possibility of extending existing rules to an ETS extension MRV system.

Fuels used for road transport in the EU must meet strict quality requirements to protect human health and the environment and make sure that vehicles can safely travel from one country to another.

Common fuel quality rules help reducing greenhouse gas and air pollutant emissions and establishing a single fuel market and ensure that vehicles can operate everywhere in the EU on the basis of compatible fuels.

The Fuel Quality Directive applies to petrol, diesel and biofuels used in road transport, and to gasoil used in non-road-mobile machinery.

In compliance with Article 7a of the FQD, for each fuel and energy supplied to the road transport and to non-road mobile machinery, Member States must report the following data, as defined in Annex I of Council Directive (EU) 2015/652:

- fuel or energy type,
- volume or quantity of fuel or electricity,
- GHG intensity, which is the rate of GHG emitted — expressed in grams of CO2 equivalent (CO2e) — over the energy produced (in megajoules, MJ),
- production pathways of biofuels.

Following the amendment of the Council Directive and of the FQD by Regulation (EU) 2018/1999, reporting on the following data is subject to a voluntary basis:

- place of purchase, which refers to the country and name of the processing facility where the fuel or energy underwent the last substantial transformation,
- origin, which refers to the feedstock trade name (FTN), but only where suppliers hold the necessary information.

The EEA is responsible for the quality assurance/quality control (QA/QC) of the data submitted at EU level and is assisted in these checks by the European Topic Centre for Air Pollution and Climate Change Mitigation (ETC/ACM) ([152]).

In 2017, 22 EU Member States plus Iceland and Norway submitted their fuel quality reports in accordance with the requirements of the FQD. Estonia, Lithuania, Poland, Portugal, Romania and Spain did not submit a complete report. During the QA/QC procedure, the ETC/ACM reviewers posed clarifying questions to EU Member States, relating to the completeness and consistency of their submitted data sets. The most common findings communicated to Member States following the quality checks performed on the information reported were:

- data reported not corresponding to the data lists provided in the template,
- data reported in aggregated form (e.g. place of purchase, feedstock trade names, etc., aggregated per fuel type).

Most of these issues could be solved directly with the Member States in the communication process, by completing missing information, correcting erroneous values or providing the necessary clarifications. Following the QA/QC procedure, six Member States submitted revised data sets. Except for the above-mentioned countries not having submitted a report, all issues were resolved during the QA/QC process.

In 2017, Table 85 shows the main information reported under FQMS for each MS (EU27 except UK).

Table 85. FQMS reporting

MS	Resp. Sampling	Resp. reporting	Location of sampling	FQMS used	Country Size	Petrol sample	Diesel sample
						S : summer W : winter	
Austria	Agrar Market Austria (AMA)	Umweltbund esamt GmbH Wien Austrian Environment Agency (AEA)	Refuelling stations	EN 14274 [153] statistical model A	Small	56 S + 50W	50 S + 50W
Belgium	Fapetro.	Fapetro.	Refuelling stations	National system	Small	2 575 S + 1 471 W	1 802 S + 1 879 W
Bulgaria	State Agency for Metrological and Technical Surveillance (SAMTS) via the	State Agency for Metrological and Technical	Refuelling stations and terminals	EN 14274 statistical model A	Small	61 S + 58 W	62 S + 60 W

[152] The ETC/ACM is a consortium of 14 European organisations contracted by the EEA to carry out specific tasks identified in the EEA strategy in the area of air pollution and climate change mitigation.

[153] EN 14274: Automotive fuels — Assessment of petrol and diesel quality — Fuel quality monitoring system (FQMS)

MS	Resp. Sampling	Resp. reporting	Location of sampling	FQMS used	Country Size	Petrol sample	Diesel sample
						S : summer W : winter	
	Directorate-General for Quality Control of Liquid Fuels (DG QCLF)	Surveillance (SAMTS) via the Directorate-General for Quality Control of Liquid Fuels (DG QCLF)					
Croatia	Ministry of Environment and Energy	Croatian Agency for the Environment and Nature.	Refuelling stations and terminals	EN 14274 statistical model C	Small	88 S + 86 W	83 S + 110 W
Cyprus	The Ministry of Energy, Commerce, Industry and Tourism (MECIT)	The Ministry of Energy, Commerce, Industry and Tourism (MECIT)	Refuelling stations	EN 14274 statistical model C	Small	331 S + 268 W	175 S + 154 W
Czechia	Czech Trade Inspection Authority (CTIA)	Ministry of Industry and Trade (MIT)	Refuelling stations	EN 14274 statistical model C	Small	434 S + 597 W	589 S + 694 W
Denmark	accredited laboratory for the Danish Petroleum Association (EOF)	Danish Environmental Protection Agency (EPA)	Refuelling stations	EN 14274 statistical model C	Small	106 S + 101 W	50 S + 50 W
Estonia	Estonian Environmental Research Centre	Estonian Environmental Research Centre	Refuelling stations	EN 14274 statistical model C	Small	200 S + 120 W	90 S + 60 W
Finland	Finnish Customs Laboratory	Finnish Customs Laboratory	Refuelling stations	EN 14274 statistical model A	Small	111 S + 116 W	59 S + 58 W
France	SGS FRANCE	Ministère de la Transition écologique et solidaire General Directorate of Energy and Climate (DGEC)	Refuelling stations	EN 14274 statistical model A	Large	218 S + 203 W	120 S + 100 W
Germany	the 16 governments of the federal states (*Bundesländer*) or their federal state agencies	Umweltbundesamt (Federal Environment Agency — UBA),	Refuelling stations	EN 14274 statistical model B	Large	438 S + 409 W	216 S + 193 W
Greece	Fuel Distribution and Storage	Directorate of Energy,	Refuelling stations	EN 14274	Small	58 S + 59 W	50 S + 50 W

MS	Resp. Sampling	Resp. reporting	Location of sampling	FQMS used	Country Size	Petrol sample	Diesel sample
						S : summer W : winter	
	Inspectorate of the Ministry of the Environment and Energy. General Chemical State Laboratory	Industrial and Chemical Products		statistical model A			
Hungary	ÁMEI Petroleum Products Quality Inspection Company	ÁMEI Petroleum Products Quality Inspection Company	Refuelling stations	EN 14274 statistical model C	Small	60 S + 60 W	60 S + 60 W
Ireland	Irish Petroleum Industry Association ITS Testing Services (UK) Ltd.	Department of Communications, Climate Action and Environment	Refuelling stations	EN 14274 statistical model C	Small	47 S + 47 W	47 S + 47 W
Italy	Different laboratories	Ministry of Environment Land and Sea	Refuelling stations	EN 14274 statistical model A	Large	100 S + 100 W	100 S + 100 W
Latvia	Ministry of Economics of the Republic of Latvia	Ministry of Economics of the Republic of Latvia	Refuelling stations and terminals	National system	Small	5 S + 28 W	9 S + 50 W
Lithuania	State Consumer Rights Protection Authority	Ministry of Energy	Service stations	EN 14274 statistical model C	Small	52 S + 52 W	50 S + 50 W
Luxembourg	three organisations	Environmental Administration of Luxembourg	Refuelling stations and terminals	National system	Small	54 S + 70 W	26 S + 36 W
Malta	Regulator for Energy and Water Services	Regulator for Energy and Water Services	Refuelling stations	EN 14274 statistical model C	Small	54 S + 54 W	52 S + 54 W
Netherlands	Human Environment and Transport Inspectorate Dutch Customs laboratory	Human Environment and Transport Inspectorate	Refuelling stations	EN 14274 statistical model A	Small	51 S + 51 W	50 S + 50 W
Poland	Office of Competition and Consumer Protection	Office of Competition and Consumer Protection	Refuelling stations	EN 14274 statistical model B	Large	266 S + 266 W	203 S + 204 W
Portugal	National Authority for the Fuel Market (ENMC)	Directorate-General for Energy and Geology	Refuelling stations	EN 14274 statistical model C	Small	212 S + 318 W	221 S + 331 W

MS	Resp. Sampling	Resp. reporting	Location of sampling	FQMS used	Country Size	Petrol sample	Diesel sample
						S : summer W : winter	
Slovakia	VÚRUP, a.s.	VÚRUP, a.s.	Refuelling stations	EN 14274 statistical model C	Small	123 S + 85 W	106 S + 80 W
Slovenia	Different laboratories	Slovenian Environment Agency	Refuelling stations and terminals	EN 14274 statistical model C	Small	60 S + 70 W	71 S + 82 W
Spain	Ministerio para la Transicion Ecologica	Ministerio para la Transicion Ecologica	Refuelling stations and terminals	EN 14274 statistical model A	Large	200 S + 200 W	100 S + 100 W
Sweden	Swedish Transport Agency	Swedish Transport Agency	terminals	National system	Small	421 S + 394 W	416 S + 431 W

Under the FQMS system, we can see that sampling are made at refuelling stations or fuels terminals. Laboratory analyses are conducted according to the standard EN14274.

As an example, in France, the national GHG inventory compilers team asked the French Ministry of Environment the possibility to use the samples made for the compliance with the FQMS to add fuels carbon contents measurements, in order to elaborate a country-specific CO2 EF for gasoline and diesel oil, which was done one year. In 2017, costs relating to these measurements were as follows:

Characteristics to be analysed **Cost per sample**	**unit price w/o VAT**	**VAT**	**Unit price with VAT**
Carbon, Hydrogen, Nitrogen	54,90 €	10,98 €	65,88 €
Oxygen	54,90 €	10,98 €	65,88 €

It should be noted that these measurements should be completed by measurements on density and NCV, to switch between EF units and to dispose of all the units available for the calculation of CO2 EF.

According to the regulated entities proposed in section 4.2, refuelling stations are not proposed as regulated entities in the design options for the road transport. Nevertheless, the possibility of using the existing FQMS samples to add further measurements (such as carbon content, hydrogen, oxygen, NCV, density) could be examined. It would increase the accuracy of the CO2 emissions monitoring and would be a good basis regarding the Tier approach existing in the EU ETS.

MRV aspects regarding existing ETS outside the EEA including road transport and/or the building sector

Existing ETS outside the EEA have already include the road transport and/or the buildings sector. Experiences gained in these ETS have been analysed on section 2.3. A focus on the MRV related aspects can be synthesized as follows:

Table 86. Summary of ETS outside EEA including road transport and/or buildings designs

	California	**New Zealand**	**Tokyo**	**Transportation and Climate Initiative - TCI (pilot in US)**
Sectors covered	**Road transport**			
	Through fuel suppliers, determined by the fuels for which distributors must purchase allowances covering the embedded carbon content of their emissions.	Transport sector is covered. Biofuels used in the transport sector are not covered by ETS.		Only the fossil fuel components of motor gasoline and road diesel fuel intended for sale or final consumption in a TCI jurisdiction would be covered.
	Buildings			
	Insofar as the covered fuels are used for domestic or commercial heating. This mainly concerns natural gas and LNG: almost two thirds of Californian households use natural gas for domestic heating	Emissions from the heating of commercial and residential buildings are captured by upstream bond points in the stationary energy sector.	Includes public buildings, educational and medical buildings. The system does not cover residential buildings. The system covers both their fuel consumption, as well as the energy consumed in the form of electricity and heat.	

	California	New Zealand	Tokyo	Transportation and Climate Initiative - TCI (pilot in US)
Regulated entities	All suppliers of fuels distributing petrol and diesel, natural gas, oxygen mixture and distilled fuel oil, and liquefied natural gas. The point of regulation is set where fossil fuel goes into commerce in California: the so-called terminal rack where oil and gas are physically transferred. Since the number of terminal racks is limited, the number of covered entities required is relatively small: only approximately 450 companies representing approximately 600 individual installations are compliance entities under the California ETS.	Suppliers of fossil fuels. The point of obligation is as high up as possible: at the point that a liquid fossil fuel supplier imports fuel or takes fuel from a refinery. This applies to all major liquid fuels used in the country, including gasoline, diesel, aviation fuel and light and heavy fuel oil, as well as "any other liquid fossil fuel". Any importer of coal or natural gas for domestic use is required to report the quantities and types of energy imported / produced, and to return a corresponding number of units calculated using emission factors provided by the government.	Building owners.	All fuel suppliers distributing gasoline and diesel, natural gas, oxygen mixture and distilled fuel oil, and liquefied natural gas. For fuels delivered by another jurisdiction (not subject to the ETS TCI system), the company delivering the fuels becomes the taxable entity.

	California	New Zealand	Tokyo	Transportation and Climate Initiative - TCI (pilot in US)
Monitoring	Operators must implement **internal audits, quality assurance, and control systems** for the reporting program and the data reported (ICAP, ETS Worldwide: Status report, 2019)	The NZ ETS MRV is modelled on New Zealand's tax system and relies on self-assessment. To calculate emissions, **default emission factors are provided for all sectors.** Participants follow a "self-assessment" model for emissions monitoring, reporting and verification. The provision of default emission factors and forestry look-up tables is intended to reduce administrative complexity and costs and support consistency of emissions reporting. Enabling unique emission factors offers a fair approach – and a further emission-reduction incentive – for those whose emissions may fall below the industry average. (Leining and Kerr 2018)	Based on 'Tokyo Municipal Government (TMG) Monitoring/Reporting Guidelines'. Energy consumption shall be calculated and verified based on **consumption certificates** that indicate the consumption measured by such gauges, as well as bills and receipts (Bureau of the Environment Tokyo Metropolitan Government, 2010).	Suggested element for the moment on MRV: the participating jurisdictions use the existing platforms for the allocation monitoring system which accompanies it, probably thinking of the Regional Greenhouse Gas Initiative (RGGI) monitoring system called COATS.

	California	**New Zealand**	**Tokyo**	**Transportation and Climate Initiative - TCI (pilot in US)**
Reporting	Annual Reporting is **required for most operators at or above 10,000 tCO2e per year** (ICAP, ETS Worldwide: Status report, 2019)	Annual With a few exceptions, participants are required to report relevant **activities, report emission units annually, in accordance with the government's GHG inventory reporting schedule.** The **government generally defines the default emission factors** for calculating emissions. However, some participants in stationary energy and liquid fuels **may request a single emission factor (UEF) if they can demonstrate that their emission factor is significantly lower than the average** (i.e. lower default emission factor).	Annual emission reporting, including emission reduction plans. The seven GHGs must be monitored and declared: CO_2, CH_4, N_2O, PFCs, HFCs, SF_6 and NF_3. Based on 'TMG Monitoring/Reporting Guidelines'	
Verification	Emission data reports and their underlying data require **independent third-party** verification annually for all entities covered by the program.	There is **no third-party verification** requirement (except for those with a single emission factor) but the **regulator verifies a selection of participants** annually. Leining and Kerr (2018) report that the regulator's annual compliance checks find that the majority of participants understand their obligations and are willing to comply with them.	Third party verification based on "TMG verification guidelines".	

Enforcement	A regulated entity that fails to surrender sufficient compliance instruments to cover its verified GHG emissions on either an annual surrender deadline or at the end of a compliance period must surrender each missing compliance instrument and will have to surrender three additional compliance instruments for each compliance instrument it failed to surrender. Failure to surrender any additional compliance instruments as described above would subject the entity to substantial financial penalties for its noncompliance.	Currently, an entity that fails to surrender emissions units when required to must surrender the units and pay a penalty of NZD 30 (USD 19.73) for each unit that was not surrendered by the due date. In certain circumstances the penalty may be reduced. As a part of the review and reform process, the government plans to introduce a new surrender penalty consisting of a cash penalty set at three times the allowance price. Entities can be fined up to NZD 24,000 (USD 15,789) on conviction for failure to collect emissions data or other required information, calculate emissions and/or removals, keep records, register as a participant, submit an emissions return when required, or notify the administering agency or provide information when required to do so. Entities can also be fined up to NZD 50,000 (USD 32,894) on conviction for knowingly altering, falsifying, or providing incomplete or misleading information about any obligations under the scheme, including emissions return. This penalty and/or imprisonment of up to five years also apply to entities that deliberately lie about obligations under the NZ ETS to gain financial benefit or avoid financial loss.	In the case of noncompliance, the following measures may be taken: First stage: The governor orders the facility to reduce emissions by the amount of the reduction shortfall multiplied by 1.3. Second stage: Any facility that fails to carry out the order will be publicly named and subject to penalties (up to JPY 500,000 [USD 4,587]) and surcharges (1.3 times the shortfall).	

Performance of the system	The ETS was a success: the latest inventory of greenhouse gas emissions showed that "California has reduced emissions below the 2020 target by a total of 7 million tonnes of CO2e. However, the California ETS was not intended to be the primary tool in the state's emission reduction toolkit. The reduction in emissions from the electricity sector were largely because electricity sellers had to meet California's stringent renewable energy quota rather than the quota price incentive. Likewise, the recent plateau and lower emissions in the transportation sector are also due to California's incentives for zero-emission vehicles and its standards for new and light vehicles approved in 2004, which require automakers to make improvements in fleet-wide fuel economy based on the 2009-2016 model - as well as the LCFS and other transportation sector policies.	Typically, reviews conclude that due to low prices, the ETS had minimal impact in terms of reducing emissions, with consequent poor economic performance and impacts on distribution. Leining and Kerr (2016) report that the government's own estimates show that all of New Zealand's mitigation measures in the stationary power and combined transportation sectors (including the ETS) have only reduced cumulative emissions from 2007-2013 only 681 kt CO2-e, equivalent to 0.3 % compared to the reference.	The Tokyo ETS is generally considered a great success in reducing emissions. During the first commitment period, all covered facilities achieved their targets. In fact, three-quarters (76%) even reached their (more ambitious) second period objectives from the first period. Arimura and Abe estimate that the actual reduction in emissions was 13.3%, about half of which was due to the ETS, and the other half due to the increase in electricity prices (Arimura and Abe 2020).	

Source: Question 1.3 and Citepa

According to the information above on ETS outside the EEA including the road transport and/or the buildings sectors, regarding the points of regulation, regulate the fuel suppliers was the preferred option across the ETS analysed, to limit the number of covered entities, streamline GHG emission monitoring and limit the transaction costs of the inclusion.

The MRV systems implemented are similar to the current EU ETS existing system. Indeed, in all systems, the regulated entities must estimate their annual emissions by monitoring the quantity of fuels sold (in case of fuel suppliers, both for the road and buildings sectors) and calculation factors.

Nevertheless, further details on specific requirements on monitoring rules implemented in the ETS studied, such as the methods used to monitor the activity data and/or the calculation factors (emission factor, oxidation factor, net calorific value, biomass content, etc.), or formulas to calculate emissions, or uncertainty, or a potential Tier approach regarding the annual emissions threshold or an annual volume of fuels sold, are quite scarce. For New-Zealand, the Government provides default emission factors which are aimed to be used by all the regulated entities, whatever the annual CO2 emission level or the specific carbon content of the fuels (which can substantially vary, in particular for coals). This choice is motivated by a reduction of the administrative burden and costs, but also by ensuring consistency between emission reports. With regards to the TCI pilot in the US, the future MRV system is aimed at relying on an existing MRV system implemented under the Regional Greenhouse Gas Initiative (RGGI).

Reporting is once a year for all systems studied. California states that reporting is mandatory for entities which emits over 10,000 tCO2/year.

Regarding the verification process, all systems examined implemented a third-party verification, unless New-Zealand, where the verification process appears less demanding, based on less accurate data. Indeed, third-party verification is only conducted when the regulated entity wants to apply a “single emission factor”, that is to say a fuel/entity-specific emission factor, instead of the (national) default emission factor provided by the Government. Moreover, not all the annual reports are verified, but only a selection of them every year. This partial verification is made by the regulator.

Dealing with non-fossil fuels

As CO2 emissions from biomass are subject to specific rules under ETS, the blending of fuels with non-fossil fuels with biofuels or e-fuels raises an issue respecting the monitoring and reporting of accurate CO2 emissions.

Again, under the EU ETS, the CO2 emission factor of biomass and other biofuels are set at zero if they comply with the sustainability criteria. Indeed, the definition of biomass in the MRR (recital (4)) should be consistent with the definitions of ‘biomass’, ‘bioliquids’ and ‘biofuels’ in Article 2 of Directive 2009/28/EC of the European Parliament and of the Council (Renewable Energy Directive (REDII)).

The blending of fuels with non-fossil fuels such as biofuels and e-fuels under the Fuel Quality Directive (FQD) also needs to be analysed regarding the new regulated entities proposed.

The analysis of Table 84 shows analysis of fuels characteristics is already done by:

- 1 Member State only in terminals,
- 19 Member States only in refuelling stations,
- 6 Member States in both.

The analysis in terminals could facilitate the analysis of both fossil fuels and biofuels carbon contents separately and also the blending (i.e. the biomass content of the blended fuel) which could be more accurate than in refuelling stations. If carbon content is analysed in refuelling station, it is complicated to estimate where carbon come from (fossil or biofuel), and so to determine precisely the fossil fuel carbon content.

In the Fuel Quality Directive, Member States are the entities who report data.

The new proposed regulated entities in this study are at the best place to report data on all fuels carbon content in the context of ETS transport, because FQD only focuses on gasoline and diesel oil, and does not cover natural gas and LPG.

- Distributors for gas products could report carbon content for fossil and bio gas, and also report the blending (i.e. the biogas content of the blended gas).
- Refineries and tax warehouse for oil products could report carbon content for fossil (gasoline, diesel oil, LPG) and bio fuels (bio gasoline and bio diesel oil), and also report the blending (i.e. the biomass content of the blended fuels).

As explained in section 5.2.1.2, there is possible overlap between REDII and the inclusion of transport in the EU ETS through all design options, as the latter in theory would also incentivise the use of biofuels. However, as the abatement costs of biofuels are relatively high, it is unlikely that ETS inclusion would have a significant impact here.

The FQD already includes high standards for tracking the non-fossil fuels, as this is important to monitor the transport targets in REDII.

Fuels used for the road transport in the EU have to meet strict quality requirements to protect human health and the environment and make sure that vehicles can safely travel from one country to another.

The Fuel Quality Directive requires a reduction of the greenhouse gas intensity (Article 7a) of transport fuels by a minimum of 6% by 2020 compared to 2010. Together with the Renewable Energy Directive (RED), it also regulates the sustainability of biofuels (Article 7b).

The greenhouse gas intensity of fuels is calculated on a life-cycle basis, covering emissions from extraction, processing and distribution. Emissions reductions are calculated against a 2010 baseline of 94.1 gCO2eq/MJ.

The 6% reduction target is likely to be achieved primarily through:

- the use of biofuels, electricity, less carbon intense fossil fuels, and renewable fuels of non-biological origin (such as e-fuels)
- a reduction of upstream emissions (such as flaring and venting) at the extraction stage of fossil feedstocks.

The Council Directive (EU) 2015/652 defines the method to calculate, and the details to report, the greenhouse gas intensity of regulated fuels. Member States shall apply these rules since 21 April 2017.

Biofuels must meet certain sustainability criteria to minimise negative impacts in their production phase.

Until 31 December 2020, the Fuel Quality Directive and the Renewable Energy Directive set out the following requirements:

- greenhouse gas emissions from biofuels must be lower than from the fossil fuel they replace – at least 50% (for installations in operation before 5 October 2015) and 60% for installations starting operation after that date,

- the feedstocks for biofuels cannot be sourced from land with high biodiversity or high carbon stock.

Considering the indirect land use change, the rising demand for biofuels can displace the production of food and feed crops, and induce the conversion of land, such as forests and wetlands, into agricultural land, thus indirectly leading to increased greenhouse gas emissions. These emissions from indirect land use change (ILUC) can significantly reduce or even wipe out the greenhouse gas savings from biofuels.

To consider this issue, the amount of biofuels produced from cereal and other starch-rich crops, sugars and oil crops and from energy crops grown on agricultural land that can be counted as a sustainable source of renewable energy is limited to 7% of the energy in transport in the Member States in 2020.

4.5.4 Complexities involved in combining and delimiting upstream and downstream approaches for different sectors

Dealing with installations excluded from current the EU ETS

Considering the new regulated entities proposed for the inclusion of the road transport and the building sectors, the question of optional exclusion of installations from the current EU ETS and the forward phase 4 needs to be examined. For instance, if a refinery or a tax warehouse supplies fuel to an installation which falls under the EU ETS scope under the activity “Combustion of fuels > 20 MW”, but was excluded by a Member State according to the article 27 or 27a of the EU ETS Directive (2018/410), and if this installation falls under the “building sector” such as a university, would the fuel-combustion CO_2 emissions be monitored and reported by the refinery as the user has been excluded according to specific rules under the EU ETS?

The definitions of exclusion criteria are shown below.

Possibilities of exclusion of small emitters from the EU ETS (phases 3 and 4):

Inclusion in the EU ETS: Directive 2018/410, Annex I activities

Criteria of exclusion: emitting less than 25 000 t CO_2e/year (here only CO_2), and, when inclusion activity is combustion of fuels > 20MW: rated thermal input below 35 MW. Undertake equivalent emission reduction as if the installation would stay in the EU ETS, by implementing equivalent measures, which are defined by each Member State. Implement simplified monitoring to check the exclusion thresholds. It is the responsibility of each Member State to exclude or not these installations, following consultation with the operators.

Conditions for re-introduction in the EU ETS: annual emissions over 25 000 t CO_2/year, or equivalent measures no longer in place. Then, the installation stays in the EU ETS for the rest of the period (until 2025 for the first sub-period of the phase 4, or until 2030 for the second sub-period of the phase 4).

Possibility of exclusion of hospitals from the EU ETS (phases 3 and 4):

Inclusion in the EU ETS: Directive 2018/410, Annex I activities (hospitals may comply with the activity Combustion of fuels > 20 MW)

Criteria of exclusion: being an hospital. Undertake equivalent emission reduction as if the installation would stay in the EU ETS, by implementing equivalent measures, which are defined by each Member State. It is the responsibility of each Member State to exclude or not these installations following consultation with the operator.

Conditions for re-introduction: equivalent measures no longer in place. Then, the hospital stays in the EU ETS for the rest of the period (until 2025 for the first sub-period of the phase 4, or until 2030 for the second sub-period of the phase 4).

According to the report on the application of the European union emissions trading directive (Article 21 responses, European Commission, 2019), in 2017, the option for exclusion under Article 27 was used by Croatia, France, Iceland, Italy, Slovenia, Spain and the United Kingdom, it has however from 2016 onwards no longer been used by Germany. The total amount of excluded emissions reported by the 7 countries in 2017 was 3 923 kt CO_2 (eq). This amount was 0.8% smaller than in 2016 and represented 0.28% of the total EU ETS emissions in 2017, in the same range as for previous years. The sectors for which emissions are most often excluded are combustion activities (2 184 kt CO_2 (eq) excluded, spread over the 7 countries). Many of the installations carrying out combustion activities may be hospitals and universities since Article 27 of the EU ETS Directive allows a more pragmatic approach concerning these installations. Those installations are not the primary target of the EU ETS and are often included because of a number of small combustion units (but over 3 MW) which cumulatively reach the 20MW threshold.

Possibility of exclusion of "very small emitters" from the EU ETS (new rule in phase 4):

Inclusion in the EU ETS: Directive 2018/410, Annex I activities

Criteria of exclusion: emitting less than 2 500 t CO_2e/year (here only CO_2). Implement simplified monitoring to check the exclusion threshold. It is the responsibility of each Member State to exclude or not these installations.

Conditions for re-introduction: emitting more than 2 500 t CO_2/year. Then the installation stays in the EU ETS for the rest of the period (until 2025 for the first sub-period of the phase 4, or until 2030 for the second sub-period of the phase 4).

Possibility of exclusion of reserve or back up units from the EU ETS (phase 4):

Inclusion in the EU ETS: be part of an installation covered by the Directive 2018/410, Annex I activities

Criteria of exclusion: operating less than 300 hours per year. It is the responsibility of each Member State to exclude or not these installations.

Conditions of exclusion and re-introduction: same as the "very small emitters".

For the preparation of the phase 4 of the EU ETS, Member States submitted to the European Commission their NIMList (National Implementation Measures) by the 30th of September 2019, including the small emitters, the hospitals, the very small emitters and the reserve or back up units that they want to exclude from the EU ETS. The list of installations excluded for phase 4 has not been published yet. But these installations must implement simplified monitoring, in order to verify that the exclusion criteria still apply.

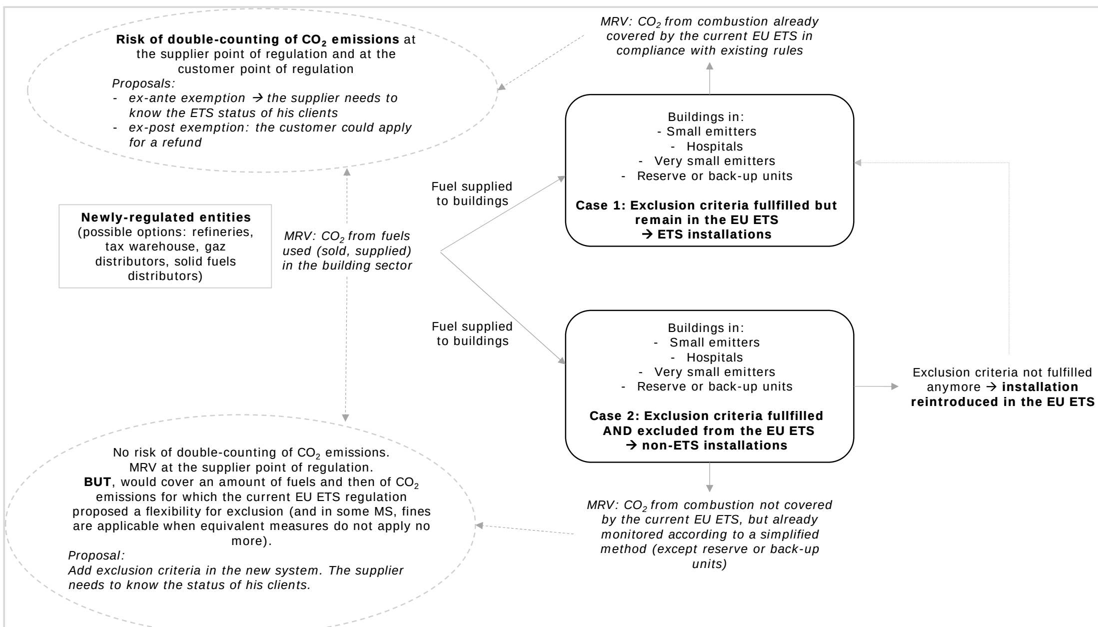
In addition, it should be noted that the equivalent measures are defined by each Member State. These equivalent measures can include fines applicable to the excluded installations if they no more comply with their equivalent measures. For example, in France, hospitals which exceed the annual emissions cap published in a national decree must pay a penalty equivalent to the difference between the annual emissions cap published and the annual emissions declared, multiplied by 4,50€/t CO_2 (decree 2015-168, 2015, France). This means that some excluded installations from the EU ETS will already pay a fine regarding the current EU ETS.

Regarding the design options proposed, the fuels supplied to buildings which fall under the exclusion criteria in the current EU ETS would then be regulated in case of the extension of the current EU ETS to the building sector (options 1a, 1b, 2b), or in case of the creation of a separate ETS for road and buildings (option 3a), or in case of a separate ETS dedicated to buildings (option 3c), while the EU ETS Directive explicitly provides provisions to exclude the small emitters or hospitals in order to limit the administrative and economic burden on these kind of installations. As such, there may be a distortion between the aims of the two systems which would coexist (in case of separate ETS), and attention should be paid on this issue.

One proposal would be to maintain the exclusion criteria in an extended EU ETS (including buildings) or in a separate EU ETS.

Nevertheless, if an excluded installation, in particular universities or hospitals (which pertains to the building sector), is re-introduced regarding the exclusion criteria under the current EU ETS (baseline) during a compliance period, it becomes a regulated entity already covered by the EU ETS, for which the CO_2 emissions related to the fuel consumption must not be reported twice. So, the crucial challenge remains in identifying the end-user of the fuel supplied by the regulated entities proposed (refineries, tax warehouse, gas or coal distributors).

Figure 91. Consideration of excluded installations in the new system



District heating

One of the characteristics to consider in order to extend the current EU ETS to the building sector is the categorization of district heating installations. District heating installations as such cannot be entirely attributed to the building sector. Indeed, the district heating installations provide heat to various entities: some of them fall under the building sector, but some of them can fall under the industry sector for example. This issue has been presented earlier (see section 1.1.2): only the share of fuel burnt in district heating installations that produces heat provided then to the building sector must be targeted.

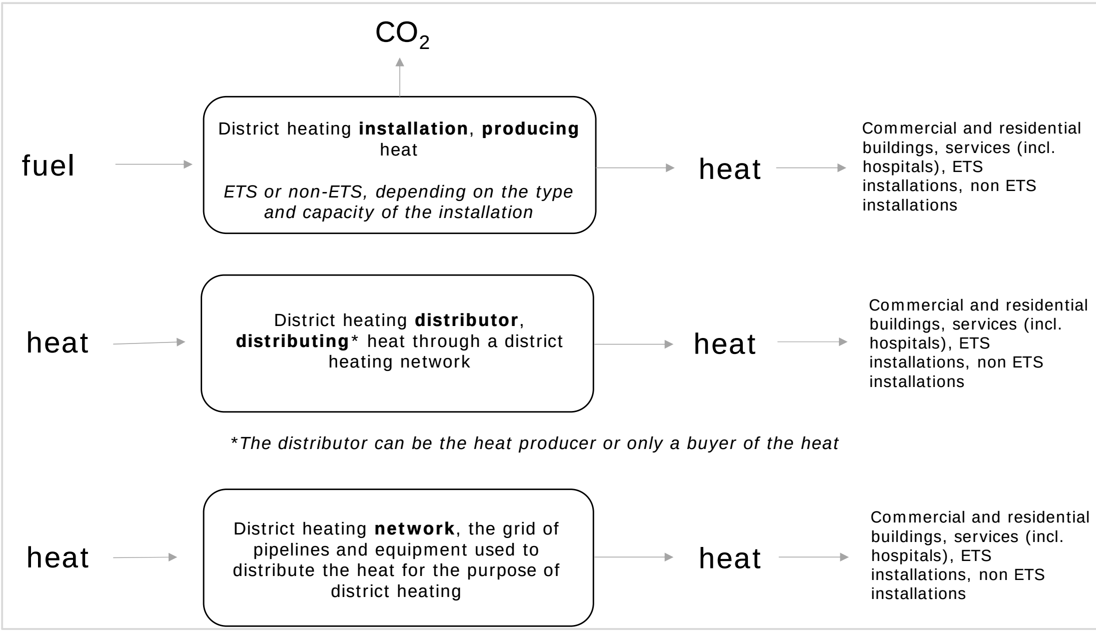
District heating raises a particular issue on potential double-counting if extending the current EU ETS to the buildings sector. Indeed, some of district heating installations are already covered by the EU ETS. The CO_2 emissions related to the combustion of the fuels which produces heat delivered to households and non ETS installations are is then already monitored and reported. Definitions regarding district heating need to be specified:

A district heating *installation* is the installation producing heat for district heating, which can be an ETS installation or a non-ETS installation, depending on the type and capacity of the installation used.

A district heating *distributor* distributes the heat through a district heating network, which can either be produced by the distributor itself or purchased from third parties.

A district heating *network* is the grid of pipelines and equipment used to distribute the heat for the purpose of district heating.

Figure 92. District heating definitions and scope associated



In order to analyse any potential MRV-related double-counting issue, the following cases are considered:

- Case 1: district heating installation, ETS.
- Case 2: district heating installation, non-ETS.
- Case 3: district heating distributor.

Case 1: district heating installation, ETS.

CO_2 emissions related to the combustion of the fuels producing heat are already monitored and reported under the current EU ETS. In this specific case, including fuels used in the building sector would lead to a compliance obligation both for the fuel supplier and for the ETS district heating installation.

To avoid double-counting without changing the rules of the current EU ETS, two options have been identified:

- **The newly-regulated fuel supplier could flag the amount of fuel sold to the EU ETS district heating installation**: this amount could be deducted from the supplier compliance obligation as it is already covered by the EU ETS. This is the case for an exemption ex-ante. This amount should however be reported by the fuel supplier for consistency purposes to control the amount of fuel reported by the EU ETS district heating installation to limit the risk of fraud.
- **The newly-regulated fuel supplier could not or did not flag the amount of fuel sold to the EU ETS district heating**: as mentioned earlier (section 3.4.4) the fuel customer would need to clearly demonstrate that the purchased fuels were consumed in an ETS installation. The customer would be able to

apply for a refund, lowering the compliance obligation of the fuel supplier. Hence, the monetary refund would also need to be paid (directly or indirectly) by the fuel supplier. This is the case for an ex-post exemption.

As the EU ETS district heating installations are already listed in the system (Member States NIMsLists and EUTL registry), the first option (the fuel supplier can flag the amount of fuel sold to the ETS district heating installation) should be preferred.

Another option could be to decide that all district heating installations do not fall under the current EU ETS anymore, regardless their combustion capacity. The newly-regulated fuel supplier would then have to report all the fuel sold to the district heating installations. However, this option would lead to the update of an already existing, furthermore recently modified, system that is the EU ETS. Thus, this option should not be preferred.

Case 2: district heating installation, non-ETS.

CO_2 emissions related to the combustion of the fuels producing heat are not monitored and not reported under the current EU ETS. The district heating installation can supply different entities: commercial and residential buildings, hospitals, ETS installations, non-ETS installations. Even if the district heating installation provides heat to an ETS installation, CO_2 emissions associated to the combustion of the fuel that produced that heat are not accounted for in the current EU ETS (baseline).

In this case, there is no risk of double-counting. The newly-regulated fuel supplier would have to report, under the new extended or separate EU ETS, the amount of fuel provided to the non-ETS district heating installation to cover the CO_2 emissions related to the combustion of the fuels sold to produce heat consumed by the building sector. The keystone is to correctly identify the end-user (see below).

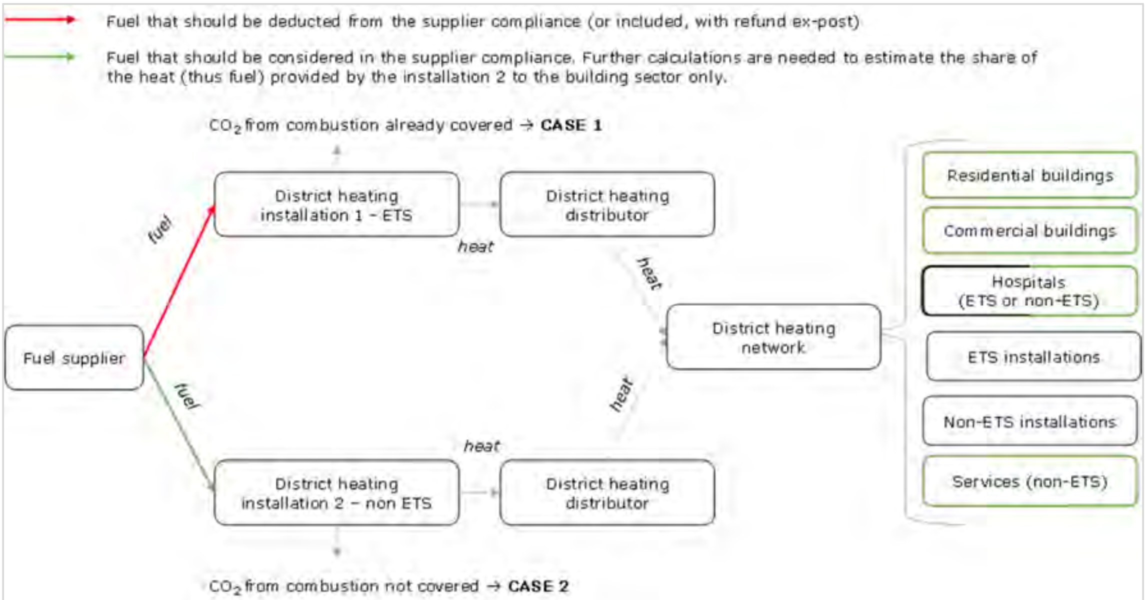
Case 3: district heating distributor

In this case, the heat that is distributed can be supplied by an ETS installation, which corresponds to the case 1, or by a non-ETS installation, which corresponds to the case 2.

Even if various entities separate the fuel supplier from the heat consumer, the crucial point is to identify the entity responsible for the fuel combustion.

- If the entity responsible for the fuel combustion is an ETS installation, there is a risk of double counting that should be considered (see case 1).
- If the entity responsible for the fuel combustion is a non-ETS installation, there is no risk of double counting and the fuel supplier should report the fuel sold that has been used to produce heat consumed by the building sector. In this case, the difficulty lies in the identification of the end-user.

Figure 93. Summary of the potential cases which can be encountered with district heating



- In the figure above, the fuel supplier knows the status of the different district heating installation (ETS / non-ETS). The fuel supplier is responsible for **the reporting of part of the fuel sold** to the district heating installation 2 (non-ETS), but should not report the fuel sold to the district heating installation 1, as the CO_2 emissions associated are already covered by the current EU ETS.
- For the CO_2 emissions reporting, the fuel supplier must know the entities connected to the district heating installation 2. In this example, the district heating installation 2 provides heat to:
- Residential buildings: heat should be considered,
- Commercial buildings: heat should be considered,
- Hospitals: heat should be considered if the hospital is a non-ETS, or not considered if it is an ETS installation (see previous section on excluded installations),
- ETS installation: heat should not be considered,
- Non-ETS installation (industry): heat should not be considered,
- Services: heat should be considered.
- The fuel supplier has to identify the share of heat delivered to every entity considered as part of the building sector (residential and commercial buildings, services, some hospitals), compared to the total heat delivered associated with the fuel burnt. This share of heat delivered to the building sector could be applied, as a proxy, to the fuel sold in order to estimate the fuel that, in the end, was used to provide energy to the building sector.
- Example: Reported fuel = Total fuel sold to Installation2 x [$\text{Installation2\_Heat}_{\text{Commercial}}$ + $\text{Installation2\_Heat}_{\text{Residential}}$ + $\text{Installation2\_Heat}_{\text{Hospitals\_non-ETS}}$ + $\text{Installation2\_Heat}_{\text{Services}}$] / [Total Installation2_Heat]

- In this kind of configuration, the fuel supplier would need strong cooperation with the district heating, in order to report the most accurate amount of fuels as possible.

4.5.5 Cost and administrative burden for the relevant stakeholders

Administrative costs are costs incurred by enterprises, public authorities and citizens in meeting legal obligations to provide information on their activities to public authorities. This captures a broad range of information including labelling, reporting, registration data, mandatory need for an accredited verifier, as well as monitoring and assessments needed to generate the information. The costs and administrative burdens that result from an MRV system for both the regulated entity and the relevant administrative bodies and agencies can be rather high so that cost efficiency of an MRV system is an important aspect to consider.

In general, a downstream approach with more regulated entities is likely to lead to both higher cost and administrative burdens than an upstream approach. For example, in the current downstream ETS, the MRV costs are the main part of transaction costs for participants. According to V.Bellasen and N.Stephan (2015)[154], empirical studies on the transaction costs of firms participating in the EU ETS suggest that MRV costs account for about 70% of the total transaction costs (between 65% and 95%). The average MRV cost per entity covered by the current EU ETS was 22 000 €/year, and 0,07 €/t CO2e.

For an ETS to be effective, it must be possible to measure and monitor emissions with low uncertainties and at reasonable cost. By contrast, covering sectors composed of many small, diffuse, or remote emissions sources may involve high administrative costs relative to benefits, as mentioned in the design options in section 4.1. Depending on the point of regulation chosen, costs are more or less high. Often there are far fewer entities involved in the extraction and commercialization of a fossil fuel than in its final consumption. For example, California's ETS applies to 85 percent of the state's emissions by covering around 450 business entities.

New Zealand's regulation succeeds in covering 100 percent of fossil fuel emissions by regulating 275 mandatory participants (2018). The upstream approach has allowed for administrative simplicity while ensuring comprehensive coverage. But in case of an upstream approach, costs reflecting the embedded CO_2 may be passed through to the consumer in the form of slightly higher fuel product prices. In New-Zealand, a few large downstream firms felt that their upstream fuel suppliers—to whom they are tied because of small markets— were not managing the GHG liabilities efficiently and hence passing on a GHG cost that was too high. In a few cases, this has been resolved through private contracts that allow the downstream firm to manage its GHG liabilities and provide units to the upstream regulated party as it buys fuel. Moreover, the government has enabled some downstream firms to "opt in" as a point of regulation, avoiding double counting by providing a rebate to the upstream point of regulation for emissions associated with the fuel sold to these downstream firms[155] (as stated in section 2.3.2 of the current report).

[154] Monitoring, reporting and verifying emissions in the climate economy, 25 March 2015, V.Bellassen, N.Stephan, I.Cochran, J.-P.Chang, M.Deheza, G.Jacquier, M.Afriat, E.Alberola, C.Chiquet, R.Morel, C.Dimopoulos, I.Shishlov, C.Foucherot, A.Barker, R.Robinson. Nature climate change, VOL 5, April 2015

[155] Partnership for Market Readiness (PMR) and International Carbon Action Partnership (ICAP): 2016. Emissions Trading in Practice: A Handbook on Design and Implementation. World Bank, Washington, DC

MRV costs can be distinguished for each step of the MRV process.

Monitoring: This ranges from direct measurement of gas concentration using gas meters to the recording of proxies such as fuel consumption based on the bills of a given entity. Both activity data and emission factor change over time and hence need to be monitored. Activity data nevertheless tend to vary more frequently than emission factors[156].

Costs associated to monitoring are mostly linked to the uncertainty that the regulated entities are required to achieve to estimate CO2 annual emissions. Uncertainty corresponds to the difference between the estimate and the actual value. In monitoring, lack of accuracy (for example a miscalibrated gas meter, or unit error in the reporting) and of precision (random errors, for example sampling error, or errors of copy in the reporting) can both lead to uncertain estimates, but only the second can be dealt with by increasing the number of samples. Bias can only be reduced by monitoring and reporting the same source of emissions with a change in the method. In reporting, both types of errors can be reduced through quality control and verification. Lower-cost approaches such as using default emissions factors can provide unbiased estimates for predict-able sources of emissions. Then, flexibility provisions can be introduced to adapt uncertainty requirements to the cost incurred by regulated entities. These provisions may take the form of de minimis thresholds (that is, threshold levels of emissions under which monitoring and reporting are not required), or 'materiality thresholds' (that is, threshold levels of errors under which errors are tolerated during verification).

Reporting covers the administrative part of the process. It involves aggregating and recording the numbers, explaining how you came up with them in the requested format, and communicating the results to the relevant authority, such as the regulator or the top management of the company.

The purpose of *verification* is to detect errors resulting from either innocent mistakes or fraudulent reporting. It is usually conducted by a party not involved in monitoring and reporting, who checks that these two steps were conducted in compliance with the relevant guidelines. Contrary to conventional wisdom, verification is usually not the main part of MRV costs. It varies mostly between 0 and 50% of total MRV costs, with an average 31% for the EU ETS. Verification costs are, however, mostly fixed costs. For smaller sources or entities, it can therefore take the lion's share of MRV costs, up to 80% of the total. Moreover, unlike monitoring and reporting costs, they cannot be internalized as the auditor is intended to be an independent third party (V.Bellassen, N.Stephan, 2015). Nevertheless, simplification could be introduced in the verification process, such as criteria for waiving site visits in the current EU ETS.

Another cost which could be taken into consideration is the accreditation of verifiers by an accreditation body. According to V.Bellasen and N.Stephan (2015), the cost could be 10,000 € per accredited entity per year in the current EU ETS. But literature on this specific topic is scarce.

According to V.Bellassen, N.Stephan (2015), economies of scale are the dominant feature of MRV costs, at least when these costs are compared on a basis of cost per tCO2e. Regulation, mandatorily applied to a large number of sources and entities, must not impose too heavy a burden on the complying entities as these cannot opt out. MRV costs decrease with the comprehensiveness of the perimeter. The larger and

[156] Monitoring, reporting and verifying emissions in the climate economy, 25 March 2015, V.Bellassen, N.Stephan, I.Cochran, J.-P.Chang, M.Deheza, G.Jacquier, M.Afriat, E.Alberola, C.Chiquet, R.Morel, C.Dimopoulos, I.Shishlov, C.Foucherot, A.Barker, R.Robinson. Nature climate change, VOL 5, April 2015

the more comprehensive a scheme, the lower the MRV costs. Jurisdictional schemes tend to cover all sources within a jurisdiction, and this adds up to a large amount of GHG emission. As a result, they exhibit much lower MRV costs than other schemes per tCO2e. However, even when the emissions amount per entity is comparable, for example between cap-and-trade schemes, comprehensiveness pushes MRV costs down. Indeed, entity-scale schemes tend to be mandatory and therefore to cover all entities that meet the inclusion thresholds (for example more than 20 MW for combustion installations under the EU ETS). As such, they must be especially careful with the costs that they impose on regulated entities as these may distort the market (for example by putting higher costs on smaller entities) or even put unbearable burden on some firms.

MRV costs also depends on the size of the regulated entity, the cost per emitted tonne of CO2 decreases exponentially with the amount of verified emissions. For smaller firms, verification constitutes the bulk of incompressible MRV: the tier approach is therefore more efficient at reducing costs for small installations than the provisions on verification.

The complexity of the entity also contributes to increasing MRV costs[157]. Nevertheless, looking at the proposed regulated entities for the inclusion of the road transport and the buildings sector, the MRV complexity does not seem to lie in the complexity of the entity, but in the tracking of the end-user to avoid double-counting, loopholes or fraud. But considering the high number of entities potentially newly regulated, specific monitoring rules accompanied with detailed guidance would contribute to reduce the administrative burden.

Administrative burden for competent authorities

Competent authorities in the EU ETS framework have been defined by each Member States. Different organisations are encountered through MS (EC, Article 21 responses analysis, 2019).

Table 87. Competent authorities' structures through MS in 2018 in the current EU ETS framework

Organization	Number of countries
Centralised system in which one Competent Authority deals with all activities related to EU ETS	6
Centralised system in which one Competent Authority deals with all activities related to EU ETS for aviation	7
Centralised system for MRV activities and inspection/enforcement while the allocation and policy making, or auctioning are allocated to a different authority.	16
Local or regional authorities responsible for permitting or inspection but one Centralised Competent Authority for approving the monitoring plans, dealing with changes to the monitoring plan, reviewing emission reports and approving improvement reports.	5

[157] Accounting for Carbon (2015): Monitoring, Reporting and Verifying Emissions in the Climate Economy, edited by V.Bellassen and N.Stephan

Organization	Number of countries
Decentralised system where multiple local and regional authorities are involved in inspection and MRV activities	11
Competent Authorities that are responsible for installation's MRV activities are organised differently than for aviation.	9

Source: Application of the European union emissions trading directive - Analysis of national responses under Article 21 of the EU ETS Directive in 2018, European Commission, SQ Consult, UBA Vienna, 22 May 2019

Where a MS has multiple Competent Authorities, it is essential to organise appropriate coordination and information exchange lines between authorities. The central Competent Authority often review and provide instructions on monitoring plans (MPs) and emission reports to facilitate coordination and to improve the quality of the MRV compliance. Where countries have allocated MRV responsibilities to one central authority or multiple authorities and inspection to other authorities, it is necessary that these authorities share information so that the authorities responsible for approving MPs and improvement reports, and assessing emission reports know what inspection authorities have found during inspections and can take further action: e.g. by imposing sanctions or re-assessing/updating MPs.

Some countries with multiple local or regional authorities responsible for MRV activities of installations MRV have assigned the responsibilities for aviation to a central authority that is managing air transport and other aviation activities.

Since the start of the trading period some MS that originally chose to have a decentralised system decided to transfer MRV responsibilities from the local or regional authorities to a central authority. However, the share of emission reports being checked or the number of inspections carried out does not depend directly on the type of decentralization but more on the available resources within the Competent Authority, the numbers of installations and how the review the emission reports and inspection approach is set-up.

Considering the inclusion of the road transport and the building sectors in the EU ETS, regardless the design options, the number of the proposed regulated entities would increase compared to the current EU ETS framework.

Table 88. Number of regulated entities which would be covered by the ETS for the road transport and the building sector

Gas products	**Oil products**		**Solid products**
Distributors (upstream) **2329 entities** Supply streams to buildings and filling stations Most important role for the building sector	Oil refineries (upstream (sales)) **87 entities** End use known, some products exported, import/export treated separately Important role for both road transport and building sectors	Tax warehouse (upstream) **~7000 entities** End use known, monitoring system existing Important role for both road transport and building sectors	Distributors (upstream) **~3000 entities** Role only for buildings

In 2017, 10 688 installations were reported in the current EU ETS (EC, Article 21 responses analysis, 2019). It should be noted that the oil refineries are already covered by the current EU ETS for the production of petroleum products.

The number of the potential new regulated entities **would increase by more than 100% the current number of regulated entities** under the current EU ETS framework.

The administrative burden for MS would therefore significantly increase. But this observation should be compared to the rather lower expected complexity of the monitoring and reporting rules for the potential newly regulated entities, where only sales and distribution of fuels for combustion purposes would occur. It corresponds to only one activity. Nevertheless, as the CO2 emissions reporting would also be based on the knowledge of the end-user of fuels in the road transport and/or the buildings sectors (design options 1a, 1b, 2a, 2b, 3a, 3c) and subsectors (freight and commercial buildings regarding the different design options 1c, 3b), it is a new kind of parameter to consider for the competent authorities to deal with regarding ways of checking and validation. A way of gaining efficiency and reducing administrative costs would be to firstly identify if some competent authorities already deal with the type of data to be monitored and reported by newly regulated entities in order to avoid double work when creating a new competent authority.

Simplified approaches could also be considered when developing MRV rules for new sectors. In the current EU ETS MRV framework, in 2017, 8 countries have developed simplified approaches, which is allowed by the MRR and AVR in certain cases. The reason why these countries have developed simplified approaches is mostly because of the high number of installations that could be eligible to use these simplified monitoring plans. However, the low number of MS applying simplified approaches can be largely explained by the extensive guidance and examples that have been developed by the Commission (EC, Article 21 responses analyses, 2019).

Considering the reporting aspect, since 2013 a growing number of MS have decided to use the Commission's templates (for monitoring plans, emissions reports, verification reports and improvement reports). Currently 12 MS are using an IT system and more MS are expected to either implement their own IT system or make use of the EC online tool called DECLARE. It should be noted that there is a large variation in both the type and the scope of the IT systems implemented in the MS (EC, Article 21 responses analyses, 2019).

Therefore, the development of specific and relevant guidance documents and templates for the integration of new regulated entities will contribute to lower the administrative burden for competent authorities.

Regarding ensuring compliance, competent authorities can also carry out spot checks and inspection of entity's implementation of MRV requirements. The type of inspection depends mostly on the administrative structures within a country and how they have set-up their permitting regime and competent authority organisation. The main reason for not carrying out inspection in some countries are the limited resources countries have and the fact that they rely more on verification to identify non-compliance issues (EC, Article 21 responses analyses, 2019).

To go deeper to estimate the administrative burden for competent authorities in an extension of the EU ETS to buildings and/or road transport, it would be useful to apply the standard cost model. The standard cost model allows to quantify the administrative burdens upon regulated entities.

According to the standard cost model, the costs of an administrative action is computed as follows: tariff x time.

Two types of tariffs can be defined:

- Internal tariff: made up of gross wage (mean statistical wage of the employee who typically performs the administrative activity), wage costs (i.e. extra allowances), material and overhead costs (needed purchase to perform administrative activities (computers, etc.) and costs associated with the use office materials).

- External tariff: cost of contracting out (accountants, legal workers, lawyers, etc.)

The "time" variable corresponds to the time needed to perform a certain activity.

For competent authorities, the increased number of administrative activities would have to be consider.

The costs of an administrative action are the multiplied by the number of times an action is required. As shown above, the structure of CA depends on the country, and an extensive investigation would have to be carried out to determine the number of employees within CAs involved with the EU ETS enforcement, and the time they would have to perform activities related to the EU ETS extended. In a CA, this time can also depend on the internal procedures of validation of the annual reports (different levels of validation due to hierarchy), and the tools that CA have at their disposal to manage their tasks more or less automatically (EXCEL tools, databases, development of automatic checks, online tools, …). Interviews could be led, and questionnaires could be sent to MS in that way.

By multiplying the two parameters, we would be able to compute the administrative burdens. The computation of administrative burdens considering the different design options would mean that an extensive investigation would have to be carried out to lead to a full analysis resulting in a standard cost model study.

4.5.6 Possibility of fraud of the regulated entity's monitoring and reporting system

Today, the MRV system is based on the single Union Registry, which is an online database that holds the accounts for stationary installations and for aircraft operators. While the Registry is managed by the EU, the accounts are managed by the EU Member States as per Article 19(1) of the EU ETS Directive. The functioning of the Union Registry is regulated by the EU ETS Registry Regulation. The registry records:

- National implementation measures (a list of installations covered by the ETS Directive in each country and any free allocation of allowances to each of those installations in the period 2013-2020)
- Accounts of companies or individuals holding such allowances
- Transfers of allowances performed by account holders
- Annual verified CO2 emissions from installations and aircraft operators
- Annual reconciliation of allowances and verified emissions, where each company must have surrendered enough allowances to cover all its verified emissions.

The evaluation of the ETS Directive confirms that a system linked to a single EU registry based on new legislation adopted in 2013 which introduced a two factor authentication and transaction signing providing a high level of security. Under these rules, Member States competent authorities apply 'know-your-customer' checks applying enhanced security requirements for the opening of the new accounts and have to review at least once every three years whether the information submitted for the opening of an account remains complete, up-to-date, accurate and true[158]. In addition, national authorities have to report to the European Commission annually on

[158] Article 25(4) of the Registry Regulation

the implementation of the KYC checks in their country which should be the basis for the European Commission to encourage harmonised application. The national administrators check all data to ensure no illegal activity takes place and to be the basis for operators to fulfil their annual compliance obligations. The verified emissions and the amount of surrendered allowances are published via the EU Transaction Log (EUTL). This log keeps an audit trail of all transfers into and out of the accounts, including checking the details of non-EU ETS GHG emissions trading units.

While there is literature analysing the impact and reasons for fraud with ETS allowances based on forms of 'missing trader fraud' like the VAT fraud, the sources of information analysing or enabling to better understand MVR fraud and potential ways to avoid it are scarce. For example, no case of fraud regarding the reporting of emissions is mentioned in Article 21 report by the EEA. Fraudulence has also been documented in certified UN offset projects and "carbon neutral" credits developed for sale on the voluntary market. The discovery of fraudulent activities prompted the rapid introduction of changes to the tax law and improvements in the security of the trading system by the European Commission. While some responses have been positive, others have been more criticized such as the decision to hide the serial numbers of permits which may increase, rather than decrease, the possibility of fraudulent activity[159].

The ETS extension to the road transport and building sector would increase the sums of money involved with the consequent incentive and potential for manipulation of carbon measurements to exaggerate results and increase payments[160]. It is therefore important to consider and eliminate any new possibilities of fraud in the system in order to ensure its integrity.

While one important factor in the design of an ETS is that a regulated entity is able to accurately monitor and report CO_2 emissions, another essential element of the system is that it is designed so that fraud in the monitoring and reporting of such emissions by the regulated entity is made impossible or very costly. Fraudulent emissions reports under the MRV system would reduce the overall effectiveness and reliability of the ETS. The regulatory solutions to prevent potential cases of fraud under the MRV system need to be designed to cover all possible situations.

The 2015 Court of Auditors report on the integrity of the EU ETS identified certain risks of fraud in the MRV of CO_2 emissions, including weak approval procedures for monitoring plans in most of the Member States, and a lack of clarity in the findings reported by verifiers, accompanied by a lack of control and follow-up of their findings by the competent authorities. With respect to the verification findings, the Court identified, for instance, a lack of detail in the descriptions, repeating of findings from year to year without adequate information on the reasons or background, or reporting of no findings in complex or large installations where findings would have been expected. Moreover, there was no real follow-up from the national competent authorities in such cases or own-initiative inspections by the authorities.

Several measures were introduced to remedy the weaknesses identified in the Court of Auditors report and in particular to ensure closer control and involvement of the Competent Authorities in ensuring compliance, such as, for instance, the adoption of a

[159] Reyes O. Letting the market play: corporate lobbying and the financial regulation of EU carbon trading. Carbon Trade Watch and Corporate Europe Observatory, Barcelona, Spain, 2011.

[160] R. Pearse, S. Böhm, Ten reasons why carbon markets will not bring about radical emissions reduction, Carbon Management, 2014.

Commission guidance document on ETS inspections by the Member State authorities.[161]

Others claim the need for measures to enhance evidence-based decision-making at all levels and to strengthen ongoing efforts of capacity-building for data collection and analysis[162]. Finally, the accuracy of monitoring, reporting and verification capabilities and requirements will be informed by technological developments. Technological possibilities which could enhance the accuracy of MRV should be considered in the development of new requirements for the EU ETS in order to contribute to the integrity of the system.

4.5.6.1 Currently applicable legal framework

As described in section 4.5.2 regarding the large package of regulations, guidance documents and templates, even though there are still differences, across Member States in the implementation of monitoring and reporting requirements[163], the risk of fraud in relation to these aspects of the compliance cycle seems to be strongly reduced as a consequence of the robustness of the system design. The guidance documents prepared by the Commission in support of the implementation of the MRR aim specifically at ensuring that a sufficient degree of detail is implemented across Member States.

These considerations will be equally important for any new sectors introduced in the EU ETS or for parallel emission trading schemes given the importance of the robustness of the compliance cycle of an ETS.

The 2015 EU ETS Evaluation concluded that, since requirements on verification and accreditation were included in the AVR a strong increase in harmonisation has been observed.[164] In particular, the accreditation system for verifiers, introduced by the AVR, (which includes a peer evaluation process among accreditation bodies) ensures a high and uniform quality of competence checks for the verifiers.[165] The report also noted the importance of the verification template prepared by the Commission in improving the quality of verification and the usefulness of the reports for the CAs.[166] Still, the Court of Auditors report from the same year identified discrepancies in the level of quality of verification across the Member States. Moreover, the Court and the evaluation team both concluded that problems exist in relation to the capacity of the CAs in the Member States to inspect and check the verified emission reports. Overall, it can be concluded that, while the verification aspect of the compliance cycle has significantly improved since the introduction of the AVR and the adoption of guidance by the Commission, and thus the overall compliance cycle can be considered robust, weaknesses lie mostly in the capacity of the authorities to check the verified reports. The recently adopted guidance document by the Commission on EU ETS inspections aims to remedy this aspect in particular.

Given its detailed nature and targeted obligations for the sectors currently covered by the EU ETS, the currently applicable legal framework for industrial installations and

[161] https://ec.europa.eu/clima/sites/clima/files/ets/monitoring/docs/gd8_mrr_inspections_en.pdf

[162] UNEP GEAS, March 2013. The impact of corruption on climate change: threatening emissions trading mechanisms? And UNODC, 2012. "Corruption, Environment and the United Nations Convention." Impact of Corruption on the Environment and the United Nations Convention against Corruption

[163] Fourth ETS MRAV Compliance Review, 2015,

https://ec.europa.eu/clima/sites/clima/files/ets/monitoring/docs/report_4th_ets_mrav_compliance_en.pdf

[164] Evaluation of the EU ETS Directive, Ecologic and SQ Consult, 2015, p. 182, https://www.ecologic.eu/sites/files/publication/2015/2614-04-review-of-eu-ets-evaluation.pdf

[165] Ibid.

[166] Ibid.

aircraft operators relating to MRV would need to be adapted to introduce any new sectors, such as the road transport and buildings sectors, to the extent that they are not yet covered by the EU ETS in a direct manner. Moreover, given the positive effect of the EC's guidance documents on implementation of the specific MRV requirements, such guidance would likely equally be needed for new sectors. The core elements of the MRAV compliance cycle under the EU ETS are considered to effectively ensure the robustness of the EU ETS and would therefore be relevant starting points for any specific MRV requirements for the road and buildings sectors, or subsectors, in particular in terms of reducing the possibility to avoid fraud in the monitoring and reporting of emissions.

4.5.6.2 ETS extension to the road transport and buildings sectors: elements to be considered in relation to fraud in MRV

As seen in section 2, the current monitoring of emissions under the ESD is based on fuel consumption and shows that the majority of building emissions are a result of fossil fuels used in residential buildings (70%) and the majority of road transport emissions are a result of fossil fuel combustion by private passenger cars (61%). As illustrated above, the long supply chain results in several possible regulated entities for the implementation of an EU ETS in these sectors, some located upstream in the supply chain, while others are downstream, from final suppliers to the end user of the fuel. Even a combination of regulated entities on both ends could be considered. The possibility of fraud will, to an extent, depend on the regulated entity chosen in each sectors. While a concrete assessment of the possibility of fraud in relation to MRV will depend of the concrete regulated entity and specific design elements of the MRV, including the technological possibilities in relation to reporting on emissions, some general elements are put forward for consideration in the design of the ETS for these sectors.

In previous sections the tax warehouse has been selected as the regulated entity because they are the entity furthest upstream that has accurate monitoring systems in place and is able to monitor the sale of fuels to the transport sector. There are between 5,000 and 10,000 tax warehouse keepers for energy products in the EU. While further upstream, the number of regulated entities would be considerably lower, the fact that tax warehouses already implement monitoring systems implies that there will not fundamentally higher administrative costs.

The integration of road transport to the ETS

The fraud-related risks for the transport sector in the ETS would typically relate to declaring false quantities of fuel sales or false shares of biofuels. The sensitivity for fraud would strongly depend on the monitoring and reporting system to be implemented. The risks of fraud are, however, minimal if the ETS is encompassed with a complete and reliable monitoring and enforcement system.

In a system designed at an upstream level (i.e. tax warehouses) the risk of fraud is lower but would increase if certain subsectors of using transport fuels would be exempted, such as agricultural vehicles or rail transport since it would be difficult to distinguish the use of fuel for transport subject to compliance obligations under the ETS and for other vehicles. This would open the opportunity for entities to declare that certain amount of fuel would be used for those vehicles not included in the ETS, in this way evading the scheme. This risk to fraud already exists and for all types of regulated entity, but current monitoring and enforcement mechanisms already exist to prevent this type of fraud. At downstream levels, the risk of fraud is in principle higher as the number of entities is larger and therefore, the design of the enforcement measures would need to take this into account. The Dieselgate scandal, in 2015, illustrated the difficulty with effective downstream emissions testing when manipulated devices were used for No_x emissions testing in laboratories while the vehicle emitted more NO_x while on the road. A large amount of regulated entities would require great detection potential by competent authorities in order to effectively avoid fraud in relation to emissions monitoring and reporting.

If the system is designed so that the regulated entities are tax warehouses, the risk of fraud due to declaration of false quantities of fuel should be considered minimal, as tax warehouse keepers have to comply with strict reporting rules for fiscal purposes. Tax warehouses invoice fuel volumes supplied to the market, subject to excise duty, and keep accounting records of invoices and excise duty for taxation purposes. For fiscal requirements and given the value of the excise duties, which create a more important risk of tax evasion, these accounting records are subject to strict requirements and subject to supervision by the tax authorities. They register fuels accurately for fiscal reasons and therefore, the risk of fraud is small[167]. The tax warehouse keepers are referred to in the ETD Directive under which Member States are required to identify tax warehouses, keep registration of these entities and the type of fuels they trade. Therefore, the chances that those entities would not be identifiable and that would not implement or comply with ETS rules is very small. The same monitoring and enforcement measures used for excise duties could be used for ETS. In this context, it is important to note that gas oil, widely used as automotive fuel for road transport, is subject to the requirements of the Euromarker Directive[168]. The Euromarker Directive requires gas oil released for consumption in the EU at a rate lower than the full excise duty rate to be dyed with a distinctive yellow colour and to contain a tracer agent. Additional national markers may be applied in parallel. The application of the markers takes place in tax warehouses before the gas oil is released for consumption. The use of markers in gas oil as a control and enforcement measure has reduced the risk of tax evasion within the EU and has been considered an effective instrument to fight fraud in this sector.[169] The quantities of fuel marked are documented and reported by the tax warehouse.

Tax warehouses monitor and register the type and the quantity of fuels consumed for transport and the taxation tariffs used as transport fuels pass through them. In addition, all imported and exported transport fuels have to pass a tax warehouse, so no additional monitoring system is required for these flows. However, natural gas (LNG or CNG) is the only transport fuel that is not currently required to pass through a tax warehouse. For this subsector the risk of fraud increases. While the market share of natural gas for transport fuels and the percentage of CO_2 emissions are quite low (i.e. 0.5% - see section 2.1 figure 38), excluding them from the systems could stimulate a shift from the fuels covered by the ETS to natural gas, leading to carbon leakage and therefore reducing environmental effectiveness of the system. Two options are proposed: one is to consider appointing natural gas suppliers as the regulated entity, which will particularly be a feasible option as they could carry out this role for both the transport and building sector. Another option could be to establish the obligation to pass natural gas through tax warehouses.

Similarly, tax warehouses would have difficulties to monitor the type and share of biofuels in transport fuels which increases the risk to fraud; e.g. fuel suppliers may

---

[167] CEDelf study

[168] Council Directive 95/60/EC of 27 November 1995 provides for the designation of a common fiscal marker to be used for gas oils and kerosene (other than jet fuel) exempted or subject to a reduced rate.

[169] European Commission, Commission Staff Working Document, Evaluation of the Council Directive 96/60/EC of 27 November 1995 on fiscal marking of gas oil and kerosene, 12 July 2019, SWD(2019)3030 final, https://ec.europa.eu/taxation_customs/sites/taxation/files/fiscal-marking-report-2019.pdf

argue that their fuels contain more biofuels than they actually do to decrease the number of allowances to surrender. However, the fuel quality directive[170] and the renewable energy directive[171] establish monitoring and reporting requirements regarding mass balances of biofuels which reduce to a minimum the risk of declaring higher shares of biofuels than there are in reality. Some Member States also register the amount and type of biofuels blended in the fuels so the biofuel content (and in the future potentially quality) could be taken into account by the tax warehouse keeper[172]. For those countries where this is not the case, it seems quite feasible for the tax warehouse keepers in these countries to gather these types of data as well.

While it should be technically feasible for tax warehouses to be the regulated entity and when necessary distinguish which transport mode fuels are delivered at every tax warehouse, expanding their responsibilities for monitoring and reporting would be needed, implying the amendment of the relevant legislation.

In addition, tax warehouses may have difficulties differentiating fuel used for transport and subject to ETS compliance and fuel for other uses. This may generate a potential for fraud where fuels declared for use for non-transport purposes and, thus, with no obligation to surrender allowances for ETS compliance would in reality be used for transport purposes. However, this possibility of fraud could be overcome as their use is already subject to monitoring and enforcement to prevent fraud with (differences in) excise duties. The same mechanism could be applied, including the possibility of a specific marking.

The integration of buildings sector in the ETS

The risk to fraud within the buildings sector in any of the designed options where it is integrated it an ETS depends on the monitoring and reporting system to be implemented. A complete and reliable monitoring and reporting system would minimise the risks of fraud. Similarly, the risk to fraud in the buildings sector either covering only commercial/institutional buildings or residential buildings as well, is linked to the defined regulated entity, responsible for monitoring and reporting emissions.

As buildings are covered by the Energy Tax Directive and the EPBD, the efficiency of integrating this sector in the ETS and the potential for fraud needs to be considered.

The analysis regarding the integration of the buildings sector in the ETS needs to consider the requirements under the current legal framework. The MRR requires accuracy and consistency of data monitored and reported and transparency of parameters and the choice of method which provides for the most complete and timely data combined with the lowest uncertainty without incurring unreasonable costs. The feasibility of complying with these rules is critical.

The analysis shows that an upstream approach is preferred to a downstream approach where the most accurate option for monitoring greenhouse gas emissions is monitoring the consumption of the fuels itself. While heating oil and other oil products pass through tax warehouses, gas and coal do not. For gas, suppliers have accurate

[170] Directive 2009/30/EC of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC

[171] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources, lastly amended by:

Directive (EU) 2018/2001 of 11 December 2018 on the promotion of the use of energy from renewable sources

[172] CEDelf 2014 report refers to Denmark, France, Germany, the Netherlands and Sweden

information on the amount of gas supplied and on the carbon content. Coal suppliers are not subject to control mechanisms, are more diverse and the carbon content of coal products varies significantly. This could result in reduced accuracy in MRV and a higher risk of fraud.

It is therefore considered that while for oil products the tax warehouse keepers are the best option as regulated entity, for natural gas and coal the fuel suppliers that supply directly to end-users are the best option as regulated entity.

In this way the entity for the oil products remains in line with the approach taken for transport so that the current excise duty system can be used for monitoring and reporting, thus reducing sensitivity to fraud. Gas oil for heating purposes is covered by the Euromarker Directive. As mentioned above, the markers are applied by the warehouses prior to the release of consumption and are therefore an important tool for avoiding excise duty evasion in relation to fuel consumption. For natural gas and coal this approach is not possible, and a system will have to be newly developed. Similarly to the transport sector, the upstream approach for the buildings sector would be based on tax warehouse keepers for oil products, and fuel suppliers (distributors) for gas and coal. Tax warehouse keepers need to keep track of the fuel buyers for tax reasons, directly providing a track mechanism by user and energy product. This provides a high level of monitoring accuracy and a low risk of fraud. The monitoring requirements of tax warehouse keepers are strict as they release fuels for sale on the market through excise duty points, at which point energy taxes need to be paid. Defining the fuel supplier as a complementary regulated entity makes it possible to develop a harmonized approach for allocation and monitoring, for the different fuels and throughout Europe.

On the contrary, fuel suppliers do not always have to track the amount of fuels with the same accuracy because gas and coal are often exempt from energy taxes.

Coal suppliers do not count with an additional control system and therefore a system based on them would be more sensitive to fraud. For coal, the regulated entity would be the coal supplier that supplies to the final consumer either directly through truck delivery or through the sale of packed products through retailers. In some Member States, coal is subject to excise duties, as a result of which the suppliers are registered, and quantities are monitored with sufficient accuracy. In other Member States, an MRV system would need to be established from scratch but nothing prevents them from doing so, which provides a good basis for building a tracking mechanism upon it. In countries where excise duty is charged for coal products the excise duty system could be used to identify regulated entities. In other countries, registrations through the chamber of commerce and information from sector organisations could be used to identify suppliers. Such a system would imply that tax warehouse keepers would also need to surrender allowances for liquid fuels sold to buildings and fuel suppliers for the gaseous and solid fuels. The basis for activity data will be the invoices that the supplier sends to its customer. Coal suppliers should monitor both coal they purchase and coal supplied to end-users in a mass balance approach. These suppliers deliver directly to the end-user and, in principle, should be able to identify user buildings. This can be based for instance on the type of contract or distribution addresses.

The sensitivity to fraud for buildings integrated in an ETS also depends on the compliance systems to be implemented.

Similarly to the transport sector, the monitoring of the type and share of biofuels used in the building sector at the fuel supplier/ tax warehouse keeper could have a higher risk to fraud; e.g. fuel suppliers may argue that their fuels contain more biofuels (biogas) than they actually do to decrease the number of allowances they have to submit. However, the Renewable Energy Directive requirements regarding the establishment of verification systems of the sustainability criteria and control of biomass content through mass balances could assist in preventing fraud.

A different system such as one based on an emission factor applied equally to all fuels regardless of their emissions levels and without a proper monitoring system, would imply a reduced accuracy in MRV and a higher risk of fraud.

However, the decision to include coal as a type of fuel used by the building sector needs to strike the balance between the effort required for the MRV and the small amount of emissions arising from coal combustion. The analysis carried out in previous sections found that based on data from 2017, at the EU-27 level, the majority of building emissions come from fossil fuels used in residential buildings (70%) but most emissions result from the use of natural gas followed by oil (**gas oil and diesel oil)** and petroleum products (LPG). However, only 14.4% of total ESR emissions are due to non-ETS CO_2 emissions in residential buildings, out of which 1.5% comes from solid fossil fuels (coal). In addition, only 6.3% of total ESR emissions are caused by commercial buildings' non-ETS CO_2 emissions with 0.15% emissions coming from solid fossil fuels (coal).

Inclusion of buildings section in the EU ETS would improve the environmental effectiveness of the ETS as it provides a financial incentive to end-users to reduce fuel consumption and thereby emissions. However, an upstream system would not increase the awareness regarding emissions reductions or innovation.

In brief, we can conclude that the risk of fraud of an ETS where transport and buildings sectors are integrated is low when the system can be monitored and enforced accurately. On that basis, the choice of regulated entities is critical. The role of tax warehouse as regulated entity for oil and natural gas provides the adequate framework for a reduced risk to fraud. However, the adoption of new legislation to recognize additional monitoring responsibilities for tax warehouse keepers might be needed. In this context, it will be important to consider and learn from existing enforcement tools, such as the fiscal markings framework for gas oil.

4.6 Robustness check of design options

In light of the findings so far and by adding further insights, we use this part of the report to present a first robustness check of the design options defined under section 4.1.1 by looking into the criteria defined under section 4.1.2: environmental criteria, economic criteria, social criteria and regulatory criteria. Part of the data used for this section is also provided in summary tables in the appendix to this section.

The following terms and definitions are used for the robustness check:

- EU ETS: refers to the sectors regulated - today or in an extended version - under the current framework of the EU ETS.
- "new ETSs": refers to new ETS that may or may not apply similar, but not necessarily identical regulations to the current EU ETS. This is particularly relevant for Options 3a - 3c where the new sectors are not integrated into the existing EU ETS, but separate ETSs are being designed for those sectors.
- scope of the current EU ETS: the data reported concentrate on the stationary part of today's EU ETS. Emissions from aviation are not being included. Further, we only include EU ETS emissions from EU 27, i.e. emissions from UK as well as Iceland, Liechtenstein and Norway are excluded.
- ETS+ESD emissions: used as basis to calculate shares for the EU ETS and the ESD. It includes the stationary part of today's EU ETS + emissions reported under the ESD.

4.6.1 Option 1a - full scope extension

In Option 1a, we assume that an EU-wide scope extension of the current EU ETS takes place to include all CO2 emissions from road transport and the buildings sector in the existing EU ETS. We further assume that this scope extension implies that the sectors become fully regulated under the EU ETS and are no longer part of the ESD, so scope of the EU ETS and the ESD change significantly compared to today.

4.6.1.1 Environmental criteria

Option 1a presents the most comprehensive extension of the EU ETS analysed in this report. Based on 2017 GHG emissions, the coverage increases from 1,590 Mt CO_2e to about 2,830 Mt CO_2e, which represents an increase by 78%. In turn, emissions covered under the ESD decrease significantly from roughly 2,250 Mt CO_2e to only 1,010 Mt CO_2e, a decrease of more than 50%. In total, the EU ETS in Option 1a covers 74% of ETS+ESD emissions, while the ESD covers only 26% of those emissions. This is a significant relocation between EU ETS and ESD compared to Option 0. In particular, the ESD covers a relatively small part of emissions, mainly coming from the agricultural sector (see section 5.1.2 for an analysis of the effects of a reduced ESD).

In the projections from the EUCO3232.5 scenario and assuming that inclusion in the ETS or ESD has no impact on the reductions reported in the EUCO scenario, EU ETS emissions under Option 1a scope go down to about 1,930 Mt CO_2e by 2030, a reduction of 900 Mt CO_2e or 32% compared to 2017 levels in 13 years. Comparing the projections with the historic reduction trends shows that significantly higher reductions are necessary to reach the ambition levels projected in the EUCO scenario. Between 2005 and 2017, a 12-year time frame, total emissions under Option 1a scope in the EU ETS were reduced by 17%. Compared to that, emissions under the EU ETS in Option 0 are projected to fall by 35% between 2017 and 2030 in the EUCO3232.5 scenario, so the scope extension would result in a slight decrease in percentage emission reductions in the EU ETS sectors. This is because in the EUCO scenario the reductions in the ESD sectors are lower than the reductions in the ETS sectors. If additional sectors are then moved from the ESD to the ETS but their reductions remain the same, the total reduction percentage of the ETS is reduced.

Emissions under the ESD are projected to fall from 1,010 Mt in 2017 to roughly 770 Mt CO_2e in 2030, a reduction by 25% in a time frame of 13 years. In contrast, historic emissions in the remaining ESD sectors were reduced by 8% between 2005 and 2017, a 12-year time frame. While projected emission reductions in the EUCO scenario for the scope Option 1a EU ETS go down, emission reductions in the sectors remaining under the ESD decrease very slightly from 26% in the baseline Option 0.

Projections under the EUCO scenario are based on the availability of abatement options. In general, an extension of the EU ETS to new sectors almost always results in an increase in the availability of abatement options (an inclusion of a sector without any abatement potential seems highly unlikely). Further, in recent years, a number of studies have analysed the potential for reaching net-zero GHG emissions. While some of them use to a large extent so called carbon dioxide removal technologies to offset emissions from other sectors (e.g. most scenarios analysed for the IPCC Special Report on Global warming of 1.5°C), there are also some studies that limit the use of carbon dioxide removal technologies and try to reduce emissions in the first place as much as possible. This later group of studies includes UBA 2014, European Commission 2018, Fraunhofer ISI 2019 or CAT 2019. These studies show that the emission reduction measures exist to (almost) completely reduce emissions in the road transport sector as well as the buildings sector. It is often more a question of R&D spending to develop certain technologies and it is not yet clear which of the technologies will be most successful (reducing emissions at reasonable costs).

Based on the analyses in task 2, in both sectors, road transport as well as buildings sector, the price-sensitive abatement potential below the baseline (Excel model EnerNEO) from energy efficiency and fuel switch measures for prices of up to 150 €/t CO2 is small (up to 11.7% (52.5 Mt CO_2) in the buildings sector and up to 7.8% (39.1 Mt CO_2) in the road transport sector at a price of 150€ per ton of CO_2). Compared to projected emissions in 2030 covered under the EU ETS in this option, the price-sensitive abatement potential based on this analysis accounts for only 2% of emissions. Other barriers - investment barriers, economic barriers, technical barriers and behavioural barriers - prevent the uptake of energy efficiency improvements in the two sectors. Those barriers would not be addressed with the introduction of a CO_2 price in those sectors. Unclear is the abatement potential coming from other options not analysed in task 2 (in particular behavioural change). However, putting costs to behavioural change options is rather difficult, while other barriers in case of fuel switch such as investment barriers or technical barriers are highly relevant. So, it is unclear whether an important source for abatement potential is not yet reflected in the analysis in task 2 that would significantly change the picture. However, due to the exclusion of the sectors from the ESD it is not very likely that extensive additional measures would be taken to address abatement potential locked by other barriers. On the other hand, additional incentives to address these barriers could come from other Commission initiatives aiming at increasing ambition to reduce GHG emissions by 2030.

4.6.1.2 Economic criteria

As pointed out above, despite relatively high CO_2 prices of up to 150 €/t CO_2, the price-sensitive abatement potential in the sectors newly covered by the EU ETS is with roughly 91 Mt CO_2 small compared to projected overall emissions of more than 1,900 Mt CO_2e. According to the scenario description of the EUCO3232.5 scenario, the CO_2 price in the EU ETS increases from 19.2€ in 2020 to 28 € in 2030. So, the prices analysed under task 2 are significantly higher than those applied in the EUCO3232.5 scenario for the existing EU ETS sectors, but still do not result in a significant abatement potential in the newly covered sectors. It can therefore be expected, that in case of an inclusion of road transport and buildings into the EU ETS, carbon prices in the EU ETS will increase assuming that a meaningful cap-setting approach is chosen. For a clearer picture on abatement costs in the existing EU ETS sectors and the newly covered sectors as well as effects on the carbon price, however, a coherent modelling analysis is needed.

What can be assessed, though, is the relative size of administrative costs of Option 1a compared to other options. For the sake of this analysis, we concentrate on the costs for the public sector and do not look at costs for the private sector, although they also present a relevant information, in particular when it comes to deciding on the point of regulation and the related question of preventing double counting. According to UBA 2014, four types of costs can be differentiated for the public sector:

- negotiation costs
- one-time administrative costs
- regularly occurring administrative costs
- costs for disclosure and sanctioning

The design elements used for the differentiation of the design options that are particularly relevant for the size of the administrative costs are the coverage of the system and the linking with the EU ETS. While other design elements are also highly relevant in this context - in particular the point of regulation, how to prevent double counting and the allocation mechanism and related compensation schemes - they are not included here as they are not adequately reflected in the design options. However, it needs to be kept in mind that those other design elements have strong, maybe even stronger impact on the different cost types than the design elements taken into consideration here.

Negotiation costs: It can be assumed that negotiations with two complete sectors as is the case in Option 1a are considerably more complex than negotiations with only one sector. In addition, the fact that the characteristics of the two sectors are so different may further complicate negotiations. In particular the automotive sector has a very strong lobby in some of the Member States, complicating negotiations with those Member States. So significant negotiation costs can be expected in case of Option 1a. Although certain design options are already set by deciding to extent the EU ETS instead of building a completely new system, many of the design elements still need to be decided on for this extension, such as point of regulation or how to prevent double counting. Therefore we do not assume that this choice has a significantly decreasing impact on negotiation costs.

One-time administrative costs: The large advantage of Option 1a regarding one-time administrative costs is, that the infrastructure already existing for the EU ETS can also be used for the sectors to be newly included. Whether one or two sectors are partly or totally covered by the system can be assumed to not affect the one-time administrative costs significantly.

Regularly occurring administrative costs: The main factors influencing the regularly occurring administrative costs is again the coverage. A higher number of regulated entities, as can be expected in case of the inclusion of the whole road transport and buildings sector, also results in high regularly occurring costs, while it can be assumed that the choice to connect with the EU ETS has no significant impact on this type of costs.

Costs for disclosure and sanctioning: As for regularly occurring administrative costs, costs for disclosure and sanctioning are closely linked to the number of regulated entities and therefore particularly high in Option 1a compared to other options due to two complete sectors being included.

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning
Coverage	++	o	++	++
Connection with the EU ETS	o	--	o	o

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

4.6.1.3 Social criteria

First and foremost, the EU ETS puts an administrative burden on the regulated entities – however, the indirect impacts on the broader society can also be remarkable, especially if different types of households are becoming at risk of facing considerably higher costs from carbon pricing than other households do (i.e. poor households versus relatively richer households), resulting in a socially unfair policy measure.

Thus, it is important to explore what impact various design options (that is, changes in the carbon cap and the so-induced changes in the carbon-price) are expected to have on the three key social criteria identified: price impact on transport and heating fuels; household spending on transport and heating fuels; and the use of auction revenues (to potentially bring about positive distributional impacts on households' disposable income).

Overall, the extended ETS is expected to increase the cost of road transport and heating.

Heating impacts are likely to be regressive, since low income households initially spend a greater proportion of their income on heating. Road transport impacts will be mixed – typically it is the 'lower-middle' and 'middle' parts of the distribution where the proportion of spending on transport is highest (because the lowest income households do not have access to a private vehicle).

Transport fuels

The increase in transport fuel prices would likely have an overall small impact on disposable incomes and on the expenditure structure of an average household. The way different household income deciles are expected to experience different impacts is discussed in more details under section 4.3 Just transition. As for cross-country differences in the EU-27, in some countries the impact would presumably be progressive, in others it would be regressive.

With regards to the possible **indirect impact** of including transport in the ETS on households, i.e. the impact of the possible rise of the prices of other, transport-intensive goods, the distributional effect on households depends on the nature of these goods. Only if these goods are necessary goods (e.g. goods produced by the food & tobacco industry), a regressive effect - comparable to that of the taxation of energy carriers used for heating and electricity - can be expected.

As argued for in CE Delft (2014), an increase of fuel prices in land-based transport may reduce its competitiveness compared to maritime transport. This phenomena could result in carbon leakage, but it is expected that its scale would be rather limited as it is only a small proportion of routes where maritime transport competes with land-based transport and especially electrified rail transport could be used more, which would not result in carbon leakage. It should be noted, however, that the carbon leakage problem only occurs if maritime transport is not regulated under an ETS, otherwise a change would even be welcome if maritime transport is more climate-friendly than road transport. Furthermore, it could also decrease the competitiveness of filling stations on the EU borders vis-à-vis filling stations just outside the EU borders, and thus with regards to impacts on end consumers, it may encourage tank tourism. However, cross-border differences in fuel prices are already considerable large and therefore the EU ETS will only have a modest impact on the scale of the above-mentioned phenomena of tank tourism. On an EU-scale, the resulting carbon leakage is considered to be small.

As for the possibilities to use auctioning revenue, while auctioning the allowances to the transport sector will increase fiscal revenues, some of the gains would presumably be offset by lower tax revenues (driven by decreased fuel use and moderate shift towards more energy-efficient modes of transport).

Household heating fuels

The increase in heating fuel prices would inevitably be larger for households that use coal, because of the higher carbon content of coal. Full inclusion of buildings sector in the existing ETS would likely have a regressive impact on household disposable incomes. In countries which currently have a lower coal price and where the expenditures on coal are high, the increase in expenditure on coal, in proportion of disposable income, is expected to be relatively higher than for the other fuels. Higher prices would also be expected for other fuels such as gas and heating oil, but these will have to face much smaller price increases in relative terms due to lower CO_2 emissions and the higher starting price. An overview of the expected price increases per Member State and fuel is shown in the two figures Figure 70 and Figure 71 in section 4.1.2.1.

4.6.1.4 Regulatory criteria

This option would require the adoption of legislative measures to amend the ETS Directive 2003/87/EC for integrating the two sectors and incorporate elements such as, relevant definitions, the impact on the EU cap, the regulated entities, potential references to benchmarking rules or carbon leakage etc. Additional legislative measures would need to be adopted in order to ensure that the Effort Sharing Regulation (EU) 2018/842 does not include road transport and building sectors. Those measures would likely fall under EU **competence** as they amend existing environmental legislation. The analysis of the subsidiarity and proportionality principle requirements under EU law would need to be done based on the design details. However, as the measures would be amending existing legislation and complementing the current framework for emission reduction in the road transport and buildings sectors, compliance with the principles would likely be positive. The analysis of the EU added value considers if the designed EU level measures perform better than similar national measures, for example in relation to bringing down the overall abatement costs[173]. In this sense, it is worth noting that the report on the evaluation of the EU ETS Directive refers to the Commission's Green Paper[174] regarding the introduction of an EU ETS which pointed out that different ETS at national level could act as barriers for improving the internal market for energy, and different types of regulation could lead to more fragmented and costly situation for the different sectors, with potentially different rules for participation, MRV, allocation, and most importantly, different ambition levels and thus carbon prices.

Furthermore, non-legislative acts will also need to be adopted to ensure the applicability of the existing compliance and enforcement ETS system to the new sectors. Measures would propose amendments to Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions amending Commission Regulation (EU) No 601/2012, Commission Implementing Regulation (EU) 2018/2067 on the verification of data and on the accreditation of verifiers;

The implementation of the MRV rules to downstream regulatory entities would be more difficult and costly than if applied upstream. Amendments to the Commission Regulation (EU) No 389/2013 establishing a Union Registry as amended in 2018 and 2019 or the Commission Delegated Regulation (EU) 2019/1868 amending Regulation (EU) No 1031/2010 on the auctioning of allowances for the period 2021 to 2030 might also be needed to ensure that the proper integration of these sectors in the Union Registry.

[173] Evaluation of the EU ETS Directive, Ecologic and SQ Consult, 2015

https://www.ecologic.eu/sites/files/publication/2015/2614-04-review-of-eu-ets-evaluation.pdf

[174] Greenhouse gas emissions trading and climatic change programme' COM(2000) 87, at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV:l28109

4.6.1.5 Summary of the assessment

Option 1a foresees a very comprehensive extension of the EU ETS coupled with a strong reduction of emissions regulated under the ESD (almost 75% share for the EU ETS based on 2017 inventory data). In contrast, the abatement potential that could be activated by a moderate carbon price in the two sectors seems to be lower than for the already regulated ETS sectors. At least for the next few years, it is expected that abatement costs in the already regulated ETS sectors will be below the costs of the buildings and transport sectors. This is mainly due to the fact that renewable electricity generation is already competitive with conventional electricity generation from fossil fuels in terms of cost (e.g. IRENA 2019). Under a meaningful cap setting it is therefore likely that the inclusion will particularly result in additional emission reductions in the already covered sectors and to lower reductions in the newly regulated sectors than would be the case under the ESD, due to the relatively high abatement costs of the new regulated sectors (assuming that in an ETS GHGs are reduced where it is cheapest and least where it is most expensive). At the same time, the missing coverage under the ESD of the two sectors makes it less likely that additional measures will be taken on an extensive basis to address abatement potential that is locked by other barriers.

Administrative costs are particularly affected by the point of regulation chosen. As that is not part of the initial design elements it could not be analysed in detail here. However, it is likely that administrative costs on the public sector are more strongly affected due to the fact that two sectors would be included compared to only including one additional sector (see also the assessment of Options 2a and 2b).

An extension of the EU ETS to road transport and buildings is expected to increase prices for fuels in those two sectors. Effects between countries and sectors can differ broadly.

Such an extension requires the adoption of legislative measures both, for the EU ETS as well as for the ESD.

4.6.2 Option 1b - full scope extension under existing ESD

Option 1b assumes a similar, EU-wide scope extension of the EU ETS to include both sectors' CO2 emissions. In contrast to Option 1a, a double-regulation takes place: although CO2 emissions from road transport and the buildings sector are included under the EU ETS, they remain regulated under the ESD.

4.6.2.1 Environmental criteria

Option 1b is equal to Option 1a regarding the increase in scope of the EU ETS. So, about 2,830 Mt CO2e or 74% of 2017 ETS+ESD emissions would be covered under the extended EU ETS. The main difference to Option 1a lays in the size of the ESD, which remains equal to its current size and covers 2,460 Mt CO2e or 59% of 2017 ETS+ESD emissions.

Until 2030, the EUCO3232.5 projections foresee a decrease of the ESD emissions to about 1,660 Mt CO2e. This accounts for 62% of ETS+ESD emissions, i.e. a slight increase in the ESD-covered share compared to 2017.

The fact, that road transport as well as buildings would be covered twice, under the EU ETS as well as under the ESD provides more options for MS to address different barriers to realizing abatement potential. In particular as a large part of the abatement potential identified under task 2 was found not to be price-sensitive, the double coverage would make sure that not only price-sensitive abatement potential is addressed, as would be the case under an ETS. To make sure that targets under the ESD are being met, additional measures would be needed for those two sectors (that make up the largest parts of emissions under the ESD). Those additional measures would ensure that emissions in the road transport and the buildings sector decrease significantly until 2030, which is likely not the case if the sectors were solely addressed by a price signal due to the missing price-sensitivity of abatement potential.

So, from an environmental perspective, the double regulation of the sectors with a price signal and additional measures that help to address other barriers could provide a useful policy mix despite the fact that the price-sensitive abatement potential is rather low. It should be kept in mind here, that certain abatement options were not included in the analysis in task 2 - such as modal shift and other behavioural changes in the road transport sector - that could well be affected with an adequate policy mix based on price increases for fuels and additional measures such as availability of and prices for alternative transport modes in case of road transport. Similarly, in case of the buildings sector, a strong price signal in addition to other measures such as investment support can help to make abatement options more attractive.

One effect needs to be considered, however, when planning for a policy mix including an integration into the EU ETS. The additional measures, that will be necessary to ensure that the MS meet their ESD targets, are affecting GHG emissions of the newly regulated sectors. Hence, they have an effect on the amount of emissions regulated under the EU ETS and hence the price signal in the market. Significant coordination efforts are needed to ensure in such a case that the emission reductions triggered by the additional measures are taken into account in the design of the EU ETS. Otherwise, a significant oversupply of allowances in the market is the result - as has been experienced in the EU ETS in the past - and renders the instrument ineffective/less effective than it could be. Although the market stability reserve should prevent large oversupplies in the future and help limit the amount of free allowances in the market, this aspect of coordination effort should be kept in mind. As measures to fulfil targets under the ESD - in particular the choice of which sectors to address most prominently - are mostly left to Member States, this can be a most demanding task.

4.6.2.2 Economic criteria

From an economic point of view, double regulation and policy mix is more difficult to argue for. In theory, the regulation under one price signal is - in the absence of further barriers - the most cost-effective solution. However, the analysis in task 2 has shown that the price-sensitive abatement potential in the road transport and buildings sector is limited and therefore other instruments are needed to realize abatement options.

Regarding administrative costs, the double regulation in Option 1b presents an interesting case. As far as aspects of the EU ETS are affected, the assessment for negotiation costs is similar to the one of Option 1a. However, an additional dimension needs to be taken into account, the coverage under the ESD.

Negotiation costs: At least on the side of the Commission, preparation of such a more entangled policy package is likely to be more complex than in a case without double regulation. Therefore it can be assumed that the coverage under the ESD results in additional negotiation costs. . In particular, for ensuring compliance in both systems, the existing regulations would need to be extended to allow for the use of allowances from the EU ETS to be used for compliance under the ESD and vice versa. In addition, a more regular update of the cap of the EU ETS - either negotiated or by negotiating a mechanism for adjustments of the cap - could be necessary to account for the additional measures in particular on Member State level.

One-time administrative costs: Both systems, ESD and the EU ETS already have the administrative instruments in place. The administrative systems already allow for a certain exchange of permits (exchange of permits between systems is already possible as the ESD allows for the use EUAs (indirectly, the allowances must be exchanged beforehand) and the EU ETS allows for the use of other permits such as CERs and ERUs, so also here the effort to allow in addition for the use of AEAs should be low), there is no or only a very limited effect from the additional coverage by the ESD on the one-time administrative costs.

Regularly occurring administrative costs: This is different for regularly occurring administrative costs. It is likely that in addition to the regularly reporting on emissions etc. in such a system as Option 1b describes also a regularly collection of measures on Member State level for the different sectors would be needed to account for effects on the cap.

Costs for disclosure and sanctioning: Costs for disclosure and sanctioning are likely not affected by the additional coverage under the ESD.

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning
Coverage	++	o	++	++
Connection with the EU ETS	O	--	O	o
Coverage by the ESD	++	-	++	o

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

4.6.2.3 Social criteria

The EU's Climate Laws are currently built on two main pillars: the Emission Trading Scheme (the EU ETS) and the Effort Sharing Regulation (ESR). While it seems likely that in case of including buildings and / or transport in the EU ETS, the current ESD would no longer apply for these sectors, we also investigate the case of the ESD remaining in place – which, essentially, would mean that double regulation applies for these sectors.

With regards to the sectors potential inclusion under Option 1b (thus with the existing ESD remaining in place), a recent Transport & Environment report[175] argues that the current 40% economy wide reduction target for 2030 (equivalent to 3.3 Gt CO_2eq by 2030) compared to 1990 is thus achieved with 2030 targets (compared to 2005) of 43% for the ETS and 30% for the ESR which stem from the EU legislation. Consequently, if sectors are subject to both schemes, it is expected that (at least) the higher reduction target would be aimed at in the relevant sectors, therefore, it can be assumed that option 1b always leads to target achievement.

[175] Transport & Environment (2020) Green New Deal: How European transport can contribute to an EU -55% GHG emissions target in 2030. Available at: https://www.transportenvironment.org/sites/te/files/publications/2020_02_TE_EGD_vision_How_EU_transport_can_contribute_minus_55.pdf

In aggregate, social impacts under this option would be similar to those discussed in Option 1a; a key difference being that if the ESD remains in place, it is expected that regulated entities would presumably seek to pass on the even more increased costs of compliance to the consumers to a relatively larger extent than under Option 1a. That is, if ESD remains in place for all sectors that are newly included in the EU ETS, the anticipated social impacts - as per Option 1a - are more likely to manifest.

4.6.2.4 Regulatory criteria

This option would also require the adoption of legislative measures to amend the ETS Directive 2003/87/EC for integrating the two sectors and the Effort Sharing Regulation (EU) 2018/842 in order to establish the necessary linking provisions, for example, to ensure that trading between both systems is possible (e.g. eliminating the requirement to comply with earlier years obligations under the ESR). Those measures would fall under EU competence as they amend existing environmental legislation. The analysis of the compliance with the subsidiarity and proportionality principles under EU law would need to be done based on the design details. However, as the measures would be amending existing environmental legislation and complementing the current framework for emission reduction in the road transport and buildings sectors, compliance with these principles would likely be ensured. Similar considerations comparing an EU act to similar national measures, as mentioned under option 1a above would be applicable, in particular the reasoning of the report on the evaluation of the EU ETS pointed out the benefits of an EU level system rather than coordination of national measures (including different ETS at national level) as these could act as barriers for improving the internal market for energy, and different types of regulation could lead to more fragmented and costly situation for the different sectors, with potentially different rules for participation, MRV, allocation, and most importantly, different ambition levels and thus carbon prices in different Member States.

As in Option 1a, the requirements under the ETS compliance and enforcement system should also be applicable to the road transport and buildings sectors regardless if the ESD applies. The necessary amendments to the relevant non-legislative acts would need to be adopted. The applicable rules would likely be similar to the existing ones and therefore, the consistency will be ensured. The feasibility of the compliance system would depend on the regulatory entities required to implement the ETS within those sectors.

4.6.2.5 Summary of the assessment

Option 1b is the only one of the options analysed that foresees a very strong double regulation of the two sectors under both, the EU ETS as well as the ESD. This double regulation would affect 1/3 of the 2017 ETS+ESD emissions. Although it is difficult to argue for double regulation from an economic perspective, the fact that both sectors show very limited amounts of price-sensitive abatement potential could be put forward as argument in favour of not excluding the two sectors from the ESD despite them being integrated into the EU ETS. However, this problem of non-price sensitivity could also be addressed in Option 1a by measures addressing market barriers, although this seems less likely without the pressure from the ESD. In case of double regulation, it needs to be ensured that the EU ETS cap and the measures under the ESD for the two sectors are being aligned to prevent large over-supply of allowances under the EU ETS which would render the system ineffective/lower effectiveness. Although the MSR would at least partly limit the oversupply, this double regulation could result in a significant additional administrative effort for the public sector in the initial negotiations and in particular also on a regularly occurring basis for ensuring the alignment.

While in general the assessment of social impacts is similar for all options, the double regulation in case of Option 1b makes it more likely that the anticipated social impacts manifest.

From a regulatory perspective it is particularly important in that case to establish the necessary linking provisions between the two systems (EU ETS and ESR).

4.6.3 Option 1c - scope extension for freight transport and commercial buildings

Option 1c foresees again an EU-wide scope extension, however, here emissions from road transport and buildings are limited to the commercial parts of the sectors. The passenger transport and residential buildings emissions remain part of the ESD only, while commercial emissions from road transport and buildings are no longer regulated under the ESD. This option can be seen as a first step towards the inclusion of road transport and buildings into the EU ETS and could at a later point in time be extended to include all road transport and buildings emissions into the EU ETS (Option 1a).

4.6.3.1 Environmental criteria

Compared to a full inclusion of all CO_2 emissions from road transport and buildings, the inclusion of only the commercial parts of those two sectors significantly reduces the coverage of the EU ETS. Based on 2017 GHG emissions, roughly 2,030 Mt CO_2e would be covered under this extended EU ETS compared to 2,830 in Option 1a and 1b and 1,590 Mt CO_2e in its current coverage. So, roughly 1/3 of the two sectors' emissions would be included in the EU ETS and hence face a price signal, leaving 2/3 of the two sector's emissions unregulated by a carbon price signal. Coverage of the EU ETS would under this scope increase to 53% of 2017 ETS+ESD emissions. At the same time, this means that 47% of 2017 ETS+ESD emissions are still regulated under the ESD (1,820 Mt CO_2e), leaving a significant amount of emissions' coverage under the ESD.

Looking into projected emissions from the EUCO3232.5 scenario, in this setting projected emissions under the EU ETS go down to 1,370 Mt CO_2 in 2030, while projected emissions under the ESD go down to 1,330 Mt CO_2. This corresponds to an emissions' split between EU ETS and ESD of 51% to 49%.

While no information is provided in task 2 on the abatement potential for freight transport, the analysis for commercial buildings finds even less price-sensitive abatement potential compared to the residential buildings sector (2% in the commercial buildings sector compared to 5% in the residential buildings sector compared to EUCOS3232.5 baseline). At least for the commercial buildings sector it hence does not seem likely that a limitation of the sectors' emissions to the commercial part increases the abatement potential.

4.6.3.2 Economic criteria

A similar assessment as for Option 1a applies. The detailed results for commercial and residential buildings imply that price-sensitive abatement potential in the commercial parts of the sectors may even be lower. However, it is difficult to transfer findings for the buildings sector to the road transport sector. As the transport sector is significantly larger, effects from the transport sector dominate the effects, but no separate analysis of the commercial part of the sector is provided in task 2.

Regarding administrative costs, the inclusion of only the commercial parts of the sectors does not result in any significant reductions of absolute administrative costs compared to Option 1a. In particular, as a downstream regulation does not seem to be a viable option, it means that the number of regulated entities if following the suggestions from section 3.2 would not change significantly and hence that the administrative expenses for the public sector are comparable to those under Option 1a.

In contrast, it is likely that more administrative effort is needed on the side of the regulated entities to separate fuels used for the commercial parts of the sectors and therefore being affected by the carbon price and the fuels being used in passenger transport or residential buildings, which are not being regulated under the carbon price.

As administrative costs are likely not significantly lower, maybe even higher in some areas, but at the same time the coverage of emissions is significantly lower, relative administrative costs (per additional ton of CO2 regulated) are much higher compared to Option 1a.

4.6.3.3 Social criteria

Under the option of including freight transport and commercial buildings only, it is expected that end consumers in the residential sector would experience little impact of the policy design in terms of changes in fuel price or their expenditure structure. Therefore, potential social impacts under this option are considered almost negligible compared to other options. Price increases, especially for transport-intensive goods, were not considered further here, but may have an influence.

4.6.3.4 Regulatory criteria

Similar considerations to Option 1a as the only difference is the scope of both sectors integrating the ETS. As in Option 1a the ESR would not be applicable to the freight and commercial buildings sectors as these sectors will integrate the EU ETS. However, the ESR would remain applicable to the other sub-sectors and certain regulatory coordination will be needed when adopting the necessary changes in the ETS Directive and the ESR.

4.6.3.5 Summary of the assessment

Option 1c presents a balanced split of emissions regulated under the EU ETS and the ESR, due to the fact that limiting the sectors' activities to the commercial part significantly reduces the amount of emissions newly covered under the EU ETS. Results for the buildings sector indicate, that limiting the emissions to the commercial part may further reduce the price-sensitive abatement potential. However, a generalization for the transport sector is difficult without further analysis.

An effect from the limitation of sectors to the commercial part is, that relative transaction costs will likely be significantly higher as the number of regulated entities is not likely to be significantly lower than in case of a regulation of the total sectors' emissions. Also, the analysis showed that a different point of regulation in case of regulation of only the commercial parts of the two sectors is not possible. Hence, no argument in favour of such an option can be found there.

From a social perspective, impacts for end consumers in the residential sector would be low and hence social impacts can be neglected.

From a regulatory perspective the assessment follows Option 1a.

4.6.4 Option 2a - scope extension to road transport

Option 2a models the option of an EU-wide scope extension of the EU ETS, but limited to road transport. Road transport would leave the scope of the ESD. CO_2 emissions from buildings, however, would remain to be regulated under the ESD and not become part of the EU ETS.

4.6.4.1 Environmental criteria

EU ETS emissions under Option 2a are about 2,360 Mt CO_2e based on 2017 GHG inventory data. This accounts for 62% of ETS+ESD emissions in 2017. The remaining emissions regulated under the ESD and hence not facing a carbon price are about 1,480 Mt CO_2e or 38% of total ETS+ESD emissions in 2017. Compared to today this option presents a significant relocation of emissions between EU ETS and ESD, still it does not reduce the ESD as drastically as Option 1a does.

EUCO3232.5 emission projections show a decrease of EU ETS emissions in Option 2a by 720 Mt CO_2e to 1,640 Mt CO_2e for 2030. Emissions under the ESD are projected to fall by 770 Mt CO_2e to 1050 Mt CO_2e by 2030. Share of emissions covered by the EU ETS and the ESD remains almost stable with 61% for the EU ETS to 39% for the ESD in this option.

As shown in task 2, price-sensitive abatement potential in the road transport sector is particularly small (only 31.8 Mt CO_2 for 2030 for prices up to 150€), so it is likely that the inclusion of the road transport sector into the EU ETS per se would not result in any significant reductions in that sector.

4.6.4.2 Economic criteria

As the identified price-sensitive abatement potential even at high prices is low in the road transport sector, it is very likely that an inclusion of that sector into the EU ETS under a meaningful cap-setting approach will result in a price increase under the EU ETS.

Regarding impacts on the administrative costs for the public sector, in particular negotiation costs could be affected.

Negotiation costs: In contrast to Option 1a, negotiations are likely less complex as they only include one sector. However, due to the strong lobby of the sector it can be assumed that negotiations are more complex with the road transport sector than with the buildings sector. Nevertheless, building on the existing rules of the EU ETS should make negotiations easier compared to negotiating a completely new system.

One-time administrative costs: As for the assessment of Options 1a and 1b, the fact that the system can build on the existing infrastructure of the EU ETS should lower one-time administrative cost.

Regularly occurring administrative costs: It can be assumed that the inclusion of the road transport sector only results in a lower number of regulated entities compare to the inclusion of two complete sectors. Therefore regularly occurring administrative costs should be lower compared to Option 1a, but could still be significant depending on the point of regulation chosen.

Costs for disclosure and sanctioning: The same argument goes for costs for disclosure and sanctioning.

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning
Coverage	+	o	+	+
Connection with the EU ETS	-	--	o	o

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

4.6.4.3 Social criteria

An emissions trading scheme that is covering the transport sector can in principal affect the disposable income of households in two ways.

First, it can have a direct effect on households as the price of the transport fuels purchased by the households may increase.

Second, it can have an indirect impact on households in the sense that some of the other goods that households consume could be transport-intensive and would therefore become more expensive.

With regards to the **direct impact** that the inclusion of transport in the ETS would mean for households, i.e. in form of a price increase of the transport fuel consumed by the households, the impacts would be comparable to the impact of an energy tax on transport fuels. This holds independent of whether a down-, mid- or an upstream approach is chosen.

With regards to the possible **indirect impact** of including transport in the ETS on households, i.e. the impact of the possible rise of the prices of other, transport-intensive goods, the distributional effect on households depends on the nature of these goods. Only if these goods are necessary goods (e.g. goods produced by the food & tobacco industry), a regressive effect - comparable to that of the taxation of energy carriers used for heating and electricity - can be expected.

4.6.4.4 Regulatory criteria

Similar considerations to option 1a will be applicable since the ETS is applicable to road transport and the ESR would not be applicable to this sector. The buildings sector will remain under the ESR framework.

4.6.4.5 Summary of the assessment

Option 2a presents a 60:40 split of emissions being regulated under the EU ETS and under the ESD. The particularly low price-sensitive abatement potential in the road transport sector, however, makes it questionable whether an inclusion into the EU ETS results in the required emission reductions in this sector. While additional measures are not impossible, the exclusion of the sector from the ESD increases the likelihood that new additional comprehensive measures will be put in place at national or EU level if necessary.

From a social perspective, the inclusion of road transport would have direct as well as indirect impacts on households, indirect impacts for particularly transport-intensive goods.

From a regulatory perspective the assessment follows Option 1a.

4.6.5 Option 2b - scope extension for buildings

Like Option 2a, Option 2b presents an extension of the EU ETS to only one of the two sectors, the buildings sector. Following the same logic as in Option 2a, the buildings sector is no longer regulated under the ESD when it becomes part of the EU ETS. The road transport sector, on the other hand, remains part of the ESD.

4.6.5.1 Environmental criteria

EU ETS emissions under Option 2b are about 2,060 Mt CO_2e based on 2017 GHG inventory data and 300 Mt CO_2e lower compared to Option 2a. This accounts for 54% of ETS+ESD emissions in 2017. The remaining emissions regulated under the ESD and hence not facing a carbon price are about 1,790 Mt CO_2e or 46% of total ETS+ESD emissions in 2017. Compared to today this option still presents a significant relocation of emissions between EU ETS and ESD, still it does not reduce the ESD as much as Option 2a does and particularly not as drastically as Option 1a does.

EUCO3232.5 emission projections show a decrease of EU ETS emissions in Option 2b by 730 Mt CO_2e to 1,330 Mt CO_2e for 2030. Emissions under the ESD are projected to fall by 420 Mt CO_2e to 1,370 Mt CO_2e by 2030. This results in an almost equal share of emissions covered under the EU ETS and the ESD.

As shown in task 2, although not as small as for road transport, price-sensitive abatement potential in the buildings sector is still small (only up to 9.6 Mt CO_2 for 2030 for prices up to 150€), so it is likely that the inclusion of the buildings sector into the EU ETS would not result in any significant reductions in that sector. As for other options except for Option 1b, due to the fact that the sector is being excluded from the ESD when it is included into the EU ETS, it seems unlikely that extensive additional measures are being taken by MS to reduce emissions in the buildings sector

4.6.5.2 Economic criteria

As the identified price-sensitive abatement potential even at high prices is low in the buildings sector, it is very likely that an inclusion of that sector into the EU ETS under a meaningful cap-setting approach will result in a price increase under the EU ETS.

Regarding impacts on the administrative costs for the public sector, in particular negotiation costs could be affected.

Negotiation costs: In contrast to Option 1a, negotiations are likely less complex as they only include one sector. Also, they are likely slightly lower compared to Option 2a as the lobby of the buildings sector is likely less strong than the lobby of the automotive industry.

One-time administrative costs: As for the assessment of Options 1a and 1b and 2a, the fact that the system can build on the existing infrastructure of the EU ETS should lower one-time administrative cost.

Regularly occurring administrative costs: It can be assumed that the inclusion of the buildings sector only results in a lower number of regulated entities compared to the inclusion of two complete sectors. Therefore regularly occurring administrative costs should be lower compared to Option 1a, but could still be significant depending on the point of regulation chosen. In particular, still all three types of fuel would need to be regulated as they all play a role in the buildings sector in contrast to the road transport sector, where particularly oil products and to a lower extent gas products are relevant. So, compared to the additional emissions being covered, it is likely that regularly occurring administrative costs are higher compared to Option 1a as well as compared to Option 2a.

Costs for disclosure and sanctioning: The same argument goes for costs for disclosure and sanctioning.

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning

Coverage	+	o	++	++
Connection with the EU ETS	-	--	o	o

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

4.6.5.3 Social criteria

Implementation of emissions trading will lead to an increase of the price of products and services supplied by the regulated entities and thus, is expected to lead to higher energy costs for households (see Section 4.3 Just transition). Eurostat data on consumption expenditure[176] show that energy expenditures rise with income, but as a share of disposable income, energy expenditures decline with higher incomes.

Introduction of emissions trading would add a fixed share to energy costs that is in the general setup independent from income. This means that the inclusion of buildings in the EU ETS would likely have a regressive impact on disposable income, as the ETS costs give a relatively larger share of the disposable income of low-income households than that of high-income households.

Impacts of household energy price increase on consumer expenditure are discussed schematically in more details in Section 4.3 Just transition.

Importantly, to a certain extent, the negative impacts on incomes could be compensated for by improvements in insulation, heating systems and / or a fuel shift to less carbon-intensive fuels – any of which would be a desired effect of the ETS.

4.6.5.4 Regulatory criteria

Similar considerations to Option 1a will be applicable since the building sector is integrated in the existing ETS and the existing ESR would be applicable to the transport sector but not to the buildings sectors.

4.6.5.5 Summary of the assessment

Inclusion of the buildings sector results in a lower increase of emissions under the EU ETS and results in an almost equal emission coverage for the EU ETS and the ESR. However, price-sensitive abatement potential in the buildings sector is found to be low. So it is likely, that prices under the EU ETS would increase (assuming a meaningful cap setting) and additional emission reductions would be realized in the sectors already today covered by the EU ETS (in particular electricity).

Transaction costs could be slightly lower compared to options integrating two sectors or the road transport sector as negotiations could be less complex. However, fuels of three types (solid, liquid and gaseous) would need to be regulated, so it is unlikely that the number of regulated entities would be significantly lower compared to options integrating both sectors. So, relative transaction costs are likely significantly higher compared to Option 1a as well as compared to Option 2a.

[176] Eurostat (n.d.) Structure of consumption expenditure by income quintile and COICOP consumption purpose. Available at: https://ec.europa.eu/eurostat/web/products-datasets/product?code=hbs_str_t223

Social impacts on households would be regressive as the introduction of a carbon price results in a fixed absolute price increase and hence low-income households would be more affected than high income households.

The regulatory criteria follows the assessment of Options 1a.

4.6.6 Option 3a - separate ETS for road transport and buildings

Option 3a models a separate ETS for road transport and the buildings sector in addition to the existing EU ETS with current coverage. Certain flexibility is being provided by allowing for a limited linking between the two ETS. The ESR remains in place for the road transport and the buildings sector.

4.6.6.1 Environmental criteria

Based on 2017 GHG inventory data, the newly created ETS for road transport and buildings would cover 1,240 Mt CO_2 and would hence be slightly smaller than the existing EU ETS in 2017 with 1,590 Mt CO_2e. Emission projections from the EUCO3232.5 scenario indicate a reduction in emissions in the new ETS for road transport and buildings to 890 Mt CO_2 by 2030.

Coverage of the ESD would not change, as the new ETS for road transport and buildings would be part of ESD. So the new ETS for road transport and buildings can be interpreted as one measure to reach the ESD targets. However, based on the analysis of abatement potential in task 2 it is very likely, that additional measures would be needed to significantly reduce emissions in those sectors.

The analysis of the abatement potential in task 2 also indicates that a linking of the ETS for road transport and buildings with the existing EU ETS would likely result in a flow of allowances from the EU ETS into the new system (assuming meaningful cap setting in both systems, in particular also in the new ETS for road transport and buildings). This link could help to limit prices in the new ETS, would at the same time, however, also result in an increase in prices in the current EU ETS. From an environmental perspective, the link would thus likely result in additional emission reductions in the current EU ETS sectors, while the emission reductions triggered by the carbon price in the sectors of the new ETS for road transport and buildings would likely be small. To still trigger emission reductions in the new ETS for road transport and buildings the flow of allowances from the new ETS into the existing EU ETS should thus be limited.

4.6.6.2 Economic criteria

Based on the assessment of abatement potential and related costs in the two sectors under the new ETS for road transport and buildings it is likely that prices in the new system would be higher compared to current and projected prices in the existing EU ETS assuming that a meaningful cap setting approach is taken. Hence, allowing for a certain amount of linking is reasonable to reduce the costs. These lower costs can be achieved because linking means that allowances from the ETS with lower abatement costs flow into the ETS with higher abatement costs. This means that the same GHG reductions are achieved at lower costs as without linking. With complete and unlimited linking, this leads to an alignment of prices and cost-effective avoidance. As already described under4.1.1, this can lead to undesired effects, which is why it may be useful to limit the linking. This can be done by limiting the number of allowances or by controlling the price, e.g. by making it no longer possible to use allowances from the linked ETS once the price has dropped below a certain level. In both cases, the GHG reduction in an ETS is prevented from falling below a certain level, thus ensuring that investment in new technologies continues and that these lead to lower abatement costs in the future. Thus, limited linking can lead to lower abatement costs than in a scenario without linking, but to higher abatement investments than in a scenario with unrestricted linking.

Regarding administrative costs for the public sector, the main factor is that a completely new system would need to be set up and negotiated with the Member States. However, in the setting assumed, it is very likely that nevertheless the new ETS for road transport and buildings would build on the practical experiences gained under the EU ETS (as well as with other systems).

Negotiation costs: As in other options, in Option 3a negotiations would need to take place with two sectors, one of them having a particularly strong lobby in some of the Member States. In contrast to all options analysed so far, completely new rules would need to be defined. At least from a negotiation perspective, that could make things more complicated as more design options could be discussed. As in Option 1b, it needs to be taken into account that the new ETS for road transport and buildings and in particular the cap setting must be aligned with the measures under the ESD. Here, additional regularly occurring coordination requirements are very likely, resulting in additional costs. In addition to the negotiation of the new ETS itself, also the link with the current EU ETS would need to be discusses, what would further complicate matters.

One-time administrative costs: Again, an important question for the size of the one-time administrative costs is in how far the new ETS for road transport and buildings would build upon or be integrated into the already existing infrastructure. It seems likely that infrastructure could be used to a certain extent, however, it may well be that certain adaptations would be needed, depending on the rules being negotiated for the new ETS. In addition, a linking with the current EU ETS requires that allowances can be transferred between systems, putting forward additional requirements to infrastructure. At the same time, the system would also need to be compatible with the ESD, however, as main trading activities take place under the ESD only (except for the limited linking with the current EU ETS), this is not likely to put forward further requirements.

Regularly occurring administrative costs: Regularly occurring administrative costs are likely comparable to those under Option 1a regarding the coverage and connection with the EU ETS.

Costs for disclosure and sanctioning: Costs for disclosure and sanctioning are mainly related to the coverage and depend to a large extent on how good they could be aligned with the existing rules under the current EU ETS.

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning
Coverage	++	+	+	++
Connection with the EU ETS	++	++	o	o
Coverage by the ESR	++	o	++	o

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

4.6.6.3 Social criteria

Social impacts under an option of setting up a semi-closed (separate, yet linked) ETS for road transport and buildings are much dependent on the anticipated volatility of future ETS allowance prices. In sum, if price volatility is similar to that in case of full inclusion (Option 1a), then the anticipated social impacts are mostly in line with those under Option 1a as well. As argued for by Achtnicht et al[177] (2015), an overall disadvantage of this approach would be that the abatement measures used are in this case likely to be more costly than abatement measures available in the sectors covered by the existing EU ETS, thereby implying a higher overall cost of GHG emission reduction (and presumably, a higher ETS price) than in a fully integrated system. This also implies that the anticipated social impacts would be similar to those in Option 1a, but of a higher scale.

4.6.6.4 Regulatory criteria

Under this option, new legislation similar to the legislation establishing the ETS for aviation will need to be adopted. This means amending the Directive 2003/87/EC with specific rules regulating the road and transport sector including definitions the impact on the EU cap, the regulated entities, potential references to benchmarking rules or carbon leakage if part of the design. The amendments should include provisions enabling the adoption of non-legislative acts regulating or amending existing rules on the registry and auctioning. Furthermore there should be other provisions linking the separate ETS to the exiting ETS to deal with potential trade between both systems. A reference under the provisions of the existing legislation establishing common rules for compliance (e.g. Article 16 of the ETS Directive 2003/87/EC) might be needed to ensure their applicability to both sectors without additional provisions.

New legislation on MRV to ensure the applicability of the existing compliance and enforcement ETS system to the road transport and buildings sectors under a separated system will also be required. Measures would propose amendments to the existing Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions amending Commission Regulation (EU) No 601/2012, Commission Implementing Regulation (EU) 2018/2067 on the verification of data and on the accreditation of verifiers.

Amendments to the Commission Regulation (EU) No 389/2013 establishing a Union Registry as amended in 2018 and 2019 would also be needed to ensure the proper integration these sectors in the Union Registry.

Furthermore, ensuring the auctioning of allowances for the road transport and buildings sectors as part of a separated ETS would require legislation amending Commission Delegated Regulation (EU) 2019/1868 amending Regulation (EU) No 1031/2010 on the auctioning of allowances for the period 2021 to 2030 or alternatively, a specific non-legislative act regulating auctioning for the allowances from these new sectors.

In relation to the ESR, similar considerations to option 1b will be applicable since the ESR would be applicable to the road transport and buildings sectors while part of a separated ETS. Linking provisions between the separated ETS for the road transport

[177] Achtnicht, Martin et al. (2015) Including road transport in the EU-ETS: An alternative for the future? Zentrum für Europäische Wirtschaftsforschung (ZEW), Mannheim. Available at: https://www.econstor.eu/bitstream/10419/111452/1/826581412.pdf

and buildings sectors and the ESR would be required. If the measures established for the new separated ETS are similar to the existing one, the consistency would be ensured.

4.6.6.5 Summary of the assessment

In contrast to the other options analysed so far, Option 3a would introduce a completely new ETS market for the sectors road transport and buildings. Although that limits the potential for cost efficiency (which can at least partly still be allowed by linking), it could be reasonable to separate the markets to realize emission reductions in those sectors despite a low price-sensitive abatement potential. At the same time, the double regulation under a carbon price and the ESD would allow (and likely require) additional measures (subsidies for certain technologies, bans on technologies or fuels, etc.) to be taken to reduce emissions in the new ETS sectors. That would, however, also result in additional coordination effort between measures taken under the ESD and the new ETS cap.

A result of the higher prices in the new ETS for road transport and buildings would also be seen by households as impacts would be similar to those in Option 1a, but of a higher scale.

The assessment of the regulatory criteria shows that a significant amount of amendments or new legislative pieces would be needed. For the ESD the assessment follows that of Option 1b.

4.6.7 Option 3b - separate ETS for freight transport and commercial buildings

Option 3b is similar to Option 3a, however it assumes that the new ETS only covers emissions from the commercial parts of the two sectors, freight transport and commercial buildings. As in Option 3a we assume a limited linking between the current EU ETS and the newly created ETS for freight transport and commercial buildings. Also, all emissions of the two sectors remain part of the ESR.

4.6.7.1 Environmental criteria

The main difference from an environmental perspective between Option 3a and 3b is the amount of emissions covered under the newly created ETS. In Option 3b emissions under the new ETS for freight transport and commercial buildings are significantly lower with only 440 Mt CO_2 based on 2017 inventory data. Hence, the ETS for freight transport and commercial buildings would be significantly smaller than the current EU ETS. (1,590 Mt CO_2e). According to emission projections under the EUCO3232.5 scenario, emissions in those sectors could fall to 330 Mt CO_2 in 2030.

Emissions coverage of the ESD would not change compared to today as again the introduction of the new ETS for freight transport and commercial buildings does not exclude those sectors' emissions from the ESD. That is, again the ETS for freight transport and commercial buildings could be seen as one measure to meet the targets under the ESD, allowing for additional measures to address potential locked by other barriers.

As price-sensitive abatement potential in the two sectors is low and prices in the new ETS are likely higher, it is likely that linking the new ETS for freight transport and commercial buildings with the current EU ETS would induce further reductions in the current EU ETS. As for Option 3a, limiting the flexibilities between the two systems would help ensure that certain emission reductions are realized within the new ETS for freight transport and commercial buildings.

4.6.7.2 Economic criteria

Although it is likely that linking the two ETS would result in further emission reductions in the current EU ETS, due to the difference in size of the two systems it can be assumed that the effect on prices in the current EU ETS is limited if flexibilities between the two systems are effectively limited.

For administrative costs, the assessment follows the assessment under Option 3a. In particular, it cannot be assumed that the number of entities covered under such a reduced ETS for freight transport and commercial buildings is significantly lower compared to covering all activities in those two sectors. Therefore it is unlikely that significant absolute cost reductions on the administrative side occur as a result of limiting the sectors' emissions to the commercial parts. As is the case for Option 1c, the relative amount of administrative costs can hence be assumed to be significantly higher compared to Option 3a where all emissions from the two sectors are covered.

4.6.7.3 Social criteria

With regards to the anticipated social impacts, this option is rather similar to Option 1c in the sense that with the inclusion of freight transport and commercial buildings only, it is expected that end consumers in the residential sector would experience little or in fact no impact of the policy design in terms of changes in residential user fuel price or the structure of their expenditure. Therefore, potential social impacts under this option are considered almost negligible compared to other options.

4.6.7.4 Regulatory criteria

Similar considerations to option 3a are applicable as the only change would be the scope of the sectors integrating the new separated ETS which is limited to freight and commercial buildings. The linking provisions between the current ETS and the separated ETS for the freight transport and commercial buildings and between the separated ETS and the ESR would need to be included. If the measures established for the new separated ETS are similar to the existing one, the consistency would likely be ensured.

4.6.7.5 Summary of the assessment

In general, the assessment follows that of Option 3a. However, a limitation of the separate new ETS for road transport and buildings to the commercial parts of the sectors would significantly reduce the emissions covered under the new ETS system. That particularly affects relative transaction costs, which would significantly increase, while from a social perspective, impacts on households can be neglected.

4.6.8 Option 3c - two separate new ETS, one for road transport, one for buildings

Option 3c is similar to Option 3a, but it assumes that not only one new ETS, but two new ETS are being created, one for road transport, one for the buildings sector. A linking of the two systems as well as of the two systems with the current EU ETS is to a limited extend possible. Again, emissions from both sectors remain regulated under the ESD.

4.6.8.1 Environmental criteria

In Option 3c, the emissions from road transport and buildings are split between two new ETS systems. The new ETS for road transport covers emissions in the order of 770 Mt CO_2, the new ETS for buildings covers 290 Mt CO_2 based on 2017 inventory data. So, the current EU ETS is significantly larger than the two new ETS systems and at the same time the new ETS for road transport is significantly large than the ETS for buildings.

The emission projections under the EUCO3232.5 scenario foresee a reduction of emissions from road transport by 160 Mt CO_2 to about 610 Mt CO_2 by 2030. In contrast, emissions in the buildings sector remain almost constant at 290 Mt CO_2 in the scenario.

According to the analysis in task 2, price-sensitive abatement potential is low in both sectors, even slightly lower in the road transport sector despite this being the significantly larger sector when it comes to emissions. Therefore, from an environmental perspective, it seems unlikely that the introduction of the two additional ETS systems and hence the introduction of a carbon price will trigger a large amount of emission reductions without additional measures. Those additional measures would likely still be needed and seen due to the fact that both sectors remain covered under the ESD and hence Member States need to take action to fulfil their ESD targets.

Linking, in particular with the current EU ETS would at least allow for a certain additional emission reduction in the current EU ETS. However, limiting that link would be necessary to prevent that additional emission reductions are solely realized in the current EU ETS sectors.

4.6.8.2 Economic criteria

From an economic perspective, separating the sectors reduces the potential for cost effectiveness, which can to a certain extent be replaced by providing for linking options. Due to the very limited price-sensitive abatement potential in the two new sectors, it is likely that prices in the new ETS systems will be higher than in the current EU ETS and hence, that linking would result in an increase in prices under the current EU ETS.

For administrative costs, the assessment largely follows the assessment under Option 3a. What is difficult to predict, though, is whether negotiating two separate ETS systems, one for each of the sectors, or negotiating one system for both sectors is more demanding. Introducing two separate ETS allows for a more sector-specific design of the system, negotiating one system may require more compromise. As, however, certain design elements will very likely be similar and simultaneous negotiations on both systems make that more likely, it may well be, that differences for the negotiation as well as the introduction and management of the one system compared to two systems does not differ too much.

One aspect, that needs specific attention when designing two separate ETS systems for the two sectors, is to ensure that the market is functioning well. In particular for the smaller of the two new ETS, it is unclear if a sufficient trading volume can be generated on the market. In particular, a system with a high number of very small regulated entities may present a problem for the functioning of the market as those are less likely to actively take part in trading themselves. Intermediaries are likely to bundle demand/supply from small entities to reduce trading costs, but that can significantly reduce the number of actively trading entities. Also, the point of regulation needs to be carefully chosen to ensure that market power is not a problem.

4.6.8.3 Social criteria

Alike in Option 3a, social impacts under this option are rather dependent on the anticipated volatility of ETS allowance prices to be developed under the designs. In this aspect, expected social impacts are similar to those in Option 3a. In addition, this option would mean a set of even less integrated systems, thus, it is expected that coordination costs would be the highest in this case for the systems as such, as well as for the regulated entities, which means that they would likely be more incentivized to pass on costs to consumers. This means that the anticipated social impacts, in sum, would likely be the highest under this option.

4.6.8.4 Regulatory criteria

Similar considerations to Option 3a are applicable under this option, taking into account that there would be two new sectoral separated ETS similar to the existing one for aviation. The linking provisions between the current ETS and both new separated ETS for the road transport and for commercial buildings and between each of the separated ETS enabling trading with the ESR would need to be included. If the measures established for the new separated ETS are similar to the existing one, the consistency would likely be ensured.

4.6.8.5 Summary of the assessment

Further splitting the markets as in Option 3c results in particular in a further lowering of the cost-efficiency potential. As price-sensitive abatement potential is very low, in particular in the new ETS for buildings, prices would either be really high or sufficient additional measures under the ESD would be needed to address the other existing barriers. Further problems, such as functioning of the market (active participation) or market power can be more pronounced in a smaller market and again social impacts can be higher if prices are significantly higher compared to other options.

Data sources and data processing

For this and the following sections, different data needed to be retrieved for the past as well as projections for the future. For consistency, we try to apply standardized data sources as follows:

- UNFCCC GHG inventories for the EU and its Member States for emissions for the transport and buildings sector as well as total GHG emissions (excl. LULUCF)
- EEA ETS data viewer for the EU and its Member States for information on ETS emissions
- PRIMES EUCO3232.5 scenario data for the EU and its Member States for information on emission projections

Unlike with the first two data sources, we do not use EUCO3232.5 emissions data directly. Main reason is, that the 2015 data provided in the PRIMES data sheet do not match the other data sources. This can have different reasons: sector definitions can vary, but also the starting year for calculations in PRIMES can be before 2015, so that 2015 data in the PRIMES data sheets is not a historic figure, but modelled. To prevent that those differences in emissions data are wrongly interpreted as emission reductions or increases, instead of using PRIMES emissions data, we calculate emission trends between 2015 and 2030 and apply them to historic 2015 emissions data.

Not provided in the PRIMES data sheet is also emission values for freight transport. To derive emissions data for freight transport, we use data for passenger transport activity (public road transport, private cars and motorcycles) and freight transport activity (trucks) and multiply them with vehicle efficiency for passenger transport activity (road transport) and freight transport activity (trucks). The change in the relation of the received figures (which represent a type of consumption per transport category) is used to calculate the change in the relation of passenger road transport emissions to freight road transport emissions. This relation can then be used to calculate 2030 emissions for freight and passenger road transport.

5 TASK 4: Impact on ESR, EU ETS and households

Any of the design options analysed under this project and the measures developed under each of them may have an impact on the current EU ETS and might affect the carbon price under the ETS. Depending on whether the additional (sub-) sectors included in an ETS are removed from the Effort Sharing Regulation (ESR), they will also have an impact on the ESR. Applying carbon prices to transport and heating also impacts the level of disposable income for different households.

Results from Task 3, in particular, Questions 4.1 (Design options) and 4.3 (Emissions Cap) have been used to recap and further analyse the potential consequences of the design options.

5.1 Question 4.1: Impact on the ETS and Effort Sharing Regulation

The design options defined in Table 56 in task 4.1 have implications on the EU ETS as well as - at least partly - also on the ESR.

The 2018 Effort Sharing Regulation (ESR) sets up binding annual greenhouse gas emission reductions targets by Member States from 2021 to 2030 and contributes to the EU's implementation of the Paris Agreement. The general emission reduction target for 2030 is set at -30% and the national targets range from 0% to -40% from 2005 levels depending on the Member State based on its economic capability in terms of GDP per capita.

In this sub-task, we provide a quantitative as well as qualitative analysis of impacts on the ETS and ESD. We apply the same overall GHG scenarios as used under task 4.3. Taking into consideration that a particular aim of the ESR is to set binding targets on the Member State level, this analysis focuses on the MS level in addition to figures for the EU as a whole.

5.1.1 Emission shares of EU ETS and ESR under different design options

Table 89 provides information on the share of total EU27 GHG emissions excluding LULUCF covered under the EU-ETS and the ESR, differentiated by design options, based on 2017 data and projections for 2030. As before, projections are taken from EUCO3232.5 (see task 4.1 and related data appendix for further information on the use and preparation of data from the PRIMES scenario).

For most design options, the shares add up to 100% as a sector is either covered under the EU ETS or under the ESR. Option 1b presents an exception to that as it assumes an overlap between coverage under the EU ETS and the ESR for the road transport and buildings sectors. That is, in Option 1b, the EU ETS is extended to fully include the sectors road transport and buildings, while those sectors at the same time remain part of the ESR and hence the ESR target and compliance system remains in place for those sectors. For options 3a-3c, again, a double-coverage exists between the ESR and the newly introduced ETS systems. However, this is independent of the coverage under the current EU ETS and hence does not show in the figures provided below.

The extension of the EU ETS can lead to an increase of emissions coverage (Options 1a-2b) from roughly 40% today to up to 74% if both sectors were completely integrated into the existing EU ETS. No effect on the coverage of the EU ETS can be found for Options 3, where a separate "new ETS" is being designed for road transport and buildings respectively the commercial parts of both sectors. Here, the scenario design assumes that this "new ETS" remains part of the ESR.

Under the projections in the EUCO3232.5 scenario, the share of the EU ETS slightly decreases until 2030 for all design options, with the share of the ESR in return becoming slightly larger compared to today. This shows that independent of which parts of the sectors road transport and buildings are being integrated into the EU ETS reduction potential in the remaining ESR sectors is seen as low in the EUCO3232.5 scenario.

Table 89. EU ETS and ESR share for different design options based on 2017 GHG emissions and projections for 2030

	2017		2030	
	EU ETS	ESR	EU ETS	ESR
Option 0	41%	59%	38%	62%
Option 1a	74%	26%	72%	28%
Option 1b	74%	59%	72%	62%
Option 1c	53%	47%	51%	49%
Option 2a	62%	38%	61%	39%
Option 2b	54%	46%	49%	51%
Option 3a	41%	59%	38%	62%
Option 3b	41%	59%	38%	62%
Option 3c	41%	59%	38%	62%

Source: Fraunhofer ISI calculations based on GHG inventory data and EUCO3232.5 scenario data

As Table 90 shows, under current EU ETS coverage the share of EU ETS emissions and ESR emissions differs widely between Member States and are between 15% and 70% for the EU ETS sectors. Reasons for EU ETS shares lower than the EU average can be found in low emissions from the electricity sector (e.g. in the case of France) or particularly high emissions in one of the ESR sectors, e.g. the transport sector in case of Luxembourg. Particularly high shares of EU ETS emissions can be found for countries like Germany, Poland or the Netherlands with high emissions from the electricity sector, but also with a strong industry sector.

Significantly extending the coverage of the EU ETS as under Options 1a and 1b increases the EU ETS share in all countries and at the same time decreases the spread of EU ETS coverage between Member States. EU ETS emissions are between 59 and 86% in those two design options. Countries, for which a particular increase in EU ETS emissions can be found for these two options are Luxembourg with an increase from 15 to 86%, Latvia (increase from 18 to 59%) and France (increase from 24 to 70%), While in Option 1a, the spread for ESR emissions also decreases accordingly, this is not the case for Option 1b for which according to the design the ESR coverage remains the same as today.

The Options 1c, 2a and 2b with a lower extension of the EU ETS compared to the Options 1a and 1b also show less pronounced effects on the EU ETS share in emissions. While in all countries the share increases in all three scenarios compared to today, the increase is limited in many of the Member States. That is particularly true for Option 1c where the extension is limited to the commercial parts of both sectors. Higher effects can in most cases be found for those countries, where the current EU ETS share is below the EU average as in those countries the new sectors are relatively more emission intensive.

According to the design chosen, no change occurs for the Options 3a, 3b and 3c. In addition, Table 90 provides information on the share of the new ETS emissions in total

ESR emissions on Member State level. It shows that the coverage can be rather small in some Member States, in particular for Option 3b, where only the commercial parts of the sectors are being covered under the new ETS system and also for the individual sectors in Option 3c. In contrast, in Option 3a for most Member States the new ETS would cover at least 50% of the ESR covered emissions in 2017.

An analysis of country groups makes these differences between countries disappear almost completely (see Figure 94). While under the current setting (Option 0) the group of Member States with a GDP/cap lower than 60% of the EU average have a slightly higher share of ETS emissions in the total of ETS+ESR emissions, they are slightly lower in Options 1a and 1b and slightly higher for Options 1c (and 3a-c, which have the same share as Option 0). The other two groups are in line with the figures for the EU average in all scenarios (differences are around 1 percentage point).

Figure 94. ETS share in ETS+ESR emissions 2017 by MS groups

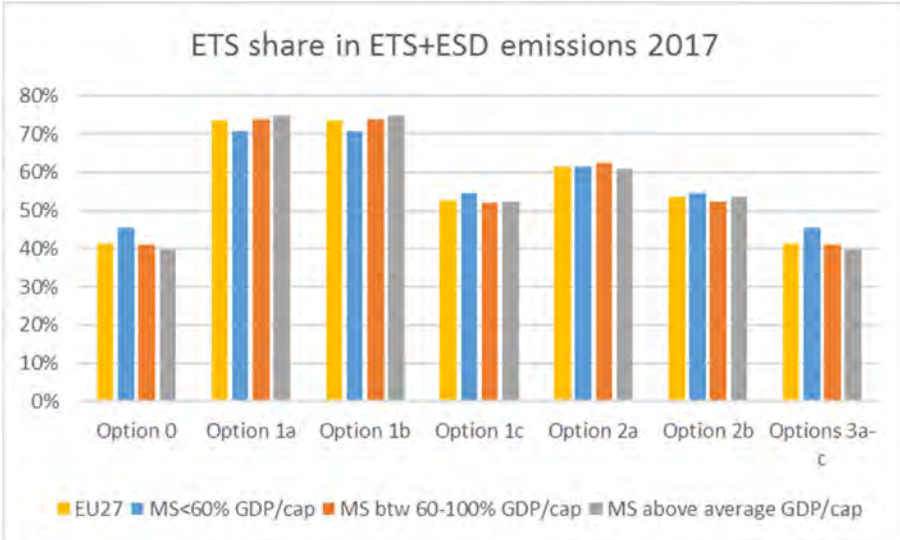

ETS share in ETS+ESD emissions 2017
80%
70%
60%
50%
40%
30%
20%
10%
0%
Option 0
Option 1a
Option 1b
Option 1c
Option 2a
Option 2b
Options 3a-c
EU27
MS<60% GDP/cap
MS btw 60-100% GDP/cap
MS above average GDP/cap

Table 90. Share of EU ETS and ESR [EU ETS/ESR%] emissions in Member States based on 2017 GHG emissions

	AT	BE	BG	HR	CY	CZ	DK	EE	FI
Option 0	37/63	38/62	57/43	33/67	52/48	52/48	31/69	70/30	46/54
Option 1a	**75/25**	**78/22**	**73/27**	**68/32**	**81/19**	**75/25**	**62/38**	**83/17**	**69/31**
Option 1b	75/63	78/62	73/43	68/67	81/48	75/48	62/69	83/30	69/54
Option 1c	**49/51**	**52/48**	**63/37**	**44/56**	**59/41**	**59/41**	**44/56**	**74/26**	**47/53**
Option 2a	65/35	60/40	71/29	59/41	75/25	66/34	57/43	81/19	65/35
Option 2b	**47/53**	**56/44**	**59/41**	**42/58**	**57/43**	**61/39**	**37/63**	**72/28**	**50/50**
Option 3a	37/63	38/62	57/43	33/67	52/48	52/48	31/69	70/30	46/54
Option 3b	**37/63**	**38/62**	**57/43**	**33/67**	**52/48**	**52/48**	**31/69**	**70/30**	**46/54**
Option 3c	37/63	38/62	57/43	33/67	52/48	52/48	31/69	70/30	46/54

	FR	DE	GR	HU	IE	IT	LV	LT	LU
Option 0	23/73	48/52	52/48	32/68	28/72	37/63	18/82	31/69	15/85
Option 1a	**67/33**	**80/20**	**73/27**	**70/30**	**59/41**	**75/25**	**53/47**	**63/37**	**86/14**
Option 1b	67/73	80/52	73/48	70/68	59/72	75/63	53/82	63/69	86/85
Option 1c	**41/59**	**59/41**	**60/40**	**46/54**	**38/62**	**48/52**	**33/67**	**43/57**	**53/47**
Option 2a	51/49	66/34	67/33	52/48	47/53	58/42	46/54	57/43	69/31
Option 2b	**40/60**	**63/37**	**58/42**	**50/50**	**40/60**	**53/47**	**26/74**	**36/64**	**31/69**
Option 3a	23/77	48/52	52/48	32/68	28/72	37/63	18/82	31/69	15/85
Option 3b	**23/77**	**48/52**	**52/48**	**32/68**	**28/72**	**37/63**	**18/82**	**31/69**	**15/85**
Option 3c	23/77	48/52	52/48	32/68	28/72	37/63	18/82	31/69	15/85

	MT	NL	PL	PT	RO	SK	SI	ES	SE
Option 0	34/66	47/53	49/51	43/57	35/65	51/49	38/62	40/60	38/62
Option 1a	**69/31**	**75/25**	**74/26**	**70/30**	**57/43**	**78/22**	**75/25**	**73/27**	**70/30**
Option 1b	69/66	75/53	74/51	70/57	57/65	78/49	75/62	73/60	70/62
Option 1c	**50/50**	**57/43**	**57/43**	**53/47**	**44/56**	**62/38**	**51/49**	**52/48**	**49/51**
Option 2a	60/40	62/38	64/36	66/34	50/50	67/33	69/31	65/35	67/33
Option 2b	**43/57**	**60/40**	**59/41**	**47/53**	**43/57**	**62/38**	**44/56**	**49/51**	**40/60**
Option 3a	34/66	47/53	49/51	43/57	35/65	51/49	38/62	40/60	38/62
Option 3b	**34/66**	**47/53**	**49/51**	**43/57**	**35/65**	**51/49**	**38/62**	**40/60**	**38/62**
Option 3c	34/66	47/53	49/51	43/57	35/65	51/49	38/62	40/60	38/62

Source: Fraunhofer ISI calculations

Table 91. Share of new ETS/ ETSs in ESR emissions [road transport/buildings%] emissions in Member States based on 2017 GHG emissions

	AT	BE	BG	HR	CY	CZ	DK	EE	FI
Option 3a	61	64	38	51	59	48	45	42	43
Option 3b	**19**	**22**	**13**	**16**	**15**	**15**	**19**	**14**	**3**
Option 3c	45/16	35/29	33/4	38/13	49/11	29/19	37/8	37/4	36/7

	FR	DE	GR	HU	IE	IT	LV	LT	LU
Option 3a	57	62	44	55	43	60	43	46	83

Option 3b	**23**	**21**	**16**	**21**	**14**	**19**	**19**	**18**	**45**
Option 3c	36/21	34/28	32/12	29/26	26/17	34/26	33/9	39/8	64/19

	MT	**NL**	**PL**	**PT**	**RO**	**SK**	**SI**	**ES**	**SE**
Option 3a	53	53	49	47	34	56	60	54	51
Option 3b	**25**	**19**	**17**	**18**	**14**	**23**	**22**	**20**	**17**
Option 3c	39/14	29/24	29/20	40/7	23/12	34/22	50/10	41/14	47/4

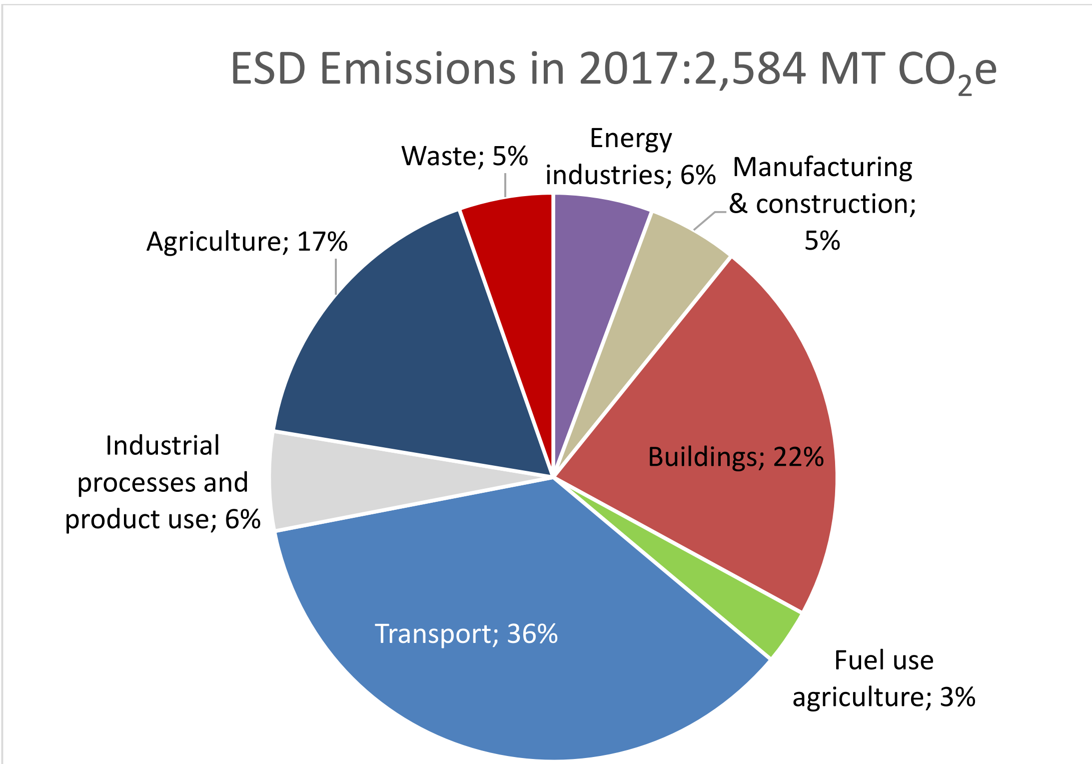
Source: Fraunhofer ISI calculations

5.1.2 Functioning of a reduced ESR (in particular Option 1a)

In some of the options analysed (Option 1a, 1c, 2a and 2b), the coverage of the ESR is reduced as the sectors included in the EU ETS are no longer part of the ESR. In particular for Option 1a this results in a significant reduction of the emissions, but also of the heterogeneity of the sectors covered under the ESR. Hence, countries lose a certain amount of flexibility (choosing which abatement measures to implement in which sectors) on where to reduce emissions in particular in the time frame up to 2030 (afterwards, the increase in ambition needed to reach net-zero emissions by 2050 would require significant efforts in all sectors covered under the ESR as well as under the EU ETS).

Currently, the main sectors covered under the ESR - apart from the sectors road transport and buildings - are: agriculture, waste and energy use and product use in small industry. The amounts of emissions in the different sectors vary significantly (see Figure 95).

Figure 95. ESR emissions by sector in 2017



Source: Fraunhofer ISI representation based on EEA Trends and Projections Report 2019

A complete exclusion of the sectors road transport and buildings as under Option 1a would result in a significantly different mix of emissions under the ESR with about 44% coming from energy and product use in smaller sectors and manufacturing and construction and the other 56% coming from mainly agriculture as well as partly from waste. This difference in emission source mix has implications for the availability, but also for the acceptance of abatement options by policy makers as well as consumers.

In particular, a high reduction of emissions in the agriculture sector seems difficult. The trend between 1990 and 2017 shows a reduction in emissions of 19% in this sector. In particular since 2000, emissions have been almost constant with a reduction of roughly 5% between 2000 and 2017. Although studies such as Fellmann 2016 show that abatement potential exists in this sector, the integration of carbon reduction measures in the agriculture sector was so far very limited in the existing EUCO scenarios (no policy incentive to reduce emissions in the agriculture sector in the EUCO30 scenario, which is also the basis for the EUCO3232.5 scenario for agriculture emissions). In addition, the reference scenario 2016 projects nearly constant non-CO2 emissions in the agriculture sector (a reduction of 1.6% below 2005 levels by 2030 for the EU 27). One great concern when it comes to asking for emission reductions from the agriculture sector is, that those reductions are realized by a reduction in activity and not by technical means.

Emissions from waste have decreased significantly between 1990 and 2017 with a 42% reduction between 1990 and 2017. According to the 2019 European GHG inventory report, main emission reductions in that sector have come from a reduction in landfilling. According to the report, countries with large emissions in that sector have decreased emissions by more than 70% in that sector already and most technical abatement options are already implemented in those countries. Accordingly, the trend of emission reductions in that sector is slowing down. So, realizing further emission reductions in the waste sector requires countries with smaller emissions from landfills to take action (this requires more action by more Member State with a lower impact on overall emissions) or turning to other sources of emissions, which also are much smaller than emissions from landfills.

Fugitive emissions from fuels (part of the energy industries) can be expected to being reduced when fossil fuel use is reduced. The larger part of fugitive emissions is coming from oil and natural gas use. Examples like Norway show that a significant reduction of those fugitive emissions is possible. However, a mix of stringent policies including a CO_2 price (of approximately 50€/t CO_2) along with a general prohibition of emitting gas or other substances into the air are important parts of the policy mix applied in Norway to reach those low fugitive emission levels (see Healy et al. 2016). As the policies were put into place from the beginning of extraction, it is the question in how far they can be effectively introduced later on when extraction has already started.

In total, it is unclear how high the contributions to reducing emissions from those sectors will be until 2030.

The remaining emissions under the ESR are coming from the burning of fossil fuels and product use in small industries. While main parts of the energy use are a result of heat production, the heterogeneity of the firms and companies is large and finding targeted policies and measures in the Member States may be difficult. A less targeted approach would be the introduction of a CO_2 price (in form of a tax or a cap and trade system) for those sectors similar to the approach taken in Germany. However, prices would need to be rather high from the beginning to provide the necessary incentives for investment. And even then it is likely that investment cycles and remaining service life of existing equipment prevents a fast conversion from old heating systems to low-CO_2 ones.

In summary, it can be assumed that a strong reduction of emissions coverage under the ESR as implied under Option 1a would result in difficulties for finding sufficient emission reduction measures in particular in the time frame until 2030 for the remaining sectors at least if the existing target split are to be continued. This problem becomes more eminent if an increase in the ambition of the overall GHG target for the EU is being agreed and results in an increase in targets under the ESR compared to the 30% reduction target for 2030 implemented so far. A redefinition of the targets between ESR and ETS might be necessary under an option like Option 1a.

For other options, the effects are significantly less pronounced as either one of the two sectors remains part of the ESR or as a large part of the two sectors' emissions remains part of the ESR. In all those cases, the functioning of the ESR compared to today should not be significantly affected.

5.1.3 Double coverage under EU ETS and ESR (Option 1b)

Option 1b opens up the question of the role of the ESR and what reasons there are for integrating the two sectors into the EU ETS and at the same time leaving the coverage of the ESR unchanged. We want to discuss two aspects in this context: compliance under the ESR on the one hand and target fulfilment under the ESR on the other hand.

In its current design, the ESR sets annual binding reduction targets for the non-ETS sectors on a Member State level. To measure compliance with those targets, the ESR, similar to the compliance system under the Kyoto Protocol, allocates emission allocations (called "Annual Emission Allocations", AEAs) to Member States based on the defined targets. Once emissions under the ESR have been reported by the Member States and reviewed by experts and final emission figures have been published by the Commission, Member States have to hand in AEAs equivalent to the MS's emissions in the ESR sectors in that year. To a certain amount, the ESR allows for flexibilities to be used to fulfil the obligation under the ESR. These flexibilities include:

- flexibilities between Member States: sale of unused AEAs and of up to 5% of a given future year to other Member States as long as a Member State is in compliance
- temporal flexibilities:
  - limited banking of unused AEAs for compliance in later years. Banking is limited to 10% for the years 2021-25 and to 5% for the years 2026-30
  - limited borrowing of up to 5% of AEAs for compliance in the previous year
- flexibilities between the ESR and the EU ETS: use of the equivalent in AEAs of a limited amount of EUAs that would normally have been auctioned by eligible Member States for compliance under the ESR. The overall amount is limited to 100 mt AEAs over the period 2021-30. According to Annex II, 9 countries are eligible and use is limited to 2-4% of 2005 ESR-sector emissions.
- flexibility to use credits from the land use sector: use of up to 280 m credits from the land use sector for compliance under the ESR over the period 2021-30.

Under Option 1b, which foresees that the two sectors under consideration remain in the ESR and are simultaneously regulated in the EU ETS, the following compliance option remains for the Member State. The Member State receives a quantity of AEAs according to its ESR targets and EUAs for free allocation and auctioning under the ETS. The quantity of AEAs is not affected for the Member State due to the switch to Option 1b, but a larger quantity of EUAs will be generated due to the inclusion of the two sectors under the EU ETS. If it now turns out that the ESR targets are not met because the reduction in the two sectors under consideration is now too small, the Member State can withhold the additional EUAs for these sectors and exchange them into AEAs so that compliance under the ESR is achieved. However, this is only possible under the restrictions described above.[178]

[178] Under the EU ETS allowances are not handed in to the local authorities in Member States, but compliance takes place at the EU level. In case of a double regulation as envisaged in Option 1b the process of handing in permits under the different instruments would need to be adjusted. If handing in of permits under the EU ETS remains under EU control, EU Commission could calculate the share of a MS's ESR emissions for which permits have already been handed in. Under the EU ETS the Member State would then only need to hand in allocations for its remaining ESD emissions.

Based on current rules, however, the mix of permits may not be sufficient under the ESR regulation which limits the use of certain permits. In particular the use of EUAs from the EU ETS could be too high if the newly regulated entities buy allowances from other EU ETS participants instead of reducing emissions. Here, but also with regards to temporal flexibilities, the ESR would need to be adapted to take into account the new situation with part of the ESR sectors being part of the EU ETS to make sure that countries can use the flexibilities from an extended EU ETS for compliance under the ESR.

Trickier, however, is the question of target fulfilment. The main idea of an ETS is to allow free trade of allowances between regulated entities to reduce emissions at lowest possible costs. To identify whether a country would still be able to fulfil its ESR targets if the sectors road transport and buildings were in addition being covered by the EU ETS it is hence necessary to find out which sectors would need to buy significant amounts of allowances in the market and which sectors would be able to reduce emissions. In general, this could also differ between Member States (in particular as sectors differ significantly between countries as can be seen in Table 90), however, for the sake of this analysis we will stick to a generalized view on the EU27.

The EUCO3232.5 scenario indicates that an implementation of a 32% target for renewable energies and a 32.5% target for energy efficiency for 2030 would result in emission reductions in the order of 58%-59% for buildings and 24% for road transport below 2005 levels. In comparison, emission reductions for power generation/district heating amount to 60% and for industry to 47% below 2005 levels (for energy-related CO_2 emissions only). So, the scenario identifies significantly higher emission reductions for the buildings sector than for the road transport sector and higher emission reductions in the energy sector than in the industry sector under the EU ETS.

It is possible to imagine two scenarios when the EU ETS is being extended to road transport and buildings regarding the implementation of other measures in these sectors. Either Member States stick to implement strong measures to reach the EU-wide existing energy efficiency and renewable energy target as well as their ESR target and the introduction of the carbon price via an extended EU ETS is completely additional to those measures. On the other hand, in the absence of additional measures in the current EU ETS sectors, it is likely that Member States would fulfil their targets under the ESR. Assuming that the measures implemented in the first place under the ESR are sufficient to fulfil the MS targets, they could even consider slightly less ambitious measures in other sectors covered by the ESR without having to fear that they would not fulfil their targets

The main question in that case is, whether the effort to extend the EU ETS to road transport and buildings and in particular the additional coordination need for defining a cap for the extended EU ETS in light of several different other sector policies which are partly implemented on the Member State level can be justified. Implementation of an additional carbon price signal in those two sectors would also be realized under Options 3a and 3c. At the same time, it seems that cap setting under Options 3a and 3c, while still being highly complex and depended on the measures taken in the Member States, could be easier or would at least not affect the current EU ETS sectors strongly in case of mismatches between the cap and the additional measures taken. In favour of an extended EU ETS as proposed in Option 1b is the higher overall amount of emissions covered by the system and hence the smaller vulnerability of the cap with regards to Member State policies in the road transport and buildings sector. Furthermore, lower abatement costs and administrative costs are also very likely.

More likely, though, is the case, that Member States will in light of an extension of the EU ETS to sectors that are also covered under the ESR not implement the same measures (subsidies, bans, support measures etc.) in the road transport and the buildings sector than they would if there was no extension of the EU ETS to those sectors. Main reason for that assumption is that policy makers in Member States expect a certain amount of emission reductions being realized in reaction to the implementation of the carbon price. In that case, it is a question of the price-sensitive abatement potential in the newly integrated sectors, the other measures being implemented in the Member States to reduce emissions in those two sectors and their effect on emissions as well as the measures being implemented under the ESR for the other sectors whether Member States still fulfil their targets under the ESR or not.

For countries to still fulfil their ESR targets, the remaining measures for road transport and buildings in combination with the price signal from the EU ETS would need to bring at least as high a reduction as the measures that would have been implemented in the absence of the implementation of the price signal via the EU ETS as long as no additional measures are being taken in the other ESR sectors not affected by the double coverage. Otherwise it is likely that Member States will no longer be able to meet their targets. If a large difference occurs between actual emissions and targets on a Member State level for many/most of the Member States, it needs to be questioned why the ESR targets remain in place for the road transport and the buildings sector as they lose meaning for realizing emission reductions on the country level. In that case Option 1a could present a preferable way to implement such a system despite the problems that may arise for the emissions remaining covered under the ESR (see section 5.1.2 for a discussion of that aspect).

5.1.4 Emission reductions under an extended EU ETS

Compared to other abatement options, an extension of the EU ETS allows for flexibility with regards to who is reducing emissions. In our particular case and as we can assume that most entities - except for the industry sectors - will not receive large amounts of allowances for free this raises the question who would reduce emissions by how much in case of an extension, in particular for the newly covered sectors and their role compared to the current EU ETS sectors. This question can be addressed from different angles. From an economic perspective differences in abatement costs play the main role in determining the amount of emission reductions being incentivized by a price signal. But also other factors may determine whether a regulated entity is able to reduce emissions or needs to buy significant amounts of allowances. In our particular setting of combining up- and downstream entities in one market[179], we want to address two additional characteristics that determine the position of an entity in the market:

- size of the entity (i.e. relevant emission volume) and role of the CO_2 price compared to other production costs and
- potential for emission reductions and cost-pass-through.

5.1.4.1 Abatement costs

Emission projections in the EUCO3232.5 scenario show significant differences in the abatement rates of the different sectors. For current EU ETS sectors, emissions from electricity generation/district heating are being reduced by 60% by 2030 compared to 2005 levels, while emissions in the industry sector (energy related only) are being reduced by roughly 50% in the scenario. Compared to that, emissions in the road transport sector are only being reduced by 24%, while emissions in the buildings sector are also reduced by nearly 60% by 2030 compared to 2005 levels. Those

[179] According to section 0, a downstream regulation of the sectors road transport and buildings is not advisable, even if the emissions being covered would be limited to the commercial parts of those sectors.

figures imply that relative emission reductions from electricity generation/district heating are likely higher than those from the industry sector as long as no additional measures are being taken that incentives abatement measures in industry. For the potentially new sectors road transport and buildings it is more difficult to compare the abatement potential and related costs in those sectors with those sectors covered under the EU ETS as here the scenario is based on other measures than the implementation of a carbon price. So it is in particular not clear whether the implementation of a carbon price could replace those measures sufficiently. Based on the results in task 2, however, it does not seem very likely due to the existence of several other barriers to implementation in those sectors.

On the other hand, the analysis in task 2 also shows that the price-sensitive abatement potential in addition to the reductions already implemented in the EUCO3232.5 scenario in those sectors is limited for prices up to 150 €/t CO_2 (10% respectively 8% compared to 2005 levels for road transport and buildings). From that it seems likely that in a joint system, in particular the road transport sector would still require significant amounts of allowances, while it is likely that the electricity generation/district heating sector will be able to significantly reduce its emissions.

5.1.4.2 Size of the entity and role of the CO_2 price compared to other production costs

The size of the entity and the role of the CO_2 price compared to other production costs are closely linked to the question of who the defined point of regulation is. Different characteristics influence the behaviour of the entity. A regulated entity high up in the supply chain is likely to cover a significant volume of emissions. Entities with higher emission volumes are more likely to actively participate in the emissions trading market as monetary relevance - at least in absolute terms - is higher. For the same reason, they can also be expected to be more likely to take measures to reduce emissions, if this presents a profitable option. This is, among others, linked to the availability of resources for dealing with the topic as such.

Another factor, that determines the activity of an entity in dealing with emissions trading or not, is the relevance of the CO_2 price compared to the costs of other production factors and hence the impact on product prices. In case of an upstream oriented system, it is mainly the price of the energy carrier and the impact of the CO_2 price on that energy price. For small mark-ups it is less likely that an entity becomes actively involved in emission reduction measures and more likely that the entity will try to comply with the system simply by buying allowances on the market if necessary. In contrast, for large mark-ups, a regulated entity will try to reduce costs as much as possible by actively engaging either in trading or in taking abatement options or both.

Lastly, a regulated entity with experience in trading at exchanges is more likely to become actively involved in trading and use it as a financial instrument and not simply trade (in particular buy) for compliance reasons. Again, a more active position in the market makes it more reasonable to assume that an entity will try to actively reduce emissions as awareness of the topic within the firm is likely higher.

In summary, a larger entity higher up in the supply chain, preferably with experience in (exchange) trading and with high mark-ups is more likely to become actively involved in an emissions trading market, including active trading in the market but also in initializing activities to reduce emissions. In relation with the design options and compared to entities currently regulated under the EU ETS, the following conclusions can be drawn:

- To enhance chances for an active involvement of entities in the market and in initializing abatement options, larger entities higher up in the supply chain should be regulated. Regarding the defined design options, this is in favour of those options that result in a larger share of emissions being covered instead of a smaller one (i.e. Options 1a, 1b, 2a and 2b to a certain extent). Option 1c, where emissions are reduced to commercial activities from this perspective is likely to have a lower positive impact on the emissions market.

- For Options 3a and 3b, this is not directly relevant, as no unlimited and direct participation of the entities regulated under the "new ETS" with the EU ETS is foreseen.
- For Options 3a, 3b and in particular 3c, instead, the number of entities is more relevant as the "new ETS" market is per se smaller. Under those three options, increasing the number of regulated entities might be preferable to prevent market power. However, it still needs to be ensured that entities have a significant size to make sure that they actively participate in the system. Otherwise, the ETS comes very close to a tax put on the entities and the idea of emissions trading is being lost. While that would not present a problem for the system per se, it could be argued that the implementation of a carbon tax would in that case be easier[180].

5.1.4.3 Potential for emission reductions and cost-pass-through

The fact that road transport and buildings would be integrated via an upstream approach has another implication on the ability and willingness of entities to engage in emission reduction measures. Abatement measures have to take place downstream, i.e. with the consumer of the energy carrier, while the regulated entity is further up the supply chain. Hence, for the regulated entity to realize emission reductions they have to incentivise abatement measures further down the supply chain. An example where something like that can work are white certificates.

White certificate or energy efficiency obligation schemes (EEOS) are used in a number of countries to promote energy efficiency measures. Since the introduction of the 2012 Energy Efficiency Directive, 15 countries in the EU now have EEOS in place. Experience from countries where those systems have been in operation for longer time periods already show, that they can be successful in helping to reduce energy demand, but that the success of such a scheme strongly depends on the details of policy design, implementation, governance and market structure and conditions (see e.g. Fawcett, Rosenow and Bertoldi (2019)). Systems that are particularly successful can be found in France, Italy and Denmark.

Despite similarities, there is one characteristic that is particularly differing between EEOS and the need for mid- or upstream regulated entities to reduce their emissions under an emissions trading system. EEOS normally allow the regulated entity to generate certified energy efficiency savings everywhere, i.e. in particular inside but also outside their existing customer base. That is, an entity can decide not to promote efficiency measures within its existing customer base, but to use the investment into efficiency measures to win new customers. That way, the regulated entity does not necessarily reduce the amount of energy it can sell, but may even be able to increase it by winning new customers. That is, competition between energy providers can increase. In case of a regulation under an emissions trading system, however, the regulated entity to profit from its investment into abatement measures needs to implement those measures within its own existing customer base. That is, in this case there is a need for the regulated entity to reduce the carbon content of its sales to lower its obligations under the emissions trading scheme. There are two ways of

[180] That may not be true for the political difficulties that may arise in agreeing a carbon tax on the EU level instead of introducing an ETS

reducing the carbon content: continuation of selling the same product with the same carbon content, but reducing the total amount. In the first place, this seems not to be in the interest of the company as it would reduce sales and - with unchanged prices - profits. Despite that, it could still be argued that it can be profitable for the regulated entity to do so, e.g. to enhance customer loyalty. The other option to reduce the carbon content of sales is to offer substitute products with a lower carbon content, e.g. synthetic gas or oil products produced with CO_2-neutral carbon, hydrogen (produced with renewable electricity) or bio-based oil products. This way a regulated entity would avoid cutting on its sales. The main point for the regulated entity in that case is to find a market for those - in many cases likely much more expensive - substitute products. The carbon price could help to lower the price difference, however, in particular in cases like synthetic energy carriers based on CO_2-neutral carbon the price difference between the fossil fuel and the synthetic CO_2-neutral substitute can be expected to be really high, in particular at the beginning.

Simple cost-pass-through would be the easiest way for regulated entities to try to incentivize abatement measures further downstream. However, the possibilities for cost-pass-through vary (see Hermann 2014). Even if costs are passed through (almost) completely, in particular the long-term reaction to higher energy prices varies significantly as the analysis of price elasticities in task 2 has shown. Hence, and from the experience with the EEOS it seems reasonable to assume that regulated entities will need to actively engage with their customers to realize meaningful abatement measures. From this it can be assumed that if the regulated entity already has experience from active customer engagement, e.g. from the use of an EEOS, it is more likely that it will also become active in reducing emissions and not simply trade at the market for compliance. As regulated entities under the EEOS differ, no clear recommendation can be made regarding the point of regulation under an ETS from this. In some EEOS energy providers (e.g. in many US systems) have to become active in reducing energy as the markets are strongly limited to few actors. In other systems, markets are larger, allowing the regulated entities to fulfil their obligations simply by trading white certificates while other actors (e.g. energy service providers) become active to engage end-users in energy reduction activities. Also, whether a higher number of customers or a smaller number of customer makes it more attractive for a regulated entity to engage in abatement activities with their costumers is difficult to predict. A smaller number of customers can imply a stronger customer relation and could help in promoting measures. However, it is very likely that more individual approaches would be looked into. A larger number of customers, on the other hand, while it implies more anonymity, also allows for using standardized approaches for reaching out to customers. This could make it easier to implement measures with a larger customer base.

5.1.5 Calculation of GHG emissions under an extended EU ETS and implications for calculation of emissions under the ESR

The EU ETS provides two different methodologies for determining the emissions to be reported annually by regulated entities: a calculation-based approach mainly based on the use of fossil fuels and a measurement-based approach. In case of an upstream integration of the road transport and/or the buildings sector, measurement of emissions does not present an option as emissions are emitted not by the regulated entity but further downstream and the number of emitters is significant. So it is clear that, independent of whether one or both sectors or only parts of the sectors are being integrated, emissions would need to be calculated.

To reduce complexity and ensure equal and fair conditions for all regulated entities under the EU ETS, current regulation on the monitoring and reporting of greenhouse gas emissions under the EU ETS could be applied also in case of the upstream regulated sectors. To be as far as possible compatible with the reporting under the

UNFCCC annual inventories (national annual inventories (NIR) and related common reporting format (CRF) tables) and the ESR reporting, the approach chosen should also be as close as possible to those calculation methods. This is particularly relevant as emissions under the ESR are determined based on the difference between NIR emissions and EU ETS emissions (and minor corrections for NF3 emissions). This general calculation that NIR emissions minus EU ETS emissions result in ESR emissions could also be applied under the different design options. However, some difficulties arise, which are discussed in the following.

NIR reporting is based on activity data and emission factors. According to the 2006 IPCC guidelines for National Greenhouse Gas Inventories, consumption data for fossil fuels is reported in common energy units (i.e. TJ). However, the detailed CRF tables for Member States also include information on the physical units of fossil fuels used. So, it would be easiest if upstream regulated entities are required to report physical units along with common energy units and emissions. To determine common energy units from the physical units, similar conversion factors should be applied under the EU ETS and the NIR. However, a difficulty arises from the fact that conversion factors used under national inventory reporting vary between Member States, while conversion factors cited in the monitoring regulation under the EU ETS uses the standard conversion factors. It is very likely that under the EU ETS entities from different Member States have to apply the same conversion factor (applying the conversion factors in the monitoring regulation). Allowing for differences in conversion factors based on Member States could be difficult due to the fact that regulations need to be equal for regulated entities. An approach to allow for differences in conversion factors would be to allow for an analytical determination of the conversion factor (as is already possible for emission factors). Hence, discrepancies can arise from this difference in conversion factors which would need to be taken into account when calculating ESR emissions as a residual between NIR emissions and EU ETS emissions.

Another source for inconsistencies could be differences in collecting activity data under the EU ETS and for NIR (bottom-up under the EU ETS vs. top-down as done for the NIR). Where whole sectors are integrated into the EU ETS, it should be possible to compare activity data. As far as possible, discrepancies should be eliminated. Where that is no longer possible, it needs to be decided whether the remaining difference in emissions (assuming it is positive) should be part of the ESR or not. However, those discrepancies should be minor and of purely statistical origin. So it should be possible to get a match by aligning activity data used for reporting under the UNFCCC with the data collected under the EU ETS.

This is not as easy when only the commercial parts of the sectors are being integrated into the EU ETS. In that case, it is likely that discrepancies from activity data will be attributed to the ESR if data available from both exercises is not sufficient to find a common data set.

For emission factors, similarly, emission factors used under the EU ETS and under the NIR should be the same to ensure consistency for the calculation of ESR emissions. A difficulty could arise from the fact that the EU ETS monitoring guidelines allow for the use of standard emission factors, but also for the use of individually determined emission factors when regulations on the frequency of analysis of the carbon content of the fuel are being fulfilled. In contrast, the top-down approach in the NIR results in a common emission factor being used for each type of fuel. As for statistical differences in activity data, this discrepancy in determining emissions cannot be solved completely. In case of integration of the total sector, an average emission factor could be determined based on reported data under the EU ETS and used for NIR to reduce/eliminate these discrepancies. Again, this is more difficult in case of only partial integration of the sectors. But also in that case, determination of an average emission factor for NIR could help to reduce the discrepancies.

5.2 Question 4.2: Impact on existing regulatory framework

5.2.1 Existing regulatory framework for emissions from road transport

This question examines the impact of the options for including the transport sector in the EU ETS (through an extension) or in a separate ETS on the current EU legal framework applied to road transport regarding greenhouse gas emissions from the sector. It considers:

- The general coherence between the objectives of EU emissions trading and the objectives of the key measures in the existing regulatory framework; and
- Potential interactions between the integration of road transport, or road freight only, into the EU emissions trading and the measures in the existing regulatory framework, and the impacts of these interactions on the effectiveness and efficiency of the measures, with a particular focus on the impacts on regulated entities and the ETS price signal.

The following EU instruments relevant to greenhouse gas emissions in the transport sector are examined:

- Vehicle CO_2 performance standards:
  - Light-duty vehicles: Regulation (EU) No 333/2014; Regulation (EU) No 253/201; Regulation (EU) 2019/631
  - Heavy-duty vehicles: Regulation (EU) 2019/1242
- The Renewable Energy Directive (Directive (EU) 2018/2001)
- The Energy Tax Directive (Council Directive 2003/96/EC, as amended)
- The Eurovignette Directive (Directive 1999/62/EC)

5.2.1.1 Vehicle CO_2 performance standards

Coherence with emissions reductions objective

The EU's main approach to achieving the objective of reducing CO_2 emissions from road transport has been through fleet-level emissions standards. These measures set CO_2 performance targets for manufacturers to meet by a certain date, thereby encouraging the supply of efficient vehicles.

A first set of standards was adopted in 2009 for passenger vehicles ('cars') with a 2015 target[181]. This was followed by standards for light commercial vehicles ('vans') in 2011, with a target for 2017[182]. These standards were then revised in 2014, with new targets for 2021 and 2020 for cars and vans respectively[183]. Further targets for 2025

[181] Regulation (EC) no. 443/2009 of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles.

[182] Regulation (EU) No 510/2011 of the European Parliament and of the Council of 11 May 2011 setting emission performance standards for new light commercial vehicles as part of the Union's integrated approach to reduce CO 2 emissions from light-duty vehicles

[183] Regulation (EU) No 333/2014 of the European Parliament and of the Council of 11 March 2014 amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO 2 emissions from new passenger cars; Regulation (EU) No 253/2014 of the European Parliament and of the Council of 26 February 2014 amending Regulation (EU) No 510/2011 to define the modalities for reaching the 2020 target to reduce CO 2 emissions from new light commercial vehicles

and 2030 have recently been adopted[184], and are already due to be reviewed in 2021 in order to raise ambition[185]. Targets for 2025 and 2030 have also recently been set by the first standards for heavy-duty vehicles (HDVs), which are due for review in 2022[186].

The CO2 performance standards have so far generally been effective at driving down emissions. The initial 2015 and 2017 targets for cars and vans were both met in 2013. Although this indicates that they were possibly insufficiently ambitious, the annual rate of reduction in CO_2 for cars following the introduction of the standards increased from 1% to 4%[187]. Emissions have continued to reduce, reaching 120.4 gCO_2 /km for new cars and 158.1 gCO_2 /km for new vans registered in 2018, according to provisional data[188]. This amounts to an average reduction of emissions by 20 gCO_2 /km (14.2%) since 2010. However, emissions for new cars and vans increased by 2 gCO_2 /km in 2018 compared to 2017, due mainly to a shift away from diesel to petrol cars and increased sales of sport utility vehicles (SUVs), as well as slow market penetration from zero- and low emissions vehicles (ZLEVs)[189]. This trend appears to have continued in 2019, based on provisional data.

If the manufacturers fail to meet their targets, they will have to pay the excess emissions premiums set by the performance standards to penalise manufacturers who miss their specific emissions targets for a given year. From 2019 onwards, the penalty is €95 for each g/km of exceedance for each car or van registered. For HDVs, excess emissions premiums will be applied at a rate of €4,250 per excess gCO_2/tkm in 2025, and then €6,800 per gCO_2/tkm in 2030. These excess emissions premiums are set at a level which significantly exceeds the average marginal costs of the technologies needed to achieve the targets, so that there can be no economic incentive to fail to meet them.

[184] Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011

[185] European Commission, *The European Green Deal* (2019). Available at: https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf, p. 11

[186] Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 setting CO2 emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC

[187] ICCT, *Road transport in the EU emissions trading system: an engineering perspective* (2014), p. 2. Available at: https://theicct.org/publications/road-transport-eu-emissions-trading-system-engineering-perspective

[188] EEA, *Monitoring of CO2 emissions from passenger cars – Regulation (EC) No 443/2009*. Available at: https://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-16

Monitoring of CO2 emissions from vans – Regulation 510/2011. Available at: https://www.eea.europa.eu/data-and-maps/data/vans-12

[189] EEA, *Average CO2 emissions from new cars and new vans increased in 2018* (2019). Available at https://ec.europa.eu/clima/news/average-co2-emissions-new-light-duty-vehicles-registered-europe-increased-2018-requiring_en

The performance standards also include mechanisms for incentivising sales of low- and zero- emission vehicles (ZLEVs) by introducing certain flexibilities. These will have to be used by car manufacturers if they are to meet their 2020 and 2021 targets[190][191].

Although the CO_2 standards and inclusion of transport into the ETS (both EU ETS extension and a separated ETS) clearly follow the same emissions reduction objective, there is limited overlap in how they would contribute to this objective due to the functioning of market-based mechanisms in this area.

Indeed, several studies note that, in a scenario where inclusion of the transport sector in the ETS (both EU ETS extension and a separated ETS) replaces CO_2 standards, EUA prices would have to be much higher than their current levels in order to achieve equivalent emissions reductions through technology innovation and penetration. For example, it is estimated that in order to provide a sufficient incentive to achieve the 2021 95 gCO_2/km target for cars, an EUA price of €370-440 per tonne of CO_2 would have been required[192]. For a 2030 target of 60 g/km, which is around what the 2030 standard would require starting from a 95 g/km 2020 baseline, the average EU ETS price is estimated to be €217.7/tCO_2[193].

These high prices are due to the fact that mainstream consumers typically severely discount future fuel savings which would ensue from investing in a more efficient vehicle in relation to its upfront cost, only taking these into account up to a horizon of a few years[194]. They therefore do not invest in fuel-saving technologies as much as would be expected from a cost-effectiveness perspective, resulting in a slower pace of penetration for innovative technology.

Such price increases would of course not be necessary under the design Options considered in this study, as in all scenarios ETS coverage of the road transport sector would be additional to the existing regulatory framework, and the emissions standards already reduce emissions on the supply side. Nevertheless, in order to achieve any significant additional emissions reductions, the price signal would have to be sufficiently high, which would have to be taken into consideration for Options 1a, 1b and 2a.

For Options 1c and 3b, which concern only freight transport, the “energy paradox” issue might be considered less pertinent, as here the purchasers are not mainstream consumers, but rather road freight companies. These could be expected to act like rational economic agents and better account for economies resulting from fuel savings over the lifetime of a vehicle, and therefore invest in more efficient technologies. However, such behaviour should in that case already be observable to some degree without the additional costs an ETS covering the road transport sector, which has not

---

[190] Transport & Environment, *Mission Possible: How car makers can reach their 2021 targets and avoid fines*, 2019. Available at: https://www.transportenvironment.org/sites/te/files/publications/T%26E_201909_Mission%20possible_vF.pdf

[191] PA Consulting, *How Europe's automotive industry can meet tough CO_2 emissions targets,* 2019. Available at: http://www2.paconsulting.com/rs/526-HZE-833/images/PA-CO2-Report-2019_2020.pdf

[192] Cambridge Econometrics, *The Impact of Including the Road Transport Sector in the EU ETS* (2014). Available at https://www.ebb-eu.org/EBBpressreleases/Cambridge_ETS_transport_Study.pdf; ICCT, *Road transport in the EU emissions trading system: an engineering perspective* (2014). Available at: https://theicct.org/publications/road-transport-eu-emissions-trading-system-engineering-perspective

[193] Cambridge Econometrics, *op.cit.*

[194] See e.g. Greene, D. L., Evans, D. H., Hiestand, J., *Survey evidence on the willingness of U.S. consumers to pay for automotive fuel economy (2013).* In: Energy Policy. 61, pp. 1539–1550.

so far been the case. Indeed, the impact assessment for Regulation 2019/1242 notes that many technologies which would have brought considerable net savings over time failed to achieve widespread market penetration, despite their low cost (generally below 1% of the price of a new vehicle) and the absence of any technical or legal constraints to their deployment[195].

The impact assessment sets out a number of barriers which contribute to explain this, including[196]:

- *Information asymmetry:* transport companies have less information than suppliers about the fuel-saving potential of technologies. As the majority of them are SMEs (85% having less than 10 vehicles), they are not well positioned to access and use this information. Transport companies also do not typically see investing in these technologies as cost effective.
- *Access to finance:* fuel efficiency is not considered by banks in their lending criteria. The relatively small SMEs which constitute most of the sector therefore might not have the necessary liquidity to cover the upfront costs of vehicles equipped with these sometimes expensive technologies.
- *Split incentives*: the buyer of the lorry is often not the one paying the fuel costs, either because the vehicle is leased (about 40% HDVs), or because the fuel costs are billed to the client as part of the transport contract.

Therefore, the road freight sector also appears ill adapted to respond optimally to market mechanisms such as the ETS.

Presumably, a separate ETS for transport as envisaged under Option 3a or 3b might be able to sustain the higher prices required to provide the necessary price signal. However, the “energy paradox” described above would still undermine the cost effectiveness of the ETS at achieving emissions reductions.

Thus, as a general comment for all design Options, extending the EU ETS to the road transport or including it in a separated ETS inclusion would have to be carried out without weakening the existing standards, as these are more effective at lowering emissions in the transport sector than is possible for the ETS.

However, ETS coverage could be complementary to the CO_2 standards to the extent that it addresses potential rebound effects, whereby customers drive more as their vehicles become more efficient due to lower usage costs[197]. Indeed, an upstream or downstream ETS inclusion would increase the price of every additional kilometer driven. This aspect might however also be addressed by the revision of the Eurovignette Directive, for which the possibility to charge for CO2 as an external cost in tolls for some trucks has been discussed.

The Eurovignette Directive 1999/62/EC[198] provides the legal framework for charging heavy goods vehicles (HGVs) for the use of certain roads. The Directive aims to eliminate internal market distortions and promote a step-wise harmonisation of

---

[195] European Commission, *Impact Assessment Accompanying the document Proposal for a Regulation of the European Parliament and of the Council setting CO2 emission performance standards for new heavy duty vehicles*, SWD(2018) 185 final, p.7.

[196] *Idem,* pages 12-16.

[197] ICCT, *op. cit*, p. 5; CE Delft, *Analysis of the options to include transport and the built environment in the EU ETS* (2014), p. 60

[198] Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures, OJ L 187, 20.7.1999.

vehicle taxes and fair infrastructure charging. However, it does not apply to lighter goods vehicles or passenger transport.

The Directive does not require Member States to introduce user charges but, if they are applied, it sets minimum levels of taxes for heavy commercial vehicles and rules for determining infrastructure charges, including cost of constructing and operating them and roads' environmental performance such as traffic-based air pollution.

Indeed, the Commission's proposal suggests extending the scope beyond heavy goods vehicles to also include HDVs and LDVs, and gradually phasing out time-based user charges with distance-based charges. The CO_2 standards also increase the supply of fuel-efficient vehicles, which would reduce the number of allowances necessary for transport in the ETS. **Coherence with regulated entities**

The CO_2 performance standards set an EU wide average emissions target, which is derived into specific targets for individual manufacturers. For cars and vans, the specific emissions targets are adjusted accorded to the average weight of the manufacturer's fleet: the heavier the fleet, the more CO_2 emissions are permitted. Manufacturers also have the possibility of pooling together to jointly meet their CO_2 targets. For heavy duty vehicles, the weighting depends on each new HDVs emissions, and its registration share in vehicle sub-groups 4, 5, 9 and 10 as defined in the CO_2 certification regulation[199]. Based on the data reported by Member States (and also by manufacturers for HDVs) on an annual basis concerning the CO_2 emissions of vehicles registered on their territory, the Commission then determines whether a given manufacturer's average emissions have exceeded their specific emissions target.

The entities concerned by these regulations are therefore the manufacturers. An upstream or downstream inclusion of transport into the ETS (both EU ETS extension and a separated ETS) would therefore not lead to any overlap in this regard. However, as a mechanism for monitoring and reporting manufacturer emissions already exists, it would be conceivable to integrate ETS mid-stream, by requiring manufacturers to buy permits for each vehicle. This however raises several difficulties. Firstly, the ETS cost would presumably require an estimation of the projected lifetime distance for each vehicle, which may lead to inaccuracy and inefficiency. Such an approach would also fail to take into account changes in the carbon content of fuel, therefore providing no incentive to fuel suppliers, and would not be able to account for differences in driving behaviours, also failing to provide additional incentives for consumers to drive less.

5.2.1.2 Renewable Energy Directive

Coherence with emissions reduction objective

In 2009, the Renewable Energy Directive[200] (RED) set a target for all EU Member States to have at least 10% of their transport fuels from renewable sources by 2020.

---

[199] Commission Regulation (EU) 2017/2400 of 12 December 2017 implementing Regulation (EC) No 595/2009 of the European Parliament and of the Council as regards the determination of the CO2 emissions and fuel consumption of heavy-duty vehicles and amending Directive 2007/46/EC of the European Parliament and of the Council and Commission Regulation (EU) No 582/2011. Available at: https://www.eea.europa.eu/highlights/average-co2-emissions-from-new

[200] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

The new Renewable Energy Directive 2018/2001 (REDII)[201] requires Member States to supply a minimum of 14% of the energy consumed in road and rail transport by 2030 as renewable energy. However, Member States can opt to reduce this share by up to 7% where their proportion of biofuels, bioliquids and biomass fuels consumed in transport and produced from food and feed crops is below 7%. Sustainability criteria are established for bioliquids for use in transport. The most recent data available shows that in in 2018, 8.26% of energy in the transport sector was from renewable sources[202].

There is possible overlap between REDII and the inclusion of transport in ETS through all design Options covering both EU ETS extension and a separated ETS, as the latter in theory would also incentivise use of biofuels. However, as the abatement costs of biofuels are relatively high, it is unlikely that ETS inclusion would have a significant impact here[203]. The increase in supply of renewable energy for transport due to REDII could however lower the number of allowances necessary for transport under the ETS leading to a lower carbon price. This would need to be factored into the design of the ETS rules for the integration of the sector.

Coherence with regulated entities

Although REDII is addressed to the Member States, the entities concerned are the fuel suppliers, who must demonstrate that the minimum share of energy supplied for transport fuels from renewable sources is met. REDII therefore includes a reporting and monitoring methodology for the energy content of transport fuels, covering petrol, diesel, natural gas, biofuels, biogas, renewable liquid and gaseous transport fuels of non-biological origin, recycled carbon fuels and electricity supplied for transport.

These reporting requirements are potentially complementary for ETS inclusion both through EU ETS extension and a separated ETS. Indeed, tax warehouses are the regulated entity selected under the options examined in this study, as they are the entity furthest upstream that has accurate monitoring systems in place and is able to monitor the sale of fuels to the transport sector. However, natural gas (LNG or CNG) currently does not pass through tax warehouses, and therefore one option would be for natural gas suppliers to be considered as a regulated entity. In this case, it would be possible to draw on the pre-existing system for natural gas in REDII to monitor flows for this fuel.

Moreover, concerning biofuels, the monitoring and reporting requirements in REDII regarding mass balances of biofuels would make it easier for tax warehouses to monitor the type and share of biofuels in transport fuels by strongly reducing the risk of fuel suppliers declaring higher shares of biofuels than there are in reality.

5.2.1.3 Energy Taxation Directive

Coherence with emissions reduction objective

The Energy Taxation Directive[204] lays down minimal tax rates for energy products fuels and electricity, above which Member States have discretion to establish their

[201] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources

[202] Eurostat, *SHARES,* Data for EU27. https://ec.europa.eu/eurostat/web/energy/data/shares

[203] CE Delft, *Analysis of the options to include transport and the built environment in the EU ETS* (2014), p. 60

[204] Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity

respective rates. These minimum tax rates have remained unchanged since 2003, and are currently unrelated to the CO_2 emissions or energy content of energy products. Some countries (i.e. Denmark, Finland, France, Ireland, Luxembourg, Portugal, Slovenia, Sweden) however apply specific carbon taxes for road transport as part of the fuel excise duties and electricity taxes[205]. Diesel is also generally taxed at a lower rate than petrol[206]. A proposal is currently being prepared in order to modify the Energy Tax Directive so as to align taxation with environmental objectives[207].

Energy taxation and ETS coverage (through any design Option including both EU ETS extension and a separated ETS) highly overlap, as they both provide a price incentive to consumers to reduce the CO_2 impact of their mobility behaviour. The limitations on their potential impact are also similar, due to the “energy paradox” effect, according to which consumers tend to significantly discount the value of future fuel savings in relation to the upfront cost of a vehicle (see section 4.2.1.1 above).

The cost efficiency of the ETS at achieving additional emissions abatements might be limited by the current heterogeneity of the fuel tax landscape. Indeed, current tax rates applied by Member States diverge quite widely, both in level and in structure. Nominal tax rates (such as those represented in the graph below) and effective tax rates or rates included in the price at the petrol pump therefore also differ[208]. These differences distort the market and would therefore prevent EU cost-efficient emissions reduction[209]. This market distortion could be partly corrected with the integration of the transport sector in the ETS if the price increase from ETS inclusion was significant in relation to the energy tax levels[210].

Furthermore, increases in fuel price due to ETS coverage of the road transport sector both through EU ETS extension and a separated ETS, could be countered by likely reductions in energy tax rates. However, this may lead to unstable revenue for the MS because the ETS prices is variable.

---

[205] European Commission, *Transport taxes and charges in Europe – An overview study of economic internalization measures applied in Europe* (2019), p.27

[206] *Idem*

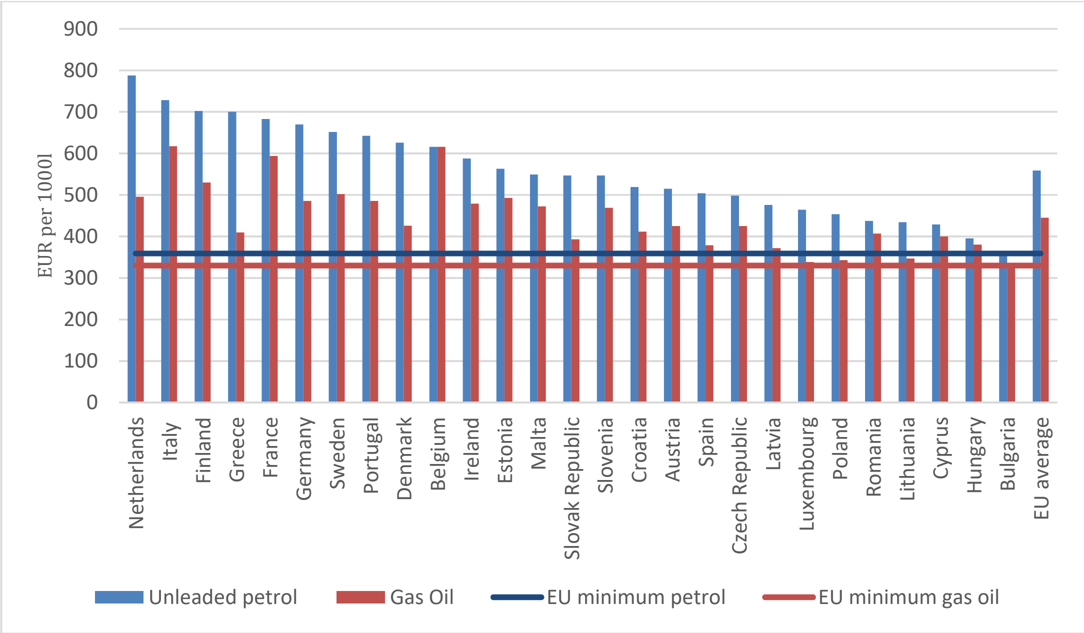
[207] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12227-Revision-of-the-Energy-Tax-Directive

[208] European Commission, *Evaluation of the Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity*, SWD(2019) 329 final, p. 26

[209] Öko-Institut, *Policy mix in the transport sector: What role can the EU ETS play for road transport* (2015). Available at https://www.oeko.de/oekodoc/2221/2015-006-en.pdf

[210] *Idem*

Figure 96. Tax rates for petrol and gas oil



Source: Taxes in Europe Database (January 2019)

EU average tax rate per tCO_2 is EUR 263,8 for unleaded petrol and EUR 163,8 for Gas Oil. Note: the diferentated rates for commercial diesel and the primary sector are not taken into account, and national tax systems are more complex than what is reported in Taxes in Europe Data Base.

Coherence with regulated entities

Energy taxes are applied as excise duties, which are ultimately paid by the consumer. The transport fuels concerned by the Energy Taxation Directive are held in tax warehouses until they are released for consumption, at which point the excise duty must be paid. The amount of these fuels which is consumed for transport is therefore monitored and registered by tax warehouses. An upstream ETS inclusion for transport would likely rely on these mechanisms.

5.2.2 Existing regulatory framework for emissions from buildings

This question examines the impact of including the building sector in the EU ETS or in a separated ETS on the current EU legal framework for greenhouse gas emissions from the sector. It considers:

- the general coherence between the objectives of the EU ETS and the objectives of the key measures in the existing regulatory framework; and
- potential interactions between the EU ETS and the measures in the existing regulatory framework, and the impacts of these interactions on the effectiveness and efficiency of the measures, with a particular focus on the impacts on regulated entities and the price signal within the EU ETS.

The analysis considers the following EU regulatory instruments relevant to greenhouse emissions in the buildings sector:

- The Energy Performance of Buildings Directive (Directive 2010/31/EU, as amended)
- The Energy Efficiency Directive (Directive 2012/27/EU, as amended)

- The Renewable Energy Directive (Directive (EU) 2018/2001 recast)
- The Ecodesign Directive (Directive 2009/125/EC, as amended) and its implementing measures relevant to space and water heating and cooling
- The Energy Taxation Directive (Directive 2003/96/EC).

5.2.2.1 Energy Performance of Buildings Directive

The objective of the **Energy Performance of Buildings Directive** (EPBD) to promote 'the improvement of the energy performance of buildings within the Union, considering outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness[211]'. This is broadly coherent with the objective in the EU ETS Directive to 'promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner'[212]. The objectives of the EPBD can be considered to complement the EU ETS, by supporting energy efficiency measures that would contribute to emissions reductions in sectors both outside the scope of the ETS and within the ETS (i.e. electricity generation).

While the EPBD has triggered the tightening of building standards in EU Member States and the certification of commercial buildings, and inspections of boilers and air conditioning systems, a significant potential to improve the full potential of energy performance in the buildings sector is still to be delivered. The inclusion of the buildings sector in the EU ETS supporting similar objectives could improve the situation.

Should the building sector be included in the current EU ETS or a separated ETS, the EPBD may help to offset some of the negative social impacts of any increases in building heating/cooling costs on vulnerable groups (tenants of residential buildings), as the EPBD will have resulted in improved energy efficiency in some buildings and therefore in reduced emissions. Similarly, the ETS may incentivise investments for further achievement of the objective of the EPBD as increased energy costs will increase the costs effectiveness of building energy efficiency measures. This interaction would require the design of the ETS and cap setting taking into account the EPBD implementation projections in terms of emission reductions – to ensure any additional environmental benefit from including the building sector in the EU ETS, the cap will need to be set at a level that ensures a price signal beyond the implicit price already imposed by the EPBD.

The EPBD establishes a system for improving building energy performance based on building standards, Member State planning and reporting, inspections of buildings, and improved information to building purchasers and tenants through energy performance certificates. Under the Directive, Member States are responsible for **setting minimum energy performance requirements** for buildings in line with the methodology framework for calculating cost-optimal levels of minimum energy performance requirements set out in Annex I of the Directive. If Member States' energy performance standards for buildings are significantly less than the cost-optimal levels, then Member States need to justify this to the Commission. The Directive also sets a target date of 31 December 2020 for ensuring that all new buildings are nearly zero-energy buildings, and requires Member States to develop national plans for increasing the number of nearly zero-energy buildings in the national building stock. It also establishes a system for energy performance certificates for buildings and for the inspection of heating and air-conditioning systems in buildings. Finally, Member States

[211] Article 1, Directive 201/31/EU as amended

[212] Article 1, Directive 2003/87/EC as amended

are encouraged to put in place financial incentives linked to the achievement of energy savings under the Directive.

The latest amendments to the Directive, to be transposed by March 2020, require Member States to adopt national long-term renovation strategies with a solid finance component to ensure the renovation of existing buildings into highly energy efficient and decarbonised buildings and facilitating the cost-effective transformation of all existing buildings into nearly zero-energy buildings[213]. Additional provisions impose obligations related to modernisation, including building automation and controls, e-mobility and inspections. As explained below, there is limited experience on EEOS supporting whole-house retrofits[214]. The integration of the buildings sector in the ETS or in a separated system with an increased carbon price could be a complementary measure triggering the adoption of appropriate actions for retrofitting existing buildings. While the ETS price might trigger the implementation of measures for retrofitting existing buildings, as the objectives in the new designed EEOS need to be additional to those in existing legislation, they will need to take into account the anticipated energy savings from the ETS.

Broadly speaking, the EPBD does not differentiate between sub-sectors. The EPBD applies to buildings in the residential, commercial and industrial sectors. There is some minor differentiation in how the measures in the Directive apply to the residential and non-residential sectors (for example, the Directive proposes different information types to be included in energy performance certificates for non-residential buildings). There is also the option for Member States to exempt certain types of buildings from the energy performance standards (e.g. buildings used for religious worship or buildings with cultural heritage values where achieving the performance standard would unacceptably alter their character or appearance).

As the instrument is an EU directive, the entities directly impacted by the EPBD are Member State authorities. However, the regulated entities responsible for complying with the building standards to be developed by Member States under the Directive, are likely to be building owners and construction companies. In general, this is not considered to lead to any problematic interactions if the sector is included in the scope of the ETS. Construction companies would not be regulated entities under the ETS, so no overlap would occur. There may be an overlap if the ETS is applied to downstream entities, such as building owners. However, the obligations on building owners arising from the EPBD are relatively short-lived, occurring at the point of construction, sale or lease of the building, and as noted in Task 3, downstream regulation appears to be unviable

In terms of key questions/issues for the integration of buildings into the ETS, an overarching question is the impact of the EPBD on the price signal under the ETS. Inclusion of buildings in the ETS both through EU ETS extension and a separated ETS, could impact the cost-optimal balance between the investments involved and the energy costs saved throughout the lifecycle of the building. Member States may need to revise their standards accordingly. However, these standards need to be revised every five years in any case under the EPBD. Finally, there is a question about whether the financial incentives that Member States are encouraged to put in place

[213] Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation (notified under document C(2019) 3352) - *OJ L 127, 16.5.2019.*

[214] Fawcett, T., Rosenow, J. & Bertoldi, P. Energy efficiency obligation schemes: their future in the EU. *Energy Efficiency* **12,** 57–71 (2019). https://doi.org/10.1007/s12053-018-9657-

under Article 10 of the EPBD could distort the ETS market. In that case, specific competition or State aid rules might need to be drafted to prevent this distortion.

5.2.2.2 Energy Efficiency Directive

The objective of the **Energy Efficiency Directive** (EED) is to establish 'a common framework of measures to promote energy efficiency' to ensure that the EU's 2020 and 2030 energy efficiency targets are met[215]. This objective is generally coherent with the objectives of the EU ETS and both legal instruments can reinforce each other. Like the EPBD, the EED addresses energy demand, ultimately contributing to emissions reductions in sectors both within and outside the ETS. Should the building sector be brought within the scope of the ETS, the energy efficiency measures promoted by the EED would likely become more cost effective, due to higher costs for building heating because of ETS implementation. This could therefore accelerate progress towards achieving the targets in the EED. As energy efficiency improvements under the EED are contributing to emissions reductions (as compared to a business as usual scenario), the EED could impact price developments in the ETS. This impact would need to be factored into the cap-setting of any extended ETS to avoid oversupply of allowances in the ETS.

The general approach taken by the EED is to set energy efficiency targets for 2020 (20% below projected consumption) and 2030 (32.5%), establish a process for identifying Member State targets, and address market failures that create barriers to improving energy efficiency, such as information failures and split incentives.

The Energy Efficiency Directive 2012/27/EU requires in its Article 3 Member States to set binding national energy efficiency targets within the 32.5% overall target for 2030 and to establish policy measures and tools to achieve their targets. Member States are required to contribute to the Directive's targets by adopting national energy efficiency obligation schemes or alternative measures to achieve the energy savings obligation of at least 1.5% of energy sales to final customers each year in the period to 2020, and of at least 0.8% of final energy consumption per year in the 2020-2030 period.

It is considered that well-designed EEOS can deliver significant, cost-effective energy savings over many years. The adoption of EEOS is specifically mandated within Article 7 of the EED as well as the adoption of alternative measures or a combination of both. The following EU countries have established ESOS: Austria, Bulgaria, Croatia, Denmark, France, Greece, Ireland, Italy, Latvia, Luxembourg, Malta, Slovenia, Spain, Poland and the UK. A number of countries do not see them as a necessary policy within their national policy framework. Analysis of member state reports shows they are expected to deliver 34% of Article 7 savings—the biggest contribution of any policy instrument[216].

EEOS requires obligated parties, generally energy utilities, to meet energy saving targets by delivering or procuring energy savings at the customer end of the energy system. The design of individual EEOS is very different from one country or region to another; there are no countries or regions with identical EEOS. Member States may decide to link EEOS to obligations placed on energy retailers or on energy distributors, or both[217].

---

[215] Article 1, Directive 2012/27/EU as amended

[216] Fawcett, T., Rosenow, J. & Bertoldi, P. Energy efficiency obligation schemes: their future in the EU. *Energy Efficiency* **12,** 57–71 (2019). https://doi.org/10.1007/s12053-018-9657-1

[217] Ibid supra

Energy savings planned under the EEOS (or alternative measures) have to be additional to those which are expected from existing EU efficiency policies. According to recent studies, in practice, this means that most savings are likely to come from efficiency improvements to buildings (beyond those mandated in the Energy Performance of Buildings Directive) or industrial processes and their management. In the residential sector, EEOS have been used primarily to deliver relatively low-cost energy-efficiency and light to medium renovation measures, as their operation so far has privileged the most cost-effecitve measures. For this reason their experience on supporting more comprehensive, whole-house retrofits has been limited[218]. The ETS price might trigger the implementation of measures for retrofitting existing buildings and in principle the regulated entities could be partially the same as EEOS. The estimates of energy savings designed under the EEOS would need to take into account the anticipated energy savings from the ETS.

Member States must outline measure to achieve their energy efficient targets under the National energy and climate plans. Member States must also ensure that mechanisms such as metering and billing information are used to ensure that final consumers of energy are fully informed about their energy consumption and costs.

One of the anticipated benefits of EEOS is that they would change the relationship between energy companies and their customers. For example, the number of consumers generating their own energy from renewable sources of energy and selling it as well as buying from their energy retailer is increasing which is linked to the increase of information on their own energy use through smart meters and feedback options. If energy customers are more active and their interest in the benefits of energy efficiency grow, it should be easier for energy companies to engage them in EEOS programmes and to deliver their savings targets. However, these more engaged customers may seek out energy savings opportunities themselves, and not be so reliant on incentives and information delivered by EEOS which will then target the less-engaged.

Member States should also consider special measures for certain groups of final consumers, including SMEs and buildings tenants. Authorities are expected to lead by example by renovating public buildings (minimum of 3% of floor space each year) and aligning public purchasing with the Directive. Member States must take specific measures to promote efficiency in energy supply, including policies promoting the use of efficient heating and cooling systems at the local and regional levels. Member States should also facilitate financing for energy efficiency investments under the Directive, through existing or new facilities in line with EU State aid rules.

Some countries have designed EEOS that set incentive measures, including subsidies, to achieve energy savings in certain sectors such as vulnerable or low-income households or community-based initiatives. Those measures promote information on efficient energy use, how to reduce the energy bill or how to read smart meters. They promote also the use of other funding instruments to support the necessary investments such as cohesion funds or innovative funding mechanisms. Others promote skill development programmes and training experts. Those measures could interact with the implementation of the ETS covering all fossil fuels by supporting regulated entities to fulfil their obligations for monitoring emissions or training verifiers.

From the above it is clear that measures adopted by Member States to meet their obligations under the EED are likely to impact a broad range of entities, including regulated entities for the buildings sector under the existing ETS or in a separated one

[218] Ibid supra

such as **energy suppliers** and hence **building owners and final consumers of heat and energy**. Member State national energy efficiency obligation schemes are likely to directly regulate **suppliers of energy** for building heating and cooling services, including suppliers of electricity, heat, gas, liquid and solid fuels. If the building sector is brought within the ETS and the obligation is imposed upstream at the point of supply, suppliers of gas, liquid and solid fuels may be regulated under both schemes. For suppliers of heat, the impact would vary according to the source of heat. Obligations on electricity suppliers would be unchanged, as electricity is already included in the ETS at the point of its generation. Any obligations linked to monitoring and reporting under the ETS might benefit from exiting tools like smart metering already introduced in buildings to support the implementation of the EED.

There are relatively limited questions regarding the compatibility of the EED with an EU ETS extended to the building sector or integrating a separate ETS, as both Directives currently cover the building sector with respect to electricity. As noted in the France case study (Task 1), there are potentially overlaps between a carbon price mechanism, such as an ETS or a tax, and energy efficiency obligation schemes. In France, the French carbon tax includes the building sector and co-exists with a white certificate scheme for energy efficiency that obliges energy suppliers to promote energy efficiency measures among their customers through the trade of energy efficiency certificates. Both schemes create a price signal aimed at reducing demand for energy. However, as the case study concludes, the energy efficiency scheme directly incentivises energy efficiency investments while the carbon tax targets the use of energy and has only an indirect impact on investments. In that case study, the instruments were found to complement each other, as they reinforce the incentives under each instrument. The energy efficiency schemes also mitigate against disproportionate impacts on low-income households, who may lack the capital to invest in energy efficiency in response to increased energy prices resulting from the carbon tax.

5.2.2.3 Renewable Energy Directive

The primary objective of the **Renewable Energy Directive** (RED) is to establish 'a common framework for the promotion of energy from renewable sources' through the setting of mandatory national targets[219] to contribute to the EU's renewable energy target for 2030 (27% of EU primary energy consumption to be from renewable sources). It also sets out rules on the use of energy from renewable sources in the heating and cooling sector, and includes measures to encourage the use of renewable energy in the sector. In addition, the RED requires the establishment of verification systems of the sustainability criteria of biofuels and of the biomass content of fuel used in the buildings which reinforces the integration of the sector in the ETS based on appropriate monitoring and enforcement system.

These objectives are coherent with those of the ETS. If the building sector is brought within the scope of the ETS, the price signal of the ETS may contribute to the objectives of the RED by increasing the cost effectiveness of renewable energy sources compared to fossil fuel energy sources. The emissions reductions achieved through the RED would potentially affect the scarcity of allowances and the price signal under the ETS. This would need to be factored during the design and cap-setting phases.

Under the RED, Member States should endeavour to meet the indicative target of increasing renewable energy use in the building heating and cooling sector by 1.3 percentage points per year in the 2021-2030 period. Member States may adopt

[219] Article 1, Directive 2018/2001/EU

measures designating certain entities, including suppliers of fuels used in building heating and cooling, required to contribute to this target. These measures could be based on energy efficiency obligation schemes adopted under the EED. Member States are also required to take measures to support final consumers of districting heating in switching to more efficient sources.

As with the EED, if the building sector is included in the EU-ETS or integrated in a separated ETS there is likely to be some overlap in terms of the regulated entities covered under each policy measure. Regulated entities under Member State measures to implement the RED are likely to include suppliers of fuel, who would also be regulated entities under an upstream approach in the ETS. However, there is already an existing overlap of measures between the RED and the ETS in the electricity sector, so this burden is likely to be manageable.

5.2.2.4 Ecodesign Directive

The objective of the **Ecodesign Directive** and its measures, work by setting minimum energy efficiency and environmental requirements for household and industrial energy-related products, thus supporting the internal market while contributing 'to sustainable development by increasing energy efficiency and the level of protection of the environment, while at the same time increasing the security of the energy supply'[220]. Complementary to it, EU energy labels provide information to consumers on the products' energy consumption and environmental performance, and help consumers make informed decisions. The implementing measures under the Ecodesign and Energy Labelling legislation include several measures for space heating and cooling equipment[221]. The Ecodesign Directive and its measures are complementary to that of the ETS. Most Ecodesign measures currently address products that use electricity, which is already within the scope of the ETS. Inclusion of the building sector in the ETS would possibly support the goals of the Ecodesign Directive: the increased costs of using inefficient heating and cooling equipment could drive faster uptake of more efficient products that meet the Ecodesign requirements. The Ecodesign Directive could also partially assist in limiting the potential negative social impacts of including space heating and cooling in the ETS by providing final residential consumers with products that could aid in reducing the costs of heating and cooling.

5.2.2.5 Energy Taxation Directive

Broadly speaking, the objectives of the **Energy Taxation Directive** (ETD) are in line of those of the ETS and their coexistence could reinforce their effectiveness. As noted above (section 5.2.1.3), the ETD sets out minimum levels of taxation for energy fuels (in Article 9 and Annex I), including fuels used for heating. While the primary objective of the ETD is to support the functioning of the internal market by harmonising energy taxation levels (Recitals 2 to 5), it notes the role that energy taxation can play in environmental protection, specifically climate change mitigation (Recitals 7 and 8). In addition, efforts have been made to strengthen the role of the ETD in reducing GHG emissions; in 2011 the Commission proposed amendments to this effect (COM(2011) 169) and in 2019 the Commission announced its planned proposal to revise the Directive in the European Green Deal (COM(2019) 640 final).

The ETS and the ETD would potentially overlap, should the building sector be brought within the ETS. Both Directives would send a price signal to end users that should

[220] Article 1, Directive 2009/125/EC as amended

[221] See, for example, Regulation (EU) 813/2013 with regard to ecodesign requirements for space heaters and combination heaters.

reduce their demand for energy, and ultimately reduce GHG emissions. The Commission's 2011 proposal aimed to align the EU ETS and the ETD.

A key challenge in extending the ETS to the building sector is identifying the appropriate regulated entities. The ETD only partially assists in this respect in the building sector – the tax warehouse operators for liquid fuels as defined under the ETD could be an appropriate regulated entity for the ETS. These are often fuel refineries, suppliers or traders[222]. However, natural gas and coal do not pass through tax warehouses, and some Member States specifically exempt these fuels from energy taxation when used in residential heating. Therefore, for these fuel sources, an alternative regulated entity would need to be identified (as suggested in previous sections, e.g. section 3.5.6).

5.2.2.6 Impact of proposed options on existing regulatory framework for emissions from buildings

This section presents a brief qualitative assessment of key issues related to the how the options identified under Question 3.1 would interact with the existing legal framework for greenhouse gas emissions from buildings. These issues relate to how the existing EU regulatory framework for emissions from buildings could address two challenges in extending the EU-ETS to this sector: Addressing market failures and mitigating social impacts.

Inclusion of the building sector within the ETS is broadly compatible with the objectives of the pieces of relevant EU legislation for emissions from the building sector; however, the extent of this interaction is linked to the price signals sent by the EU-ETS. Any higher price signal for heating or cooling of buildings that results from the ETS will support the objectives of the analysed Directives. Similarly, these Directives will help to overcome market failures that impede emissions abatement that cannot be overcome by a price signal alone.

For the options where some or all emissions from the building sector were not covered by the ESR – Options 1a, 1c, 2b – these potential synergies would potentially become more important. As noted in Tasks 3 above, an ETS price signal flanked by other supporting measures can help to overcome barriers related to behavioural change and fuel switching. Under the options where building emissions would be covered by the EU-ETS but not the ESR, Member States would be unlikely to adopt additional measures to overcome such barriers; thus the role of the EED, RED and EPBD in addressing market failures would become more critical.

The EED and the EPBD may also help to mitigate negative social impacts of the ETS in terms of higher energy prices on vulnerable groups by promoting energy efficiency investments that help these groups reduce their energy demand. The degree to which these synergies can be achieved is linked to the carbon price imposed in the building sector through the ETS. This synergy would be important for the options where emissions from residential buildings are included under an ETS: Options 1a, 1b, 2b, 3a and 3c. As noted in Task 2, these options would likely have a regressive impact on households. The EED and EPBD may to some extent mitigate this impact by incentivising measures such as investments in residential building energy efficiency.

[222] CE Delft, SQ Consult and Cambridge Econometrics, *Analysis of the options to include transport and the built environment in the EU ETS*, February 2014

5.3 Question 4.3: Just transition

5.3.1 Context of the 'Just transition'

In accordance with the European Commission's policy agenda, the potential for a 'just transition' is of utmost relevance in the design options analysed. A key goal, therefore, in this part of the analysis is to assess how changes in the carbon cap (to be designed in line with the European Commission's Long Term Strategy) and the so-induced carbon price, under different design options for the extension of the ETS, would impact household income. More specifically, the aim is to investigate whether different types of households are at risk of facing different costs from carbon pricing.

5.3.2 Our approach to assessing the 'Just transition'

In this task of the project, we investigate what impact an extension to buildings and transport is expected to have on average household expenditure patterns across income deciles, in terms of their transport and heating costs. The analysis covers a representative sample of EU Member States at a country-level and is based on the best and latest available household expenditure datasets.

Assessment criteria

In assessing the viability of the policy design options for the ETS extension, two key social criteria are investigated:

- The impact on household spending on heating and transport and
- Distribution of final consumption expenditure across consumption categories

We estimate how consumption patterns change as prices change.

Dataset

In our analysis we build on detailed consumer expenditure data for EU-27 by three income deciles provided for the analysis by the European Commission, DG Climate Action[223]:

- Decile 1 (representing Poor households)
- Decile 3 (representing Lower-middle class households) and
- Decile 5 (representing Middle class households).

The dataset includes absolute values in EUR per household values of final consumption expenditure by key consumption categories, and amongst others, provides details on the following consumer expenditure categories relevant to our analysis.

Figure 97. Consumer expenditure categories

Broad consumption category	Detailed consumption category
Electricity, gas and other fuels	Gas
	Liquid fuels
	Solid fuels
	Diesel

[223] The same raw dataset that was used in the 2018 version of the Energy Costs and Prices report of the European Commission. Available at: https://ec.europa.eu/energy/sites/ener/files/epc_report_final_1.pdf

Fuels and lubricants for personal transport equipment	Petrol

Key assumptions

In this analysis, we use the following modelling assumptions:

- full cost pass-through from industry to end users in both transport and energy,
- a simple demand response to increasing fuel prices, with no implicit technology substitution.

Price elasticities of demand for energy carriers and transport fuels are non-linear for technology substitution, implying that in both cases there are tipping points where a new technology becomes cost-effective. Models[224] investigating the dynamic selection and diffusion process of innovations, for instance, use a decision-making core for investors wanting to build new electrical capacity, facing several options. The decision-making takes place through pairwise levelized cost (LCOE) comparisons of technologies, conceptually equivalent to a binary logit model, parameterised by measured technology cost distributions. Costs include reductions originating from learning curves, as well as changing marginal costs of technologies, using cost-supply curves. The diffusion of technology follows a set of coupled non-linear differential equations, which represent the better ability of larger or well-established industries to capture the market, and the life expectancy of technologies. Due to learning-by-doing and, most often, increasing returns to adoption, model results often yield path-dependent technology scenarios.

- With our linear estimation, technology substitution is not deliberately included, thus, we are taking into account the direct changes in household energy and transport fuel costs of consumers.

[224] For methodological background, see for instance:

Mercure, Jean-Francois, Florian Knobloch, Hector Pollitt, Leonidas Paroussos, Serban Scrieciu, Richard Lewney (2019) Modelling innovation and the macroeconomics of low-carbon transitions: theory, perspectives and practical use. Climate Policy, in press.

Mercure, Jean-Francois, Hector Pollitt, Neil R Edwards, Philip B Holden, Unnada Chewpreecha, Pablo Salas, Aileen Lam, Florian Knobloch, Jorge E Vinuales (2018) Environmental impact assessment for climate change policy with the simulation-based integrated assessment model E3ME-FTT-GENIE. Energy Strategy Reviews, Volume 20, April 2018, Pages 195–208.

- Households differ substantially in terms of their exposure to energy poverty: for instance, it is reasonable to assume that Poor households (Decile 1) are relatively more vulnerable to the risk of experiencing inadequate levels of essential energy services (due to a combination of proportionally high energy expenditure within their total expenditure which they may fail to pay, low incomes and inefficient buildings and appliances infrastructure). The following text box gives more context to understanding the pressing social problem of energy poverty across EU countries, based on the currently applied definition of the EU Energy Poverty Observatory[225].

What is energy poverty?

According to the EU Energy Poverty Observatory, *"energy poverty is a distinct form of poverty associated with a range of adverse consequences for people's health and wellbeing – with respiratory and cardiac illnesses, and mental health, exacerbated due to low temperatures and stress associated with unaffordable energy bills*".

Energy poverty therefore has an indirect effect on many policy areas - including health, environment, and productivity. Securing access to essential energy services and thereby allowing for a decent standard of living and health for European citizens, as well as supporting them in fulfilling their potential and enhancing social inclusion are clearly crucial tasks on the European Union's social agenda.

In turn, addressing the pressing issue of energy poverty has the potential to bring several benefits, too, including: less money spent by governments on health, a decline in air pollution, better comfort and wellbeing of European citizens, improved household budgets, and an in-sum increased economic activity.

Like in the dimension of energy expenditure, households are also different based on their spending on transport. With regards to long-run price elasticities, although not the same across deciles, we assume:

- Household spending on household energy is more inelastic (widely supported by the literature, see for instance recent evidence for the UK and for other economies across Europe and internationally[226]), while

[225] https://www.energypoverty.eu/

[226] Department of Energy and Climate Change (2016) National Energy Efficiency Data Framework: Annex D - Gas price elasticities: the impact of gas prices on domestic consumption – a discussion of available evidence. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/532539/Annex_D_Gas_price_elasticities.pdf

P.J. Burke - H. Yang (2016) The price and income elasticities of natural gas demand: International evidence. Energy Economics 59., pp 466–474. Available at: https://www.sciencedirect.com/science/article/pii/S0140988316302420

- household spending on transport[227], compared to heating, is more elastic as a response to changes in the price of transport fuels (which is ultimately induced by changes in the price of carbon).
- With regards to household heating gas and transport fuel demand elasticities, the following assumptions are used as taken from literature[228,229]:
- The demand elasticity of household gas (assumed uniformly for the all household deciles): 0.25
- The demand elasticity of transport fuel for Decile 1[230]: 0.3
- The demand elasticity of transport fuel for Decile 3 and Decile 5: 0.44

In our analysis we assume that – irrespective of the final design option – including the road and/or buildings sector in the ETS is likely to act as a small carbon tax on transport/ heating fuels used, and as such, through an increased carbon price, raise the fuel price for end consumers[231]. The dataset used (consumer expenditure data for EU-27 by three income deciles, provided for the analysis by the European Commission, DG Climate Action) does not include public road passenger transport. To stay in line with the scale and ranges of future carbon price analysed in other parts of the report too (e.g. in Task 2), the following changes in fuel prices are assumed in line with a carbon price falling in the range of 25-30 EUR/tCO2eq:

---

[227] See, for instance:

Dunkerley et al (2014) Road traffic demand elasticities: A rapid evidence assessment. RAND Europe report for the UK Department for Transport. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/395119/road-traffic-demand-elasticities.pdf

Sterner, T. (2012) Distributional effects of taxing transport fuel. Energy Policy (41), pp 75-83. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0301421510001758

Schulte, I. – Heindl, P. (2016) Price and Income Elasticities of Residential Energy Demand in Germany. Discussion Paper No. 16-052, Centre for European Economic Research. Available at:

http://ftp.zew.de/pub/zew-docs/dp/dp16052.pdf

[228] Department of Energy and Climate Change (2016) National Energy Efficiency Data Framework: Annex D - Gas price elasticities: the impact of gas prices on domestic consumption – a discussion of available evidence. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/532539/Annex_D_Gas_price_elasticities.pdf

[229] Schulte, I. – Heindl, P. (2016) Price and Income Elasticities of Residential Energy Demand in Germany. ZEW Discussion Paper No. 16-052; page 33.

Available at: http://ftp.zew.de/pub/zew-docs/dp/dp16052.pdf

[230] Evidence base for the differentiated elasticities come from the above-cited Schulte – Heindl (2016) study, and are based on the following detailed assumptions in the referred study: demand elasticity of 0.3 is assumed for Quartile 1 (and applied for Decile 1 in the current study), while a demand elasticity of 0.44 is assumed for Quartile 2 (which is applied for Decile 3 and Decile 5 in the current study). Both referred evidences are based on a representative household type of a couple with one child.

[231] Achtnicht, Martin et al. (2015) Including road transport in the EU-ETS: An alternative for the future? Zentrum für Europäische Wirtschaftsforschung (ZEW), Mannheim. Available at: https://www.econstor.eu/bitstream/10419/111452/1/826581412.pdf

- 5% increase in household fossil energy price (which, based on an EU28 average[232] retail gas price of around 60 EUR/MWh, is equal to an around 3 EUR/MWh increase).
- 10% increase in transport fuel price (end-user prices), resulting from an inclusion of road transport sector in the EU ETS. The assumption, more specifically, is derived based on a recent expert estimation[233] arguing that if ETS was to include road transport fuels, the result would be that oil companies have to buy carbon allowances, raising fuel prices by EUR 0.06/litre (based on an ETS carbon price of 25 EUR/tCO2eq, as of January 2020). To stay conservative in our estimations and to capture the potentially larger negative social impacts of a transport fuel price increase, a slightly higher parameter of EUR 0.1/litre is assumed in our modelling.

Both cases include the above assumption of full cost pass-through from industry to households. As part of the final deliverables, a supplementary spreadsheet presenting all the modelling assumptions and the calculation tool will be delivered to the European Commission, DG Climate Action, which will also allow for modifications of the hypothetical assumptions of the analysis by the European Commission, thereby allowing for the assessment of outcomes under different parameters.

5.3.3 Findings

As a starting point in the analysis of social dimensions of a potential ETS extension, we have investigated how final household expenditure is distributed in the EU-27 member states across the main relevant consumption categories:

- Food and non-alcoholic beverages
- Household energy costs
- Transport (excl. public transport)
- Other

In the case of three different income groups:

- Poor households (Decile 1)
- Lower-middle class households (Decile 3)
- Middle class households (Decile 5)

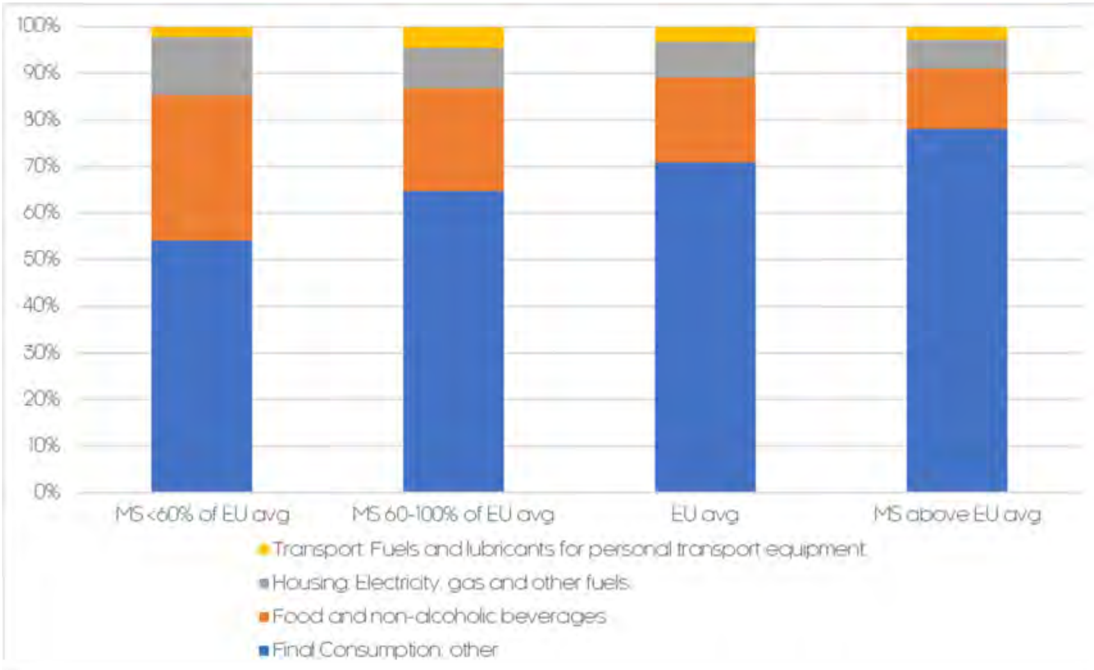
As expected, and also illustrated by the chart below, household energy costs, that are expected to increase as a result of a price change of fossil fuels, already give a significant share of total final expenditure of poor households – even in rich countries, such as Denmark or Ireland. When looking at country group averages, the relative share of household energy expenditure within total expenditure can be observed to increase from the poorest country group (countries with GDP per capita below 60% of the EU-27 average) towards the richer country groups; mostly due to (on average)

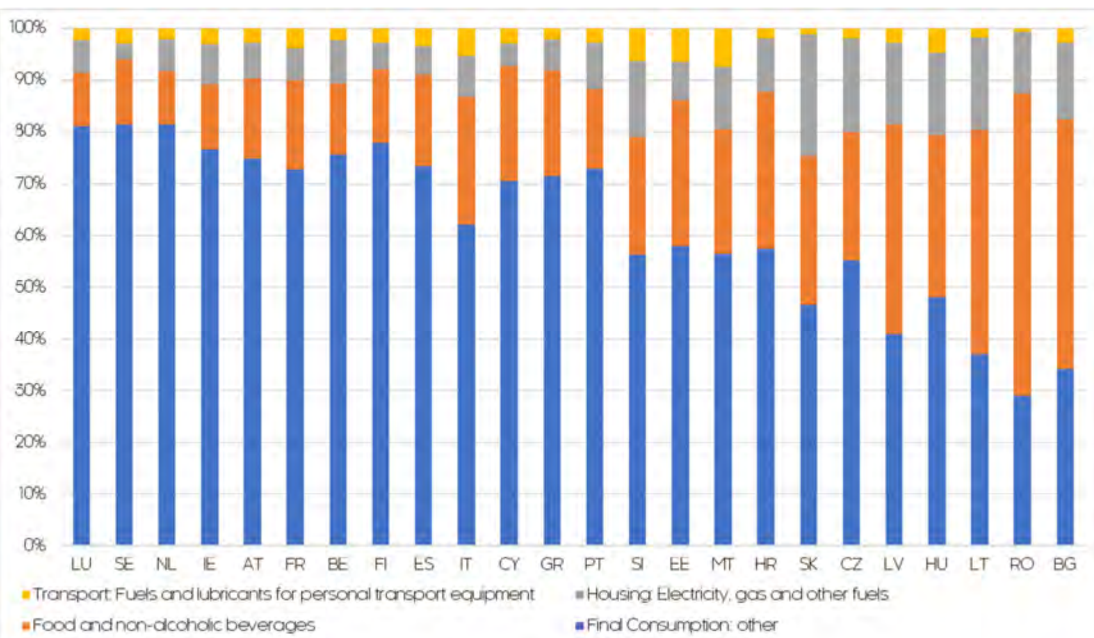
[232] Based on a recent, comprehensive study investigating the impact of energy prices and costs on households: European Commission – DG Energy (2018) Study on Energy Prices, Costs and Subsidies and their Impact on Industry and Households. Available at: https://www.enerdata.net/about-us/company-news/energy-prices-and-costs-in-europe.pdf

[233] Todts, W. (2020) Road transport in the EU ETS: A high-risk, low-reward strategy. Euractiv online, 10 Jan 2020. Available at: https://www.euractiv.com/section/energy-environment/opinion/road-transport-in-the-eu-ets-a-high-risk-low-reward-strategy/

poorer countries' households spending a relatively larger amount of their disposable income on Food and non-alcoholic beverages.

Figure 98. Distribution of final household expenditure (as % of total) across main expenditure categories in EU-27 countries and for the relevant country groups, Poor households (Decile 1), EUR per household, data of latest available





Source: Cambridge Econometrics calculations, based on final household expenditure data provided by the European Commission, DG Climate Action.

Notes: Data is for latest available year for all countries (oldest year: 2010, latest year: 2015). Countries ordered by total final consumption expenditure, largest to smallest. Group averages represent averages for MS groups below 60% of EU average GDP/capita, between 60% and 100% of EU avg GDP/capita, EU average and MS group with above EU average GDP/capita. DE, DK, PL not included in EU averages, no data available on transport fuel expenditure.

To better illustrate the initial structure of household expenditure in the three investigated income categories (*baseline*), as well as the distributional impacts of an assumed hypothetical percentage increase in natural gas price on household expenditure (*scenario*) will be presented in detail in tables. An exemplary table for Austria is shown below.

Table 92. Distribution of final household expenditure, in baseline and scenario, across the main expenditure categories in Austria, EUR per household, Decile 1, Decile 3 and Decile 5

	Poor households (Decile 1)		Lower-middle class households (Decile 3)		Middle class households (Decile 5)	
	baseline	scenario	baseline	scenario	baseline	scenario
Final Consumption expenditure	**17,035**	**17,035**	**22,119**	**22,119**	**29,858**	**29,858**
Food and non-alcoholic beverages	**2,643**	**2,631**	**3,055**	**3,043**	**3,703**	**3,689**
Housing, water, electricity, gas and other fuels	**4,612**	**4,628**	**5,153**	**5,173**	**5,912**	**5,925**
Electricity, gas and other fuels	1,157	1,173	1,305	1,325	1,535	1,548
Electricity	576	576	617	617	690	690
Gas	*152*	*158*	*230*	*238*	*245*	*254*
Liquid fuels	*154*	*160*	*168*	*174*	*218*	*226*
Solid fuels	*138*	*143*	*135*	*140*	*167*	*173*
Heat Energy	135	135	155	155	205	205
Electricity, gas and other fuels: other	2	2	0	0	10	10
Housing, water, electricity, gas and other fuels: other	3,455	3,455	3,848	3,848	4,377	4,377
Transport	**1,664**	**1,697**	**2,893**	**2,930**	**4,566**	**4,624**
Fuels and lubricants for personal transport equipment	491	524	723	760	1,125	1,183
Diesel	*216*	*230*	*363*	*382*	*616*	*648*
Petrol	*270*	*288*	*354*	*372*	*500*	*526*

	Poor households (Decile 1)		Lower-middle class households (Decile 3)		Middle class households (Decile 5)	
Fuels and lubricants for personal transport equipment: other	*5*	*5*	*6*	*6*	*9*	*9*
Transport: other (e.g. Spares parts and accessories for personal transport equipment, such as tyres; or Maintenance and repair of personal transport equipment)	1,173	1,173	2,170	2,170	3,441	3,441
Final Consumption: other	**8,116**	**8,079**	**11,018**	**10,973**	**15,677**	**15,619**
Share of household fossil fuel energy expenditure in total (%)	2.6%	2.7%	2.4%	2.5%	2.1%	2.2%
Share of transport energy expenditure in total (%)	2.9%	3.1%	3.3%	3.4%	3.8%	4.0%

The *change* in the *distribution of disposable income across consumption categories* as a result of an increase in natural gas price is derived based on

1) Data on absolute consumer expenditure on transport and heating fuels

2) The share of spending on transport and heating fuels within that total expenditure, per three income groups:

- Poor households (Decile 1)
- Lower-middle class households (Decile 3)
- Middle class households (Decile 5)

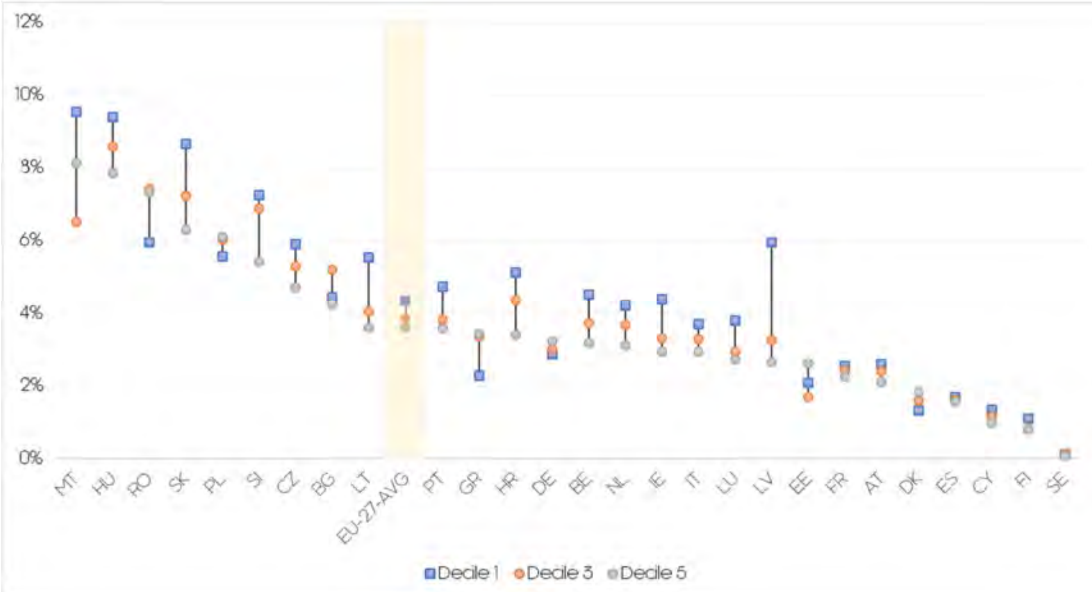
3) A hypothetical increase in transport fuel price and household fuel price separately, both induced by an increase in natural gas price.

The below charts present the initial share of household fossil fuel energy expenditure in total final consumption expenditure, and the share of household transport fuel expenditure in total final consumption expenditure; and the resulted increase in these shares in these three income categories, driven by the modelled hypothetical price increase.

In sum, poorest households (Decile 1) are expected to be impacted relatively the most negatively in case of Household fossil fuel energy, mainly as a result of their initial large share of energy- / transport-related expenditure within total expenditure and the relatively low price elasticity of household fossil fuel energy demand.

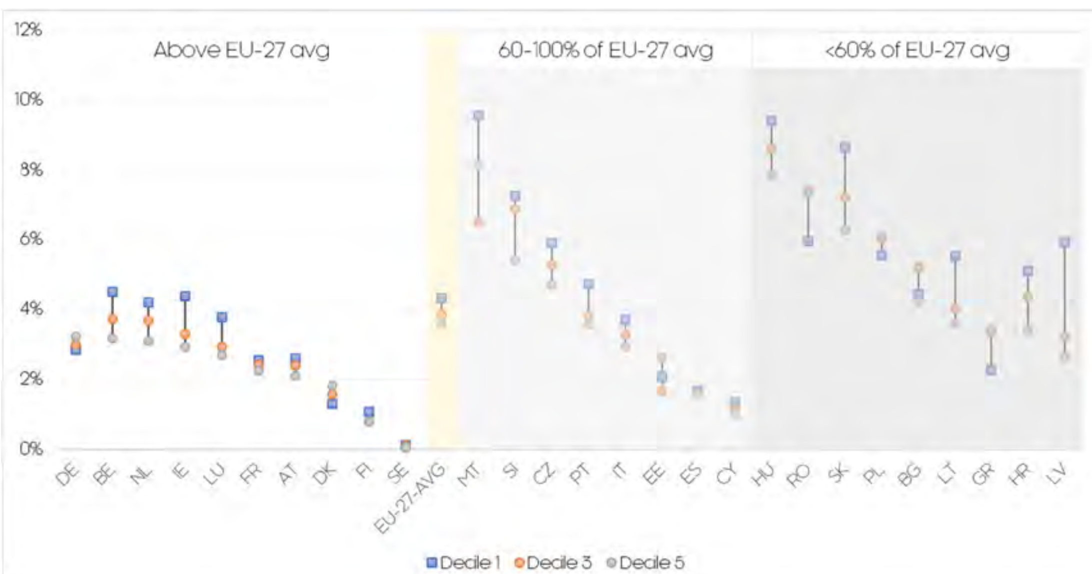
Initial results are a bit more mixed for household transport fuel expenditure. It is important to highlight that the initial share of transport fuel costs within total final consumption expenditure, in contrast to the case of household fossil fuel energy costs, tend to be the highest for Decile 5 out of the three investigated income groups, and clearly lowest for Decile 1. Largely explained by this initial observation, an increase in transport fuel costs will have the relatively largest impact for Decile 5, while the relative increase in transport fuel expenditure (at the expense of other types of expenditure) is also notable for most countries' Decile 3 groups.

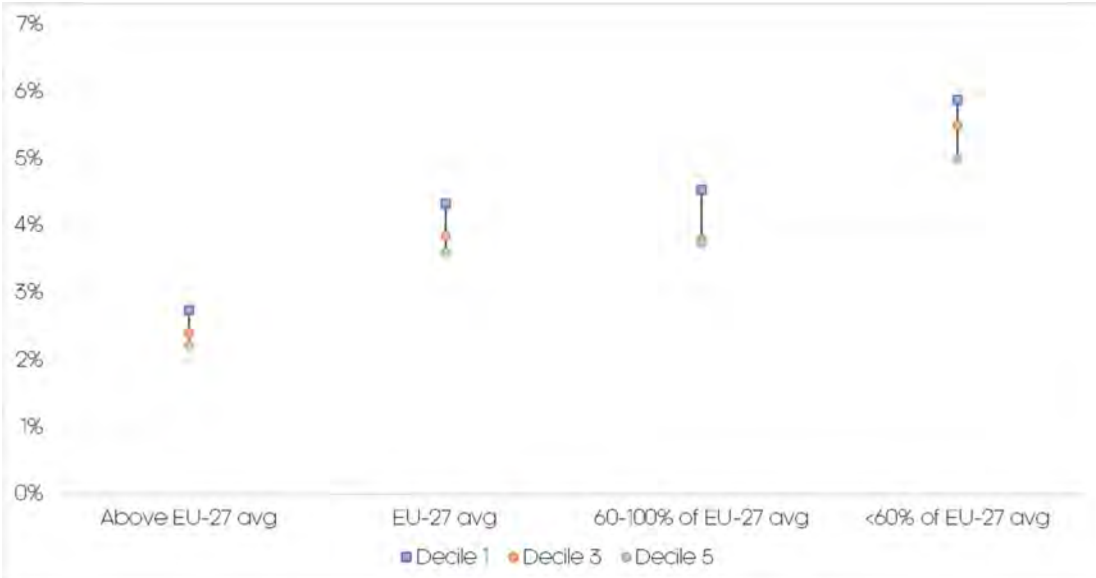
Figure 99. Share of Household fossil fuel energy expenditure in total final consumption expenditure of Decile 1, 3 and 5, in EU-27, %



Source: Cambridge Econometrics calculations, based on final household expenditure data provided by DG Climate Action. Data is for the latest available year for all the countries (oldest year: 2010, latest year: 2015). Ordered by share of household fossil fuel energy expenditure in total final consumption expenditure in Middle class households (Decile 5), largest to smallest.

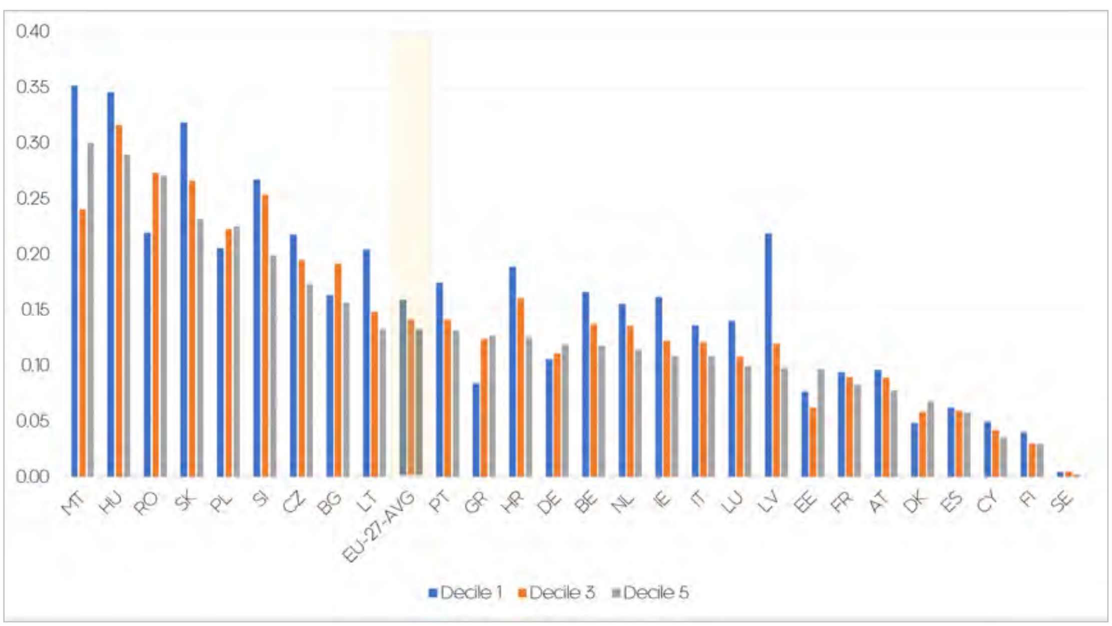
Figure 100. Share of Household fossil fuel energy expenditure in total final consumption expenditure in EU-27 countries grouped by GDP per capita (above EU-27 avg, 60-100% of EU-27 avg, <60% of EU-27 avg), and country group averages, in Decile 1, 3 and 5, %





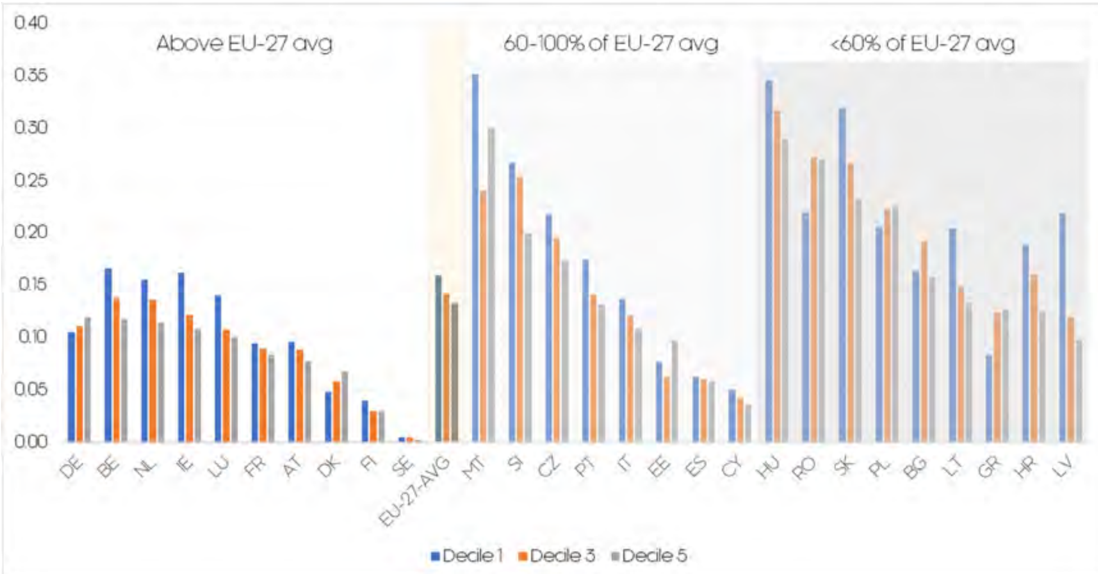
Source: Cambridge Econometrics calculations, based on final household expenditure data provided by DG Climate Action. Data is for the latest available year for all the countries (oldest year: 2010, latest year: 2015). Split into country groups by GDP/capita, within group ordered by share of expenditure in total final consumption expenditure in Middle class households (Decile 5), largest to smallest.

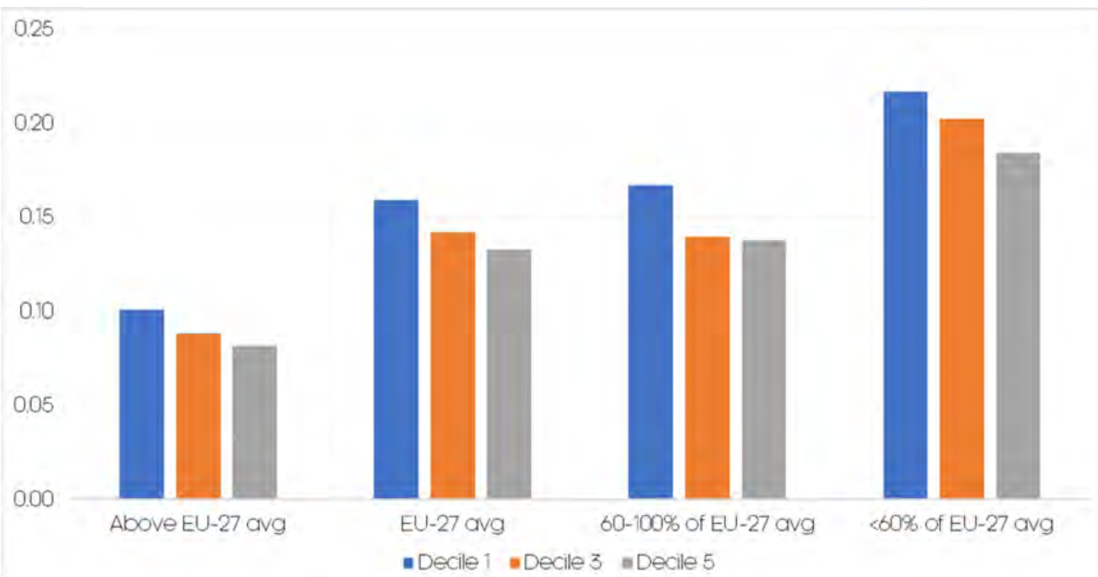
Figure 101. Percentage point increase in share of Household fossil fuel energy expenditure in modelled scenario vs. baseline in EU-27, in Decile 1, 3 and 5



Source: Cambridge Econometrics calculations, based on final household expenditure data provided by DG Climate Action and the assumptions introduced earlier in this section. Data is for the latest available year for all the countries (oldest year: 2010, latest year: 2015). Ordered by share of household fossil fuel energy expenditure in total final consumption expenditure in Middle class households (Decile 5), in baseline, largest to smallest.

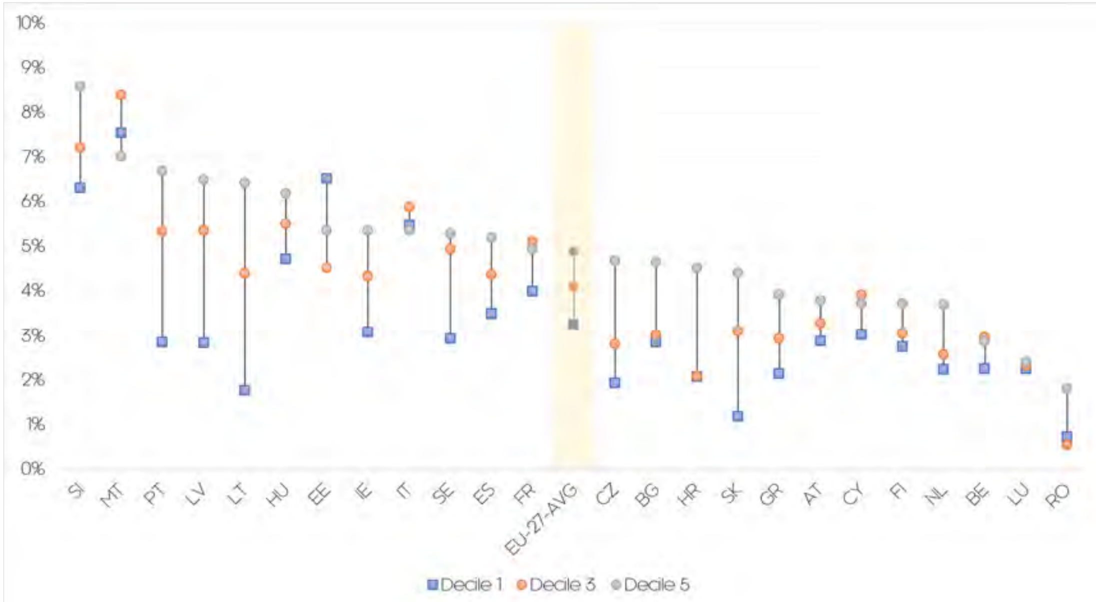
Figure 102. Percentage point increase in share of Household fossil fuel energy expenditure in modelled scenario vs. baseline in EU-27 countries grouped by GDP per capita (above EU-27 avg, 60-100% of EU-27 avg, <60% of EU-27 avg), and country group averages, in Decile 1, 3 and 5





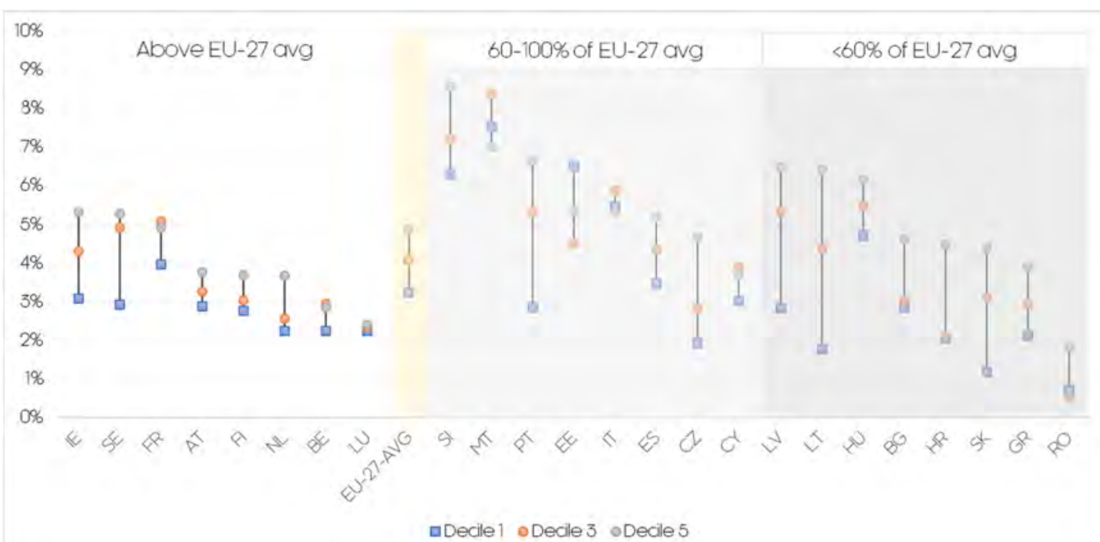
Source: Cambridge Econometrics calculations, based on final household expenditure data provided by DG Climate Action. Data is for the latest available year for all the countries (oldest year: 2010, latest year: 2015). Split into country groups by GDP/capita, within group ordered by share of expenditure in total final consumption expenditure in Middle class households (Decile 5), largest to smallest.

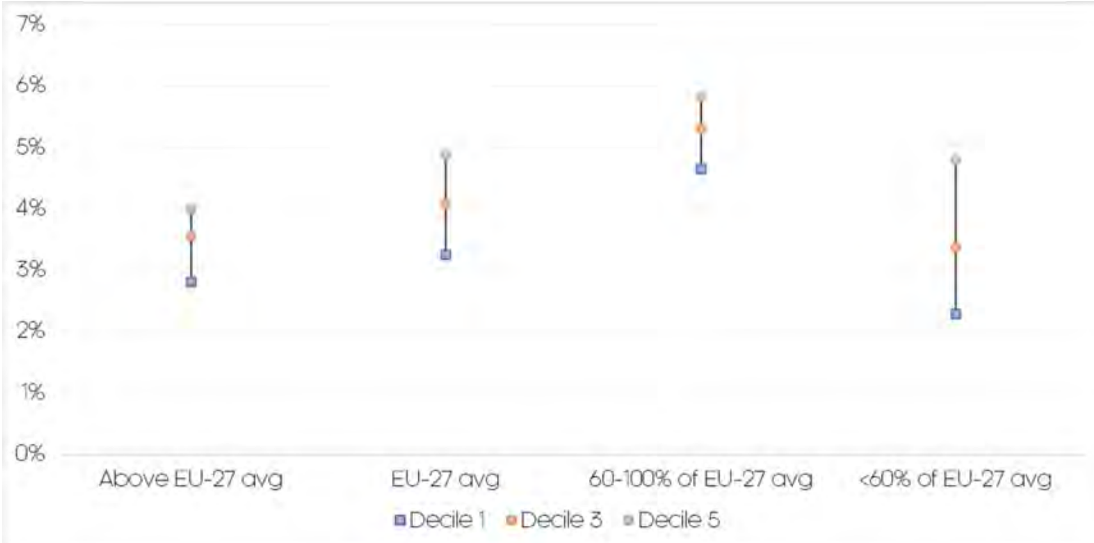
Figure 103. Share of Household transport fuel expenditure in total final consumption expenditure of Decile 1, 3 and 5, in EU-27, %



Source: Cambridge Econometrics calculations, based on final household expenditure data provided by DG Climate Action. Data is for the latest available year for all the countries (oldest year: 2010, latest year: 2015). Ordered by share of household transport fuel expenditure in total final consumption expenditure in Middle class households (Decile 5), largest to smallest.

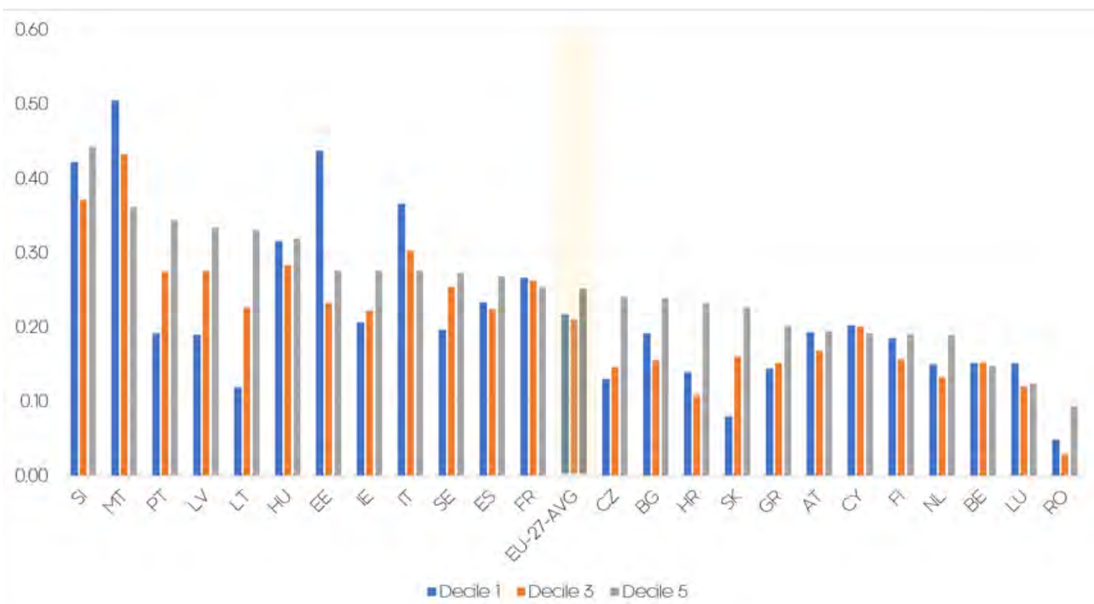
Figure 104. Share of Household transport fuel expenditure in total final consumption expenditure in EU-27 countries grouped by GDP per capita (above EU-27 avg, 60-100% of EU-27 avg, <60% of EU-27 avg), and country group averages, in Decile 1, 3 and 5, %





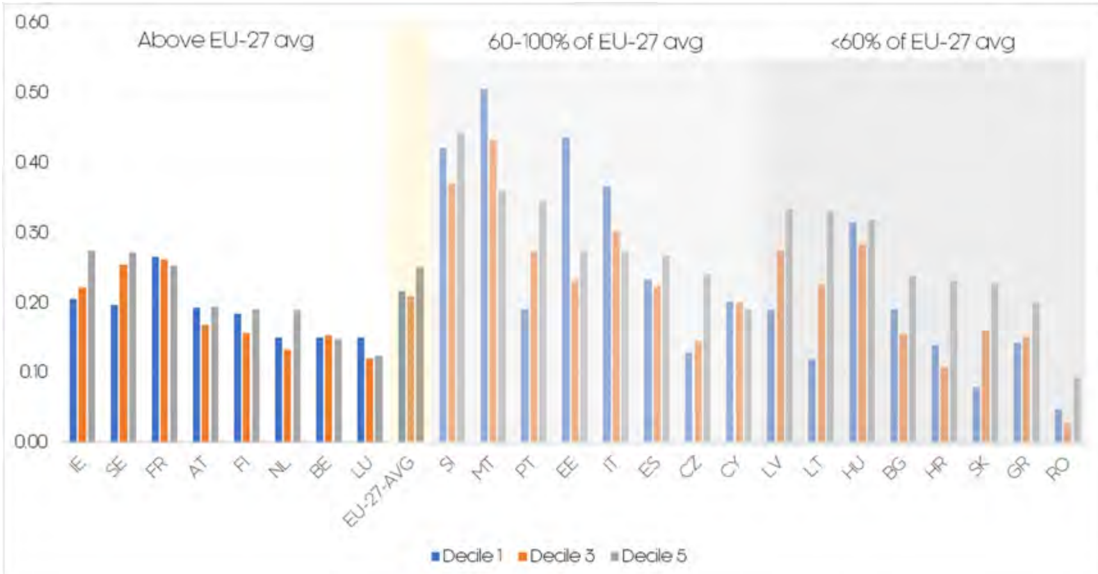
Source: Cambridge Econometrics calculations, based on final household expenditure data provided by DG Climate Action. Data is for the latest available year for all the countries (oldest year: 2010, latest year: 2015). Split into country groups by GDP/capita, within group ordered by share of expenditure in total final consumption expenditure in Middle class households (Decile 5), largest to smallest.

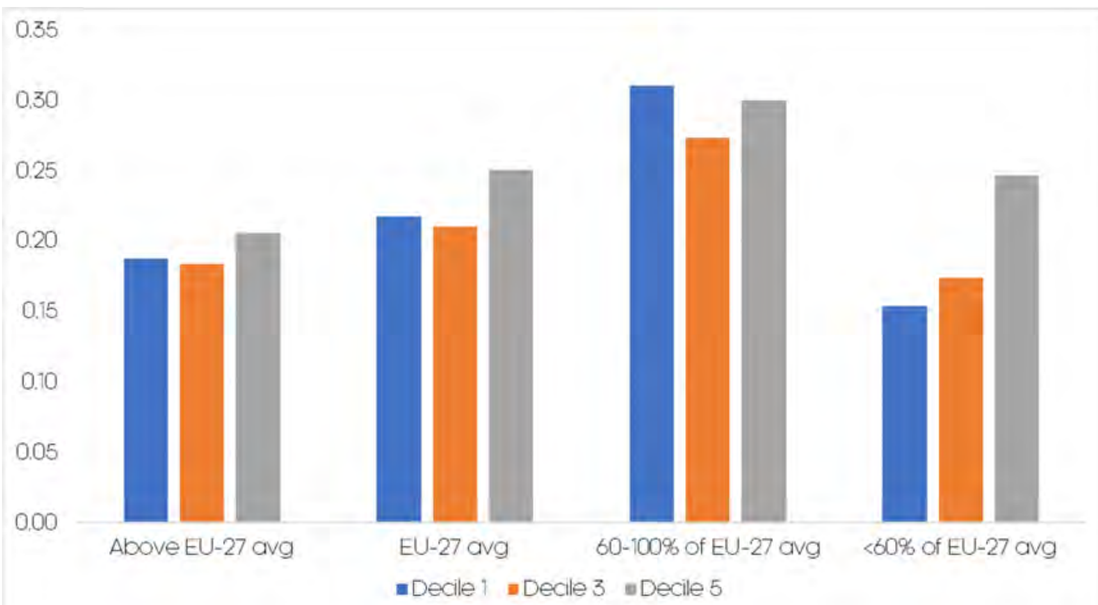
Figure 105. Percentage point increase in share of Household transport fuel expenditure in modelled scenario vs. baseline in EU-27, in Decile 1, 3 and 5



Source: Cambridge Econometrics calculations, based on final household expenditure data provided by DG Climate Action and the assumptions introduced earlier in this section. Data is for the latest available year for all the countries (oldest year: 2010, latest year: 2015). Ordered by share of household transport fuel expenditure in total final consumption expenditure in Middle class households (Decile 5), in baseline, largest to smallest.

Figure 106. Percentage point increase in share of Household transport fuel expenditure in modelled scenario vs. baseline in EU-27 countries grouped by GDP per capita (above EU-27 avg, 60-100% of EU-27 avg, <60% of EU-27 avg), and country group averages, in Decile 1, 3 and 5





Source: Cambridge Econometrics calculations, based on final household expenditure data provided by DG Climate Action. Data is for the latest available year for all the countries (oldest year: 2010, latest year: 2015). Split into country groups by GDP/capita, within group ordered by share of expenditure in total final consumption expenditure in Middle class households (Decile 5), largest to smallest.

6 TASK 5. Possible inclusion into an emissions trading system of all fossil fuel emissions

A more radical extension of the current ETS than the above described options would be its extension to all GHG emissions from the extraction and use of fossil fuels. In this case all CO_2 emissions resulting from the combustion of fossil fuels as well as CO_2 and methane (CH_4) emissions resulting from the extraction of the fuels are considered. This option would have the advantage that it would cover almost all man-made greenhouse gas emissions. Only the non-energy GHG emissions from agriculture and waste in some cases also the process emissions from e.g. clinker production or from the chemical industry would not be covered by such an approach. On the other hand, such an approach also affects very small businesses, for which additional costs may cause major financial problems. According to the most recent GHG inventories of the EU, the most important additional (sub-)sectors are small emitters from the industry sector, not covered by the current ETS, as well as fugitive emissions from fossil fuel extraction, navigation and fossil fuel use in the agricultural and forestry sector (all with annual greenhouse gas emissions higher than 20 Mt). Smaller (sub-) sectors not yet covered are non-electric rail transport, fishery and the military sector (all with annual greenhouse gas emissions lower than 10 Mt). Table 93 gives an overview of the additional emissions covered by this approach compared to an extension to include the buildings and transport sectors. In total, this would cover about 262 Mt. more CO_2e, as if the extension only covered buildings and road transport. The additional emissions that would be covered by an ETS would therefore be about 20% higher than if the extension included only buildings and road transport.

Table 93. Additional emission sources covered in this approach compared to an extension only to the buildings and transport sector

Emission source	Emissions in 2017
Non-ETS industries	81 Mt. CO_2
Fugitive Emissions	80 Mt. CO_2e
Fuel use in agriculture	70 Mt. CO_2
dom. navigation	16 Mt. CO_2
Non-electric railway	4 Mt. CO_2
Other	10 Mt. CO_2

Source: Fraunhofer ISI illustration based on EEA, Annual European Union greenhouse gas inventory

The option of an ETS covering all fossil GHG emissions was also already discussed and assessed in the period 2012-2014. The most promising option was seen to be given by an even more upstream approach than those discussed for the extension to road transport and buildings, namely, to regulate fossil fuel importers and extractors as well as the users of fossil fuels for non-energy purposes. This approach could be applied to all fossil GHG emissions. In this case, there would be substantially less regulated entities than in the current ETS, namely 3,000 instead of the 13,000 regulated entities (CE Delft 2014). This approach, however, could be applied only to those outside the current ETS as well. Again, the general architecture of the extension as well as the interaction with the existing regulatory framework will have a large impact on the effectiveness of such an ETS extension.

As is the case for an extension to road transport and buildings, it is important to understand the use of fossil fuels and the existing abatement potentials in the additional sectors. Accordingly, Task 6.1 analyses energy consumption, emissions and abatement options in the three largest additional sectors (non-ETS industry, fugitive emissions, fossil fuel use in agriculture), Task 6.2 assesses a number of design options for an emissions trading scheme covering all fossil fuels and Task 6.3 analyses their interaction with existing regulatory framework.

6.1 Question 5.1: Energy use, emissions, abatement possibilities outside the EU ETS in sectors other than Road Transport and Buildings

Under Question 5.1, we take a look at the supply chains of natural gas, mineral oil products and coal products and analyse whether there are any deviations from the supply chains analysed in section 2, we assess quantitatively the use of fossil fuels and greenhouse gas emissions and describe possible abatement options and related barriers in the non-ETS sectors that are not part of the road transport and buildings sector. As mentioned above we analyse fugitive emissions from fossil fuel extraction, small emitters from industry and emissions from fuel use in agriculture and forestry. The minor sectors are not included in the analysis because of their low emissions and thus their minor importance, but this does not mean that these sectors are necessarily exempt from a fossil fuel ETS. Navigation is also not considered here, as it is already subject to analysis in other projects of the EU Commission. In addition to the three sectors, as in the previous sections, a distinction is made between solid, gaseous and liquid fuels, resulting in coal, gas and petroleum-based fuels.

6.1.1 Supply Chains of fossil fuels in non-ETS sectors and not part of the road transport and buildings sector

The fossil fuel supply chains for non-ETS industries and agriculture differ only slightly from the supply chains analysed in section 2. This applies in particular to the highly regulated natural gas sector and the petroleum products. Drawing a supply chain for fugitive emissions makes no sense, as these emissions are emitted during the extraction, production, processing and transport of fuels, so that they affect the whole supply chain and do not result from one source by burning fuels at a specific site.

Gas products

As mentioned in previous section 3.2, industry is supplied with natural gas either through the distribution grid or the transmission grid. This includes both the industry covered by the EU ETS and the industry that is not regulated in the EU ETS, although in the latter case it can be assumed that a large part of these industries are more likely to be connected to the distribution grid as they only buy small quantities. The same can also be assumed for agriculture, forestry and other sectors, as the highly regulated market makes it almost impossible to supply large quantities of natural gas outside the grids. Only a very small amount is provided via gas cylinders, which are not considered in this analysis due to their minor importance. The supply chain therefore has no further elements than the supply chain already described in section 2 and section 3.2.

Mineral oil products

For mineral oil products there is a difference to the buildings and transport sectors with regard to the industrial sector, as large industry is usually supplied directly by refineries. This is done via pipelines (e.g. BASF pipeline from Karlsruhe to Ludwigshafen), ships, rail or trucks. This means that independent suppliers are not always placed between the refinery and the industry in the supply chain. The last stages of the supply chain are therefore mostly bypassed by the industry. The supply chain for the other sectors, such as agriculture and forestry, does not include any important stages other than those analysed in the previous sections. Although agricultural diesel and other fuels used in agriculture are exempt from energy tax in some Member States, farmers generally buy their fuel from petrol stations and can then receive compensation equal to the amount of the energy tax.

Coal

Coal is the least regulated market of the three main fuels and the supply chain is therefore the least transparent. For the industrial sector, it can be assumed that a large part of the coal is purchased from terminals, storage depots or directly from the producer. The coal is then delivered by rail, ship or truck. The same applies to the other sectors, such as agriculture and forestry, although, depending on the size of the firm, they may also buy their coal from coal suppliers or retailers. So, there are no specific elements in the supply chain for the agricultural or non-ETS industry that are not included in the supply chains presented in section 2.

6.1.2 Use of fossil fuels in non-ETS sectors and not part of the road transport and buildings sector

In the following we analyse the amount of fossil fuels used per fuel type in the three categories non-ETS industry, fugitive emissions and agriculture and forestry in all the Member States.

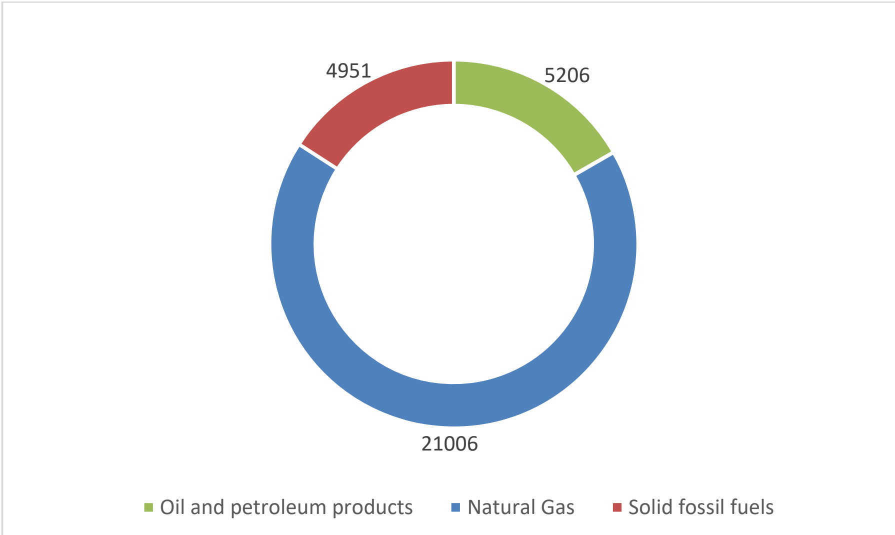
Use of fossil fuels in non-ETS industries

The data shown in this section as well as the data on emissions from non-ETS industries shown in section 6.1.3 are estimates by Enerdata based on total industrial emissions and industrial emissions covered by the EU ETS. The shares of fuels were assumed similar in EU ETS industries and non-regulated industries.

Figure 107 shows the fossil fuel use of the non-ETS regulated industries by fuel type in 2017. 31,163 thousand tonnes of oil equivalent were used in total, of which 17% was oil products, 67% natural gas and 16% solid fossil fuels. In 2005, about 77,306 thousand TOE were used, a decrease of about 60%, with oil products showing the highest decrease (-71%) and natural gas the lowest (-54%).[234]

[234] Non-biogenic waste is also considered a non-renewable fuel, but no data on its use in the non-ETS industry were available.

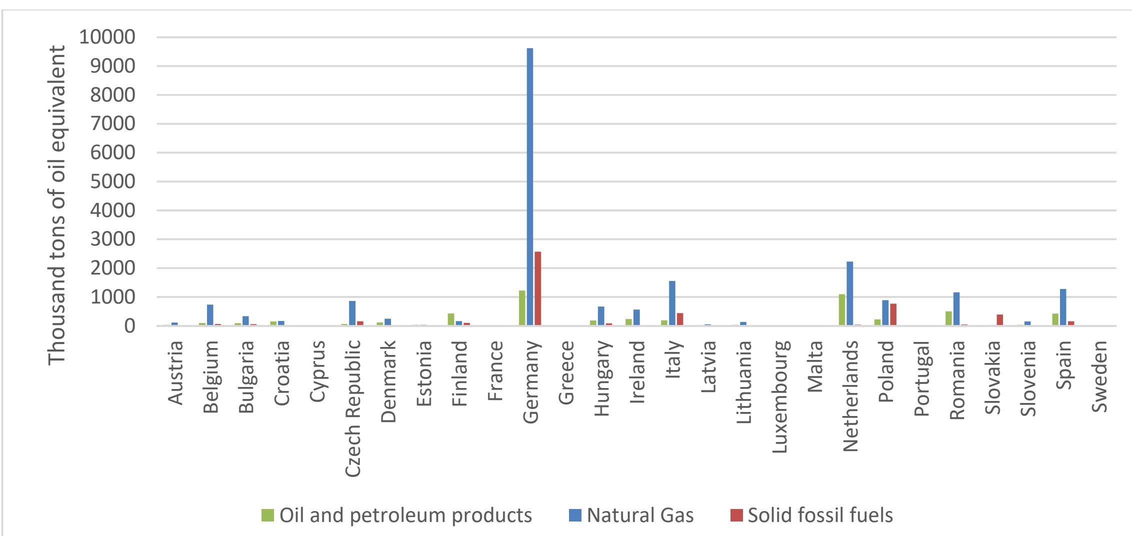
Figure 107. Fossil fuel use in non-ETS industries in EU in 2017 in thousand tons of oil equivalent



Source: Enerdata estimation.

Figure 108 shows the use of fuels by Member State. Germany shows the highest share with about 43% of all industrial fuel use not regulated in the EU ETS. It is followed by the Netherlands with about 11%, Italy with 7% and Poland and Spain with 6%. In most Member States, natural gas is the most commonly used fuel. Coal plays a significant role in Germany, Poland, Slovakia, Italy and the Czech Republic in particular. Petroleum products mainly in Germany, the Netherlands, Romania, Spain and Finland, where it is even the main fuel in non-ETS industries.

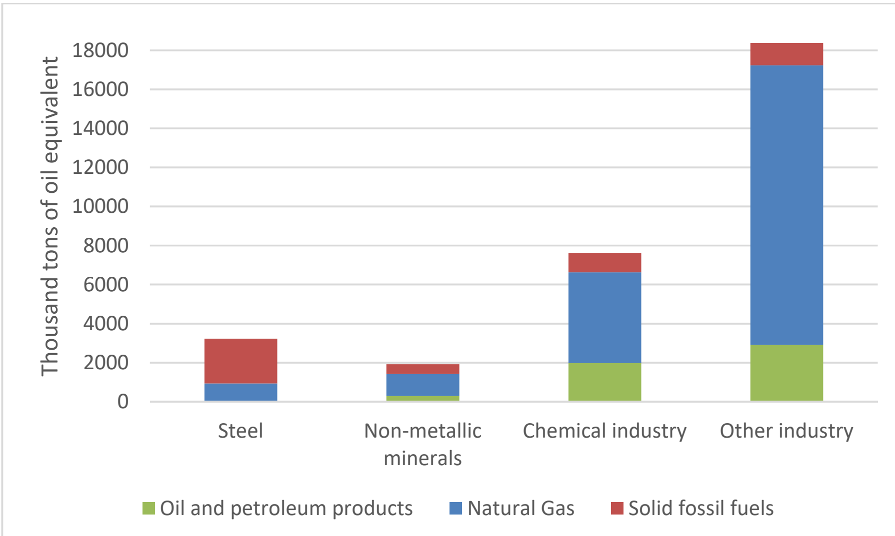
Figure 108. Fuel use in non-ETS industries in EU-ETS Region in 2017 per Member State in thousand tons of oil equivalent



Source: Enerdata estimation.

Figure 109 shows the fuel use in specific sectors. The chemical industry shows the highest fuel use with about 7,632 thousand TOE, the steel industry about 3,233 and the non-metallic minerals about 1,918 thousand TOE. The remainder of 18,379 thousand TOE is attributable to the other industries. It can be seen that the steel industry uses mainly coal fuels, whereas natural gas is the main fuel in all the other industries.

Figure 109. Fuel use in selected industrial sectors outside the EU ETS in 2017 per fuel in thousand tons of oil equivalent

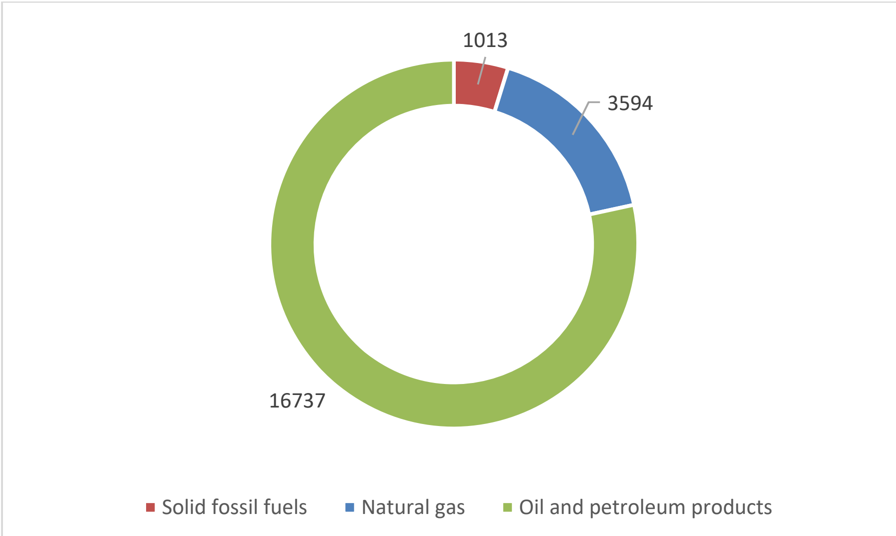


Source: Enerdata estimation.

Use of fossil fuels in Agriculture, Forestry and Fisheries sector

Figure 110 shows the quantities of natural gas, solid fossil fuels and oil and petroleum products used for energetic purposes in agriculture, forestry and fisheries in 2017 in thousand tonnes of oil equivalent, based on the figures of the energy balances from EUROSTAT. In 2017, a total of 21,344 thousand TOE were used in the EU ETS member states in the sector under consideration, which implies a decrease of almost 25% since 1990. Oil and petroleum products account for 78%, by far the largest share, followed by gas with a share of about 17%, whereas solid fuels (coal-based) account for only 5%. These shares have remained roughly the same since 1990. However, coal use has decreased the most, while oil and

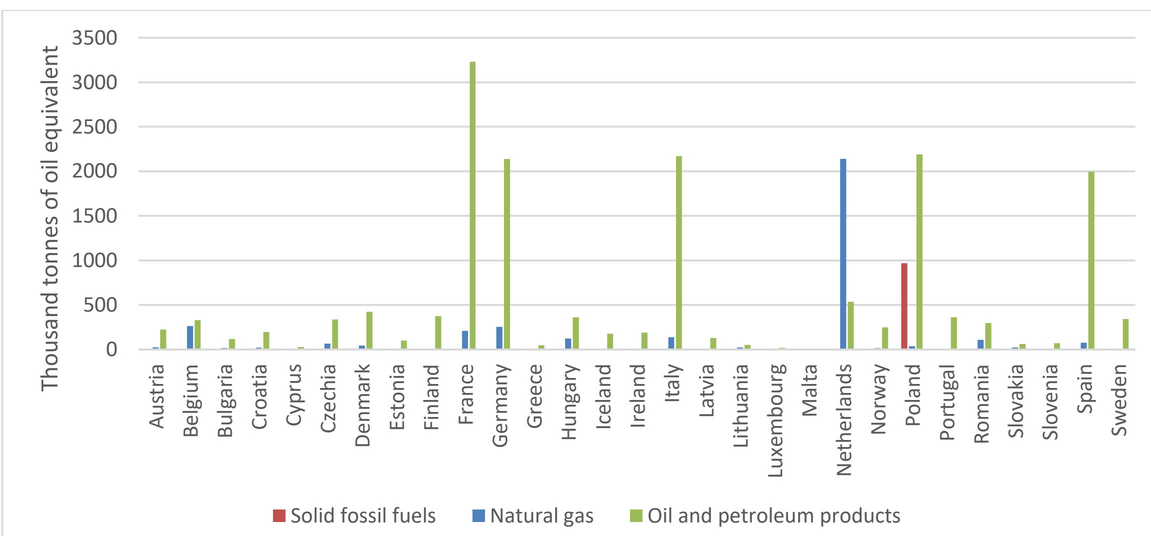
Figure 110. Fuel use in Agriculture/Forestry/Fisheries sector in EU-ETS Region in 2017 in thousand tons of oil equivalent



Source: EUROSTAT, Energy balances

Figure 111 shows the use of the three fuels in agriculture, forestry and fisheries for each Member State. In all Member States, except the Netherlands where mainly natural gas is used, oil and petroleum products are the main fuel. Poland is the only member state in which solid fossil fuels are also widely used. It is also evident that the highly populated countries France, Germany, Italy, Spain and Poland in particular have high fuel consumption. An exception to this is Romania, which ranks after these countries in terms of population, but has a relatively low fuel consumption in the sector under consideration, which is surprising, as Romania has large agricultural areas.

Figure 111. Fuel use in Agriculture/Forestry/Fisheries sector in EU-ETS Region in 2017 per Member State



Source: EUROSTAT, Energy balances
Volume for Germany for petroleum products from 2018, as value for 2017 is missing.

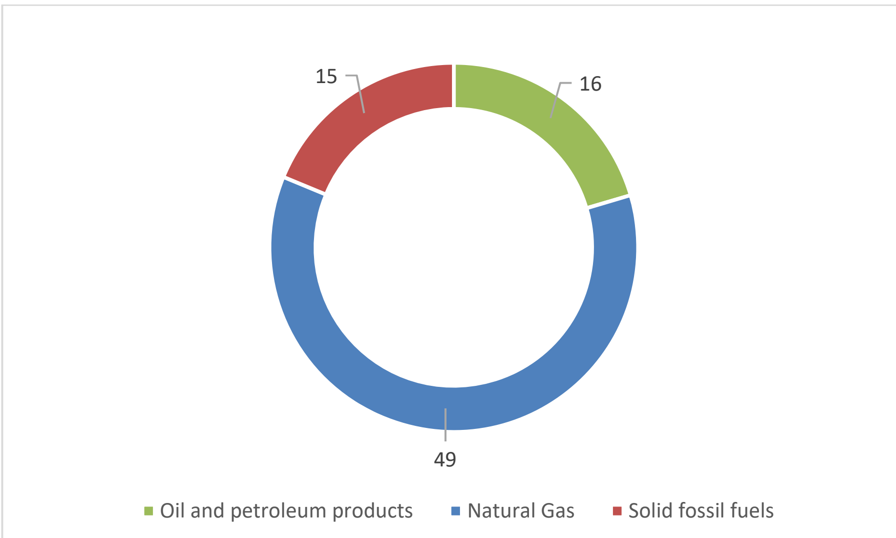
6.1.3 Greenhouse Gas Emissions from fossil fuels in non-ETS sectors and not part of the road transport and buildings sector

In addition to the quantities of fossil fuels used, we analyse in the following section the GHG emissions in total and per Member States three categories non-ETS industry, fugitive emissions and agriculture and forestry.

Emissions in non-ETS industries

As can be seen in Figure 112, in 2017 81 Mt CO_2 were emitted in the industry not regulated by the existing EU ETS. Of this, 20% was due to oil and petroleum products, 61% to natural gas and 19% to the combustion of solid fossil fuels. In 2005, non-ETS emissions amounted to 199 Mt. CO_2, a decrease of 59%, with the largest decrease (71%) being realised in emissions from petroleum products.

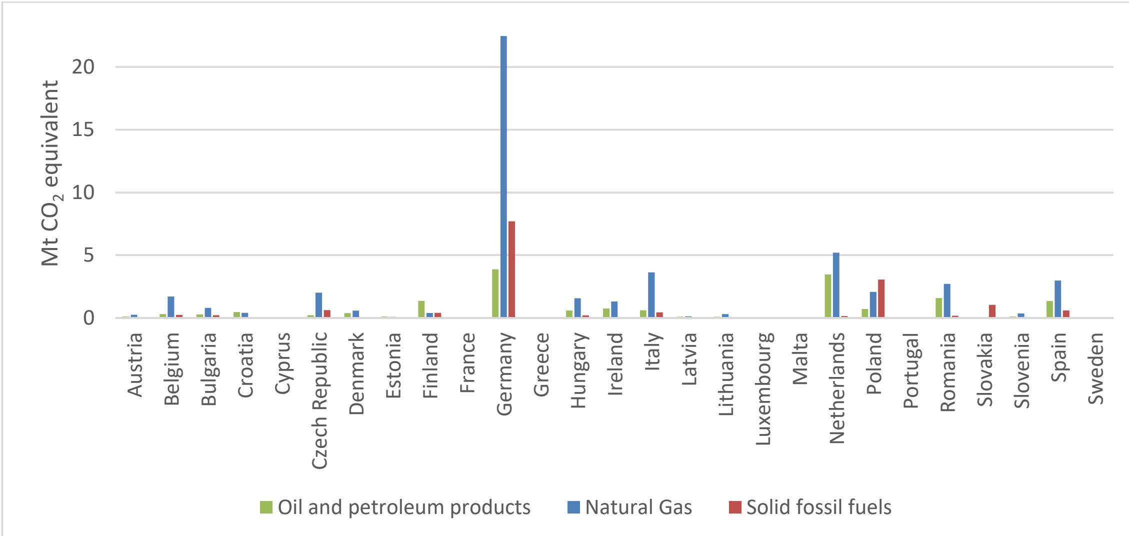
Figure 112. Emissions from non-ETS Industries in 2017 per fuel in Mt CO_2



Source: Enerdata estimation.

Figure 113 shows the emissions of industries not regulated under the EU ETS in the member states in 2017 in Mt CO_2 equivalent. Germany with 34, Netherlands with 9, Poland with 6 and Italy and Spain with 5 Mt CO_2 equivalent were the member states with the highest industrial emissions outside the EU ETS. As is already the case with fuel use, it can also be seen from the emissions that natural gas accounts for the largest share of emissions in almost all member states. Only in Poland and Slovakia the largest share of emissions results from the combustion of coal fuels.

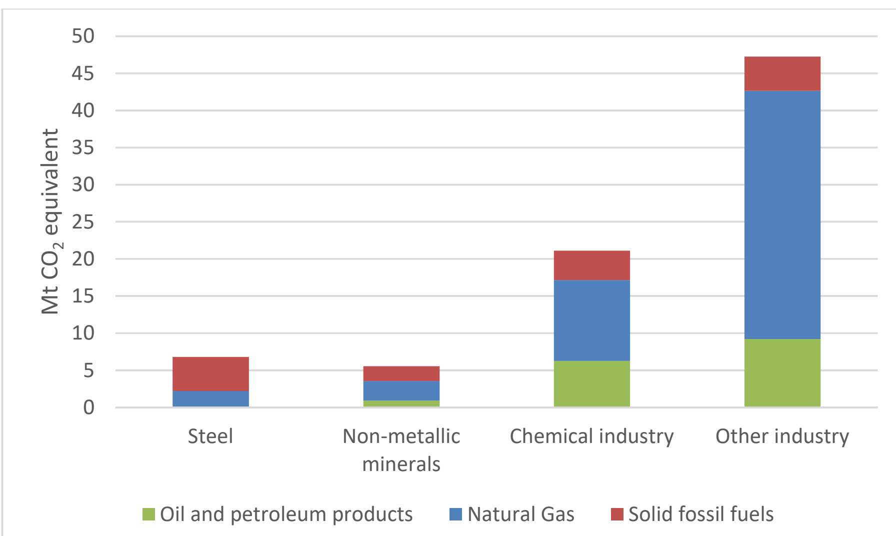
Figure 113. Emissions from non-ETS Industries in 2017 per MS and fuel in Mt CO_2 equivalent



Source: Enerdata estimation.

Figure 114 shows the emissions of selected sectors. The chemical industry shows the highest emissions with about 21 Mt CO_2, the steel industry about 7 and the non-metallic minerals about 6 Mt CO_2. Coal emissions have the largest share in the steel industry, whereas in all other industries, emissions from natural gas have the largest share.

Figure 114. Emissions of selected industrial sectors outside the EU ETS in 2017 per fuel in Mt CO_2 equivalent



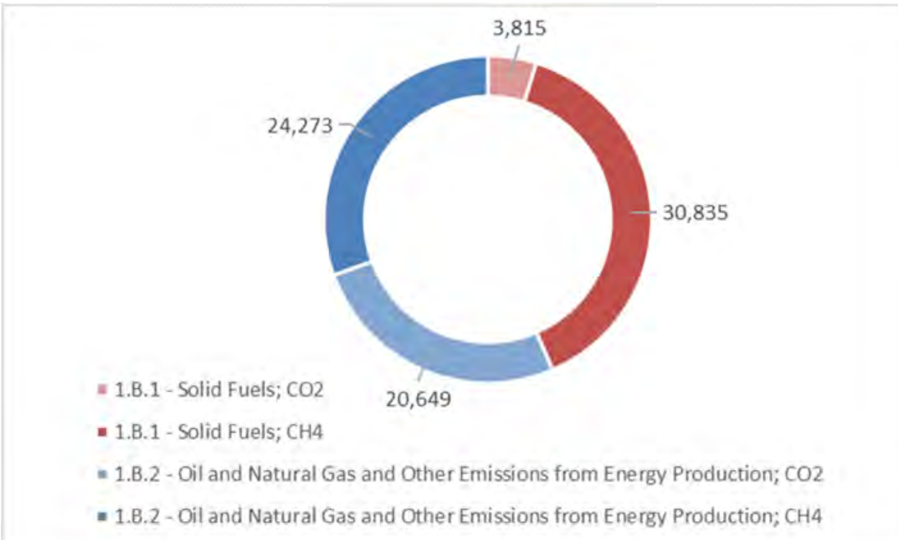
Source: Enerdata estimation.

Fugitive emissions from fossil fuels

Figure 115 shows the fugitive emissions in 2017 in Kt CO_2e and not in CO_2, since methane emissions in particular play a major role in fugitive emissions. A total of 79,572 Kt CO_2e was emitted into the atmosphere, of which about 44% (34,650 Kt

CO_2e) was caused by the mining and production of solid fuels and about 56% (44,922 Kt CO_2e) by the extraction, production, processing and transport of natural gas and petroleum products. In 1990, about 154,867 Kt CO_2e were emitted, which corresponds to a decrease of about 49% between 1990 and 2017. In total, approximately 69% of these emissions are methane emissions. In particular, the extraction of solid fuels leads to methane emissions (89%). In the case of liquid and gaseous fuels, the share of methane emissions is much lower at around 54%. In contrast to fuel combustion, which causes mainly CO_2 emissions, the focus of fugitive emissions must also be on methane emissions.

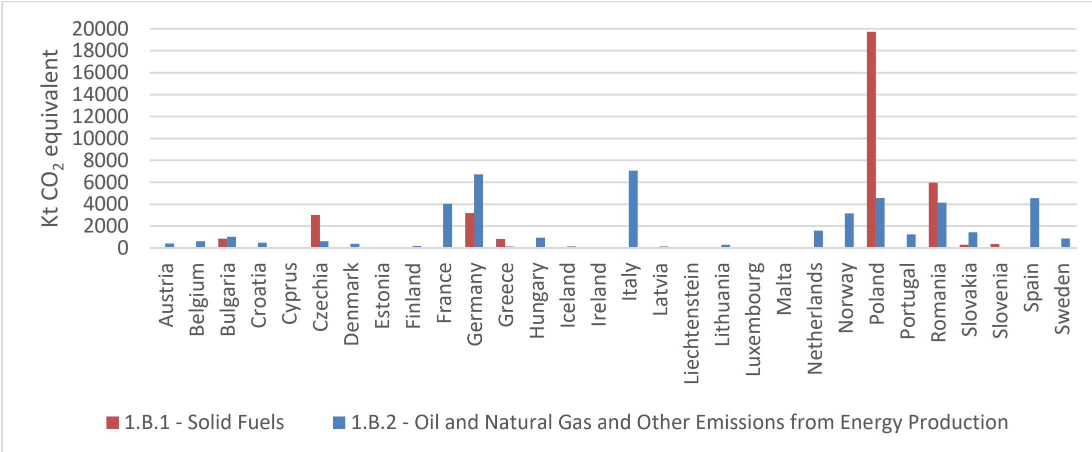
Figure 115. Fugitive Emissions from Fuels in EU-ETS Region in 2017 in Kt CO_2e



Source: EEA, Annual European Union greenhouse gas inventory

Figure 116 shows the fugitive emissions by Member State. It can be seen that most Member States have low emissions and most often only for gas and petroleum products. In the category of these products, Italy with 7,057 Kt CO_2e, Germany with 6,721 Kt CO_2e, Poland with 4,563 Kt CO_2e, Spain with 4,543 Kt CO_2e, France with 4,031 Kt CO_2e and Norway with 3,157 Kt CO_2e are the countries with the highest emissions. In the mining and production of solid fuels, the countries with the highest emissions are Poland 19,730 Kt CO_2e, Romania 5,957 Kt CO_2e, Germany 3,178 Kt CO_2e and the Czech Republic 3,023 Kt CO_2e. Emissions have decreased or remained unchanged in almost all countries between 1990 and 2017. The exceptions are Portugal, Spain and Sweden, whose fugitive emissions in the gas and petroleum

Figure 116. Fugitive Emissions from the production of fuels per Member State

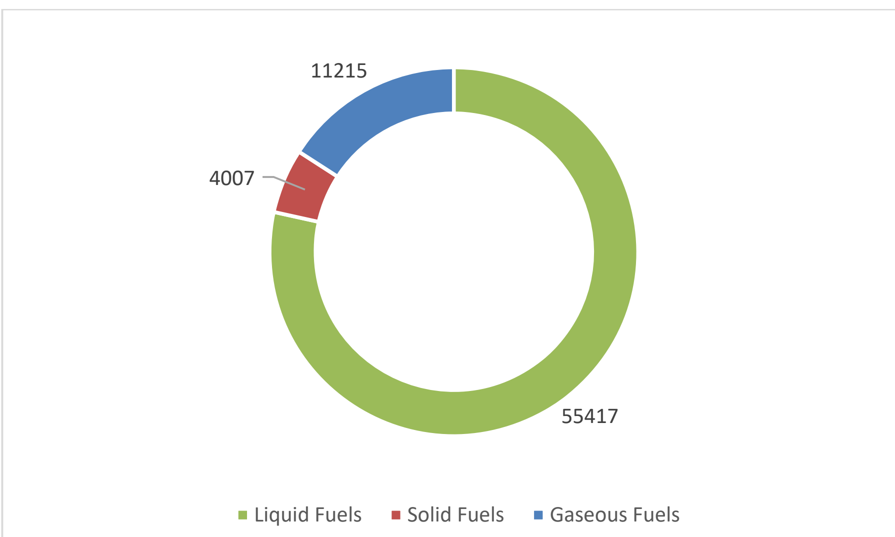


Source: EEA, Annual European Union greenhouse gas inventory

Emissions from fossil fuel use in Agriculture, Forestry and Fisheries sector

Figure 117 shows the emissions from agriculture, forestry and fisheries caused by energetic use of fossil fuels in 2017 in all the Member States, broken down by fuel. The fuels are used, for example, for the operation of machinery, power generation, and fishing vessels. A total of 70,639 Kt CO_2 was emitted, of which 55,417 Kt CO_2 (78%) was caused by liquid fuels, 11,215 Kt CO_2 (16%) by gaseous fuels and 4,007 Kt CO_2 (6%) by solid fuels. Between 1990 and 2017 emissions have decreased by about 18%.

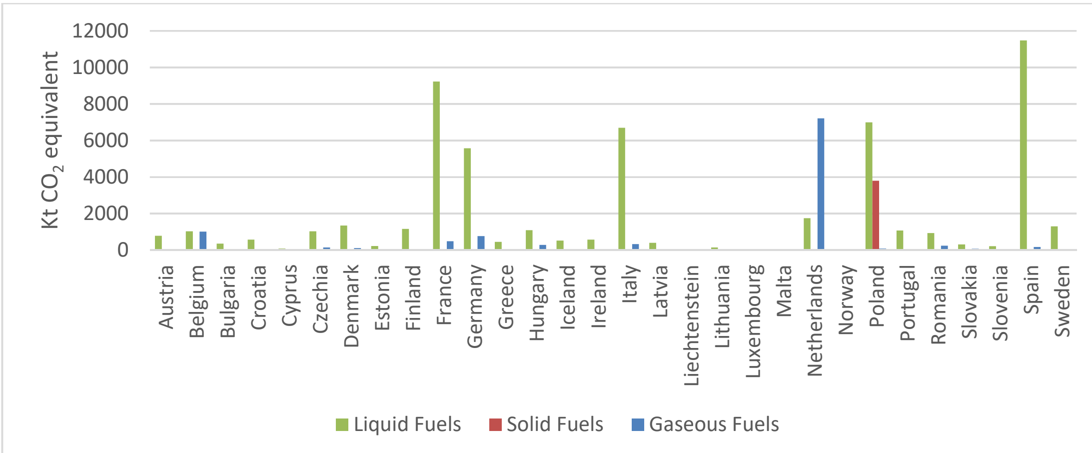
Figure 117. Emissions from fossil fuel use in Agriculture/Forestry/Fisheries sector in EU-ETS Region in 2017 in Kt CO_2



Source: EEA, Annual European Union greenhouse gas inventory

Figure 118 shows the emissions of the sector by Member State. Similar to the situation for fuel use, it can be seen that the largest emissions source in agriculture/forestry and fisheries in all countries except the Netherlands are liquid fuels. Gaseous fuels play only a minor role in all countries except the Netherlands, where it is the main source of emissions. Emissions from solid fuels, on the other hand, only play a larger role in Poland. In all other countries these emissions are very low.

Figure 118. Emissions from fossil fuel use in Agriculture/Forestry/Fisheries sector per Member State



Source: EEA, Annual European Union greenhouse gas inventory

6.1.4 Abatement options and related barriers in non-ETS sectors and not part of the road transport and buildings sector

In recent years, a number of studies have analysed the potential for reaching net-zero GHG emissions. However, the focus was mainly on the sectors with the highest GHG emissions. Niche sectors, such as fuel use in agriculture, or more unspecific emission sources, such as fugitive emissions, were analysed less strongly. Nevertheless, an overview of possible abatement options and barriers in the three areas of fuel use in agriculture, non-ETS industry and fugitive emissions is given in the following.

Agriculture, Forestry and Fishery

Fossil fuels in agriculture and forestry are mainly needed when machines such as tractors, harvesters or dryers are used. Fossil fuels in the fishing industry are mainly needed for the fishing vessels. Thus, energy emissions from agriculture and forestry are most comparable to the road transport sector and, due to the size of the machinery, most comparable to trucks for freight transport, while shipping vessels are most comparable to navigation. Therefore, the main technical measures to reduce emissions are the same as in road transport sector: (i) energy-efficiency increases for conventional machines and vehicles, (ii) electrification of machines and vehicles (hybrid or battery-electric vehicles) accompanied by increased shares of renewable energy sources in electricity generation and (iii) use of alternative fuels, in particular bio-fuels or CO_2-free synthetic fuels. The non-technical measures appear to be much more difficult to implement in the agricultural sector than in road transport, as the routes of agricultural vehicles cannot be shifted to railway or other alternatives and the fields have to be tilled on certain days.

So far, the market penetration of zero-emission agricultural machinery is far from being as advanced as in road transport (McKinsey & Company 2020). Although the market leaders piloted the prototypes, these products were not launched on the market. However, the broader market dynamics of alternative engine systems suggest that internal combustion engines could be forced out of the market by 2050 (McKinsey & Company 2019). McKinsey & Company (2019) show that under specific conditions and assumptions, the use of electrified heavy machinery can even make sense today from a total cost of ownership perspective. Although higher investment costs have to be borne for an electrical machine, in the model the lower maintenance costs and the higher energy efficiency can compensate for the higher investment costs over the life cycle. The report names the lack of charging infrastructure, limited product availability and the limited experience with electrified machines as the biggest barriers. In particular, the remoteness of some farms and the insufficiently developed power supply for high-power charging in some regions worsen this problem in the agricultural sector. The high investment costs for the purchase of an electrified machine, however, are likely to be lower in the coming years, as a significant part of the machine costs is due to the battery, whose costs are likely to continue to fall in the future (Kochhan et al. 2017). However, it must be taken into account that the life of e.g. a tractor can vary greatly and in some cases can be longer than 30 years (Lips 2017). This means that if a greenhouse gas neutral Europe is to be achieved in 2050, investment in electrified agricultural machinery must be made today.

Fugitive Emissions

Fugitive emissions occur along the entire supply chain of oil and gas products and for coal mainly during the mining of coal. They occur during production and processing, for example from abandoned wells and mines, from compressors, connections, valves, open-ended pipes and pumps. Further down the supply chain, these emissions occur due to leaks in pipelines or at meters etc. in the transit or distribution grid or at the point of use. Most of the emissions are methane emissions.

According to Laconde (2018), fugitive emissions in the gas and oil sector are mainly generated in the following three areas.

- *Wells: methane is normally piped and recovered through the well casing but some can escape into the atmosphere through the soil in the area around the boreholes (Kang et al. 2014). These diffuse discharges can last a decade after the end of operations (Boothroyd et al. 2016),*
- *During gas transportation and storage: defective sealing of valves and fittings, breaks and leaks, intentional or uncontrolled degassing, etc.*
- *During the processing of petroleum products: a refinery has tens of thousands of valves that can leak small amounts of greenhouse gases or other pollutants.*

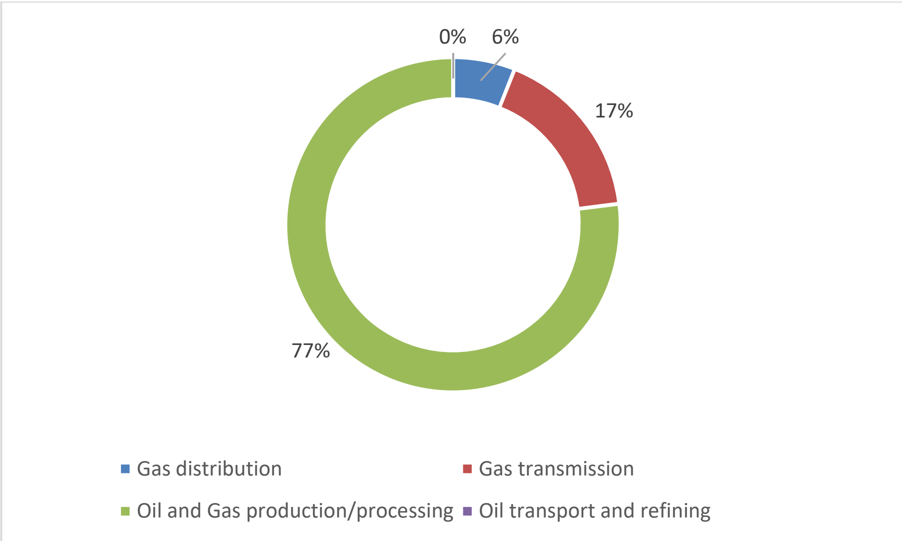
And in the coal sector in these three areas.

- *During coal mining: the fracturing of the ore releases trapped methane. In an open cast mine, the gas occurs directly in the atmosphere. When the mine is underground, the methane spreads in the tunnels before being evacuated by the ventilation system. The concentration of methane in the ventilated air outside mines is usually a few tenths of a percent, while the risk of explosion ("firedamp") starts from a few percent.*
- *During the transportation and storage of coal: the gas still present in the ore is released into the atmosphere*
- *Following decommissioning: methane can continue to escape through cracks and wells created during operation. In the United States, for example, there are several thousand abandoned mines, including 400 identified as discharging significant quantities of methane (EPA 2017).*

These gases from coal production can be captured and used as natural gas, so this could be a profitable activity.

Figure 119 shows the shares of the different steps of the supply chain of the total fugitive emissions in the oil and gas sector for the ECE region. The figure shows that the biggest share of emissions is emitted during extraction and production, about 17% of the emissions occur in the gas transport grid and about 6% in the gas distribution grid (UNECE & GMI 2019).

Figure 119. Breakdown of oil and gas methane emissions by segment, for ECE member states, 2015.



Source: Ecologic illustration based on UNECE & GMI (2019).

Technical solutions to reduce/prevent such fugitive emissions are highly dependent on their source, but meanwhile there are a number of abatement options (e.g. they are available by closing pipeline leaks or using better valves). IEA (2017) has estimated that 75% of global oil and gas methane emissions are technically feasible to eliminate and 50% can be mitigated with a positive net present value. The biggest challenge is the detection of these emission sources. However, in addition to the largest leaks, which pose a risk to the plant or its staff, it is often not economically profitable for the plant operators to detect and repair such smaller leaks, as the investment cost is often higher than the cost of the lost gas (Laconde 2018).

Cost-efficient and effective mitigation measures typically rely on sound results from MRV methods and practices. The most important programs to reduce fugitive emissions are the Leak Detection and Repair (LDAR) programs which are implemented in refineries, in the chemical industry but also along the supply chain of natural gas. According to Element Energy (2019), these programmes are also one of the most cost-effective abatement measure. Table 94 is taken from Element Energy (2019) and provides an overview of mitigation options for the UK and the estimated cost effectiveness of each option.

Table 94. Summary of mitigation option costs and direct abatement potentials

Option	**2016 Cost (£/tCO2e)**	**Direct abatement potential**
CCS offshore well – low CO2 concentration	£284	90%
CCS onshore well – low CO2 concentration	£152	90%

CCS offshore well – high CO2 concentration	£226	90%
CCS onshore well – high CO2 concentration	£94	90%
CCS SSF oven, calcium looping	£144	90%
CCS SSF oven, amines	£224	90%
Hydrogen fuel switch	£200 - £209	100%
Electricity fuel switch from grid	£28 - £473	100%
Electricity fuel switch from wind with battery	£766	100%
Electric compressors from grid	£596 - £686	100%
Electric compressors from wind with battery	£1,101 - £1,180	100%
Heating fuel switch to electric grid	£478	100%
Gas recovery to sales	£-104 - £-17	50%
Continuous monitoring	£98	90%
LDAR	£15	40%
Strong LDAR (x6)	£66	80%
Reduced emissions completions	£240	71%
Reduce vent and flare	£13	40%

Source: Ecologic illustration based on Element Energy (2019)

Further studies on technical reduction options can be found, for example, in the CCAC Technical guidance documents, in the Best Available Techniques Guidance Document on upstream hydrocarbon exploration and production of the European Commission (European Commission 2019), in Reducing Methane Emissions: Best Practice Guide (Methane guiding Principles 2019) from the Methane Guiding Principles or in Ipieca Exploring methane emissions (Ipieca 2015).

According to UNECE & GMI (2019), the main obstacles and barriers are four main points. Lack of awareness and knowledge, economic and financial aspects, regulatory aspects and structural aspects. In the following, the identified barriers are explained based on UNECE & GMI (2019).

Methane emissions are often unknown to the public and even if awareness is present, there is a lack of motivation or experience in implementing these technologies. Furthermore, lack of methane inventories at both the national and company level hinders mitigation efforts, and even if methane emission inventories exist, uncertainties about estimates can stop decision making at the company level and confuse participants in the policy debate and prevent consensus building.

Financially, there are two main aspects. Firstly, reduction measures are often not implemented even if they are economically profitable. This is due to the fact that there is often competition for resources within the company and that some profitable projects are not implemented due to resource shortages. Secondly, the financial return of methane emission reduction projects depends on the price that can be earned for the methane that is captured and sold on the market. When investment analyses use the prices realised on the relevant gas markets, or when prices are kept low by oversupply, regulations or subsidy programmes, the incentives for gas production are often too weak. A further barrier exists when the gas market is "demand constrained", which means that the additional supply created by gas capture does not lead to higher gas sales but only to lower production.

In some countries, methane emissions from the oil and gas sector receive little political attention, which is why regulatory measures are limited. Four factors can explain this. (i) Limited understanding of the climate impact of methane, in particular its temporal effects, (ii) many dispersed small emission sources and no large point source, (iii) major challenges in developing and implementing good regulations, including the demanding task of creating competent regulatory institutions and (iV) national revenues of the oil and gas industry are threatened by the efforts to mitigate climate change.

Structural obstacles are often caused by the fact that the transporter or processor of the gas is often not the owner or the person who can dispose of it. In the upstream segment, states often retain ownership of the gas produced in connection with oil, which provides little incentive for operators to develop and manage gas handling facilities. As a result, significant amounts of gas are flared or otherwise wasted. With the increased focus on reducing flaring, many countries have taken steps to change the legal and regulatory framework to provide incentives for gas use. In the middle and downstream segments of the gas value chain, distribution and transmission companies often do not buy and sell the gas, but are only paid according to the amount of gas transmitted, which is measured at the entry points. Consequently, their revenues may not be sensitive to the level of losses, so their incentives for maintenance, leak detection and repair are determined only by contractual obligations, safety considerations and the avoidance of supply disruptions. These and other barriers could be removed by agreed framework conditions achieved at different levels.

<u>Non-ETS Industries</u>

So far, studies on abatement potentials and abatement options in industry have focused less on whether the industries are non-ETS or ETS industries but on the processes that lead to emissions. For industries not regulated under the EU ETS, it can be assumed that most emissions result from heat generation. Fraunhofer ISI (2019), for example, shows that in Germany in 2018 about 90% of the fuels used in industry (ETS and non-ETS) were used to generate process heat. Only about 8% were used for room heating, and 1% respectively for hot water and mechanical energy. Therefore we will focus on process heat in the following.

Despite the already well progressed fuel switch from oil and coal to gas, there is considerable additional potential. Next to carbon capture and storage (CCS), fuel switch to biomass, synthetic gases or synthetic liquid fuels and in particular electrification of industrial processes are discussed to change the demand structure (Luh et al. 2020). Three categories of fuel switch can be identified: First, gradual fuel switch in existing installations, e.g. by co-firing of biogenic material. Second, fuel switch in new installations but within established production process, e.g. electric instead of natural gas-fired boilers. Third, the adoption of new production processes, e.g. replacement of blast furnaces with natural gas- or hydrogen-based direct reduction (Lechtenböhmer et al. 2016).

CCS, i.e. the capture and storage of greenhouse gases, so far appears to be economically viable, if at all, only for larger emitters with process emissions, which are generally regulated under the EU ETS. (e.g. cement, lime, iron and steel). For smaller emitters (non-ETS industries), this technology seems too expensive and it depends very much on how strongly the technology penetrates the market, how much the prices drop and how large the CO_2 transport grid will be, whether CCS will ever be economically viable for smaller emitters.

Synthetic gases and synthetic liquid fuels are in general also an alternative for smaller emitters. However, they consume a lot of electricity in their production process, which makes direct use of electricity more advantageous from an energy efficiency perspective. In addition, electrification can also lead to significant efficiency gains as heat can be supplied at a much more precise temperature (heat from fossil fuels is often well above what is needed) and there would be less heat loss because the heat can be generated closer to the production process. Furthermore, electrical heating technologies are generally quicker, more controllable and less labour intensive. For example, induction and infrared take just minutes to complete a heating task that would require several hours in a conventional gas furnace (Beyond zero emissions 2018). On the other hand, however, it must be mentioned that in some regions, due to the current electricity mix, the electrification of industry would not lead to greenhouse gas savings, as the direct use of electricity has higher emission factors in these regions than the use of natural gas (REHFELDT 2020). However, this is expected to be changed soon if the decarbonisation of the power sector and in particular the coal phase-out is further pursued.

According to Beyond zero emissions (2018) there are five main technologies that can drive industrial electrification.

Industrial heat pumps

Heat pumps use electricity to produce hot water, air or steam, they can produce water or steam up to 160°C, which is hot enough for many industrial processes. The main potential application for heat pumps is to replace the inefficient centralized gas boiler systems found in most factories.

Electromagnetic heating

The main examples of electromagnetic heating technologies are: (i) Infrared radiation has a very broad potential in many industries, especially in drying and hardening. (ii) Electrical induction heating is a fast, efficient, non-contact method for heat treatment and melting of metals. (iii) Dielectric heating offers an efficient method for heating bulky materials such as bricks or wood.

Electrical resistance

Electrical resistance heating involves generating heat by passing an electric current through a resistive heating element, like an electric bar heater. It is a simple alternative to most industrial gas-fired heating systems. For example, electric resistance boilers produce hot water or steam up to 220°C and could replace gas-fired boilers.

Electric arc heating

Electric arc heating processes and electric arc furnaces will be a crucial part of a future zero-emission industry (especially steel). Electric arcs are also used in plasma arc furnaces (plasma torch furnaces can reach 5,000°C or more, far more than any coal- or gas-fired furnace), which offer new opportunities for the electrification of high-temperature, high-volume processes.

Hydrogen

Hydrogen can be produced by passing an electric current through water (electrolysis) and is therefore an indirect way to electrify industry.

A further technology that can contribute to electrification is electricity-based heat storage. In a grid that is 100% renewable, there will be times when wind and/or sun will generate more electricity than needed. During these times, electricity costs can drop dramatically and sometimes even negatively. The periodic availability of free or cheap energy makes the storage of electricity as heat economically attractive.

Despite significantly more energy-efficient technologies compared to the burning of fossil fuels, electrification has not yet become widely implemented in industry. This is mainly due to the very high price of electricity compared to gas in many EU countries. For example, the average electricity price per kWh in the EU-28 in 2016 was 3.8 times higher than the price of gas. In Italy it was even 5.7 times higher and in Germany 4.5 times higher. In Sweden, on the other hand, it was only 1.7 times higher (Arpagaus 2019). The price difference is important, because only about 5% of the total costs of ownership are investment costs (Rehfeldt 2020). Rehfeldt (2020) concludes that even high CO_2 prices and investment subsidies are not sufficient to push electricity-based facilities into the market, but subsidies on energy costs could help in this respect. Although regulatory bans on gas-fired boilers or similar would not represent a market-based solution, they would in principle also be an option for pushing electrification forward. Further barriers to electrification are high investment costs for the new electrical technologies compared to existing technologies. For example, a high temperature heat pump costs about 420€/kw, whereas a gas boiler costs only about 60€/kw (Arpagaus 2019). The use of new electrical technologies is therefore neither economically advantageous in terms of investment nor in terms of use. Inexperience of the companies with the new technologies as well as uncertainties with regard to the technologies that will succeed in the market are further barriers.

6.2 Question 5.2: General architecture of a possible inclusion of all fossil fuel emissions

6.2.1 General Design Elements and Definition of Design Options

The general design elements of an EU ETS extension were already described in section 4.1.1.1 With the exception of the second element listed, "full or partial inclusion of sectors", these are also relevant if all fossil fuels are included in an ETS. The element "immediate or gradual extension" will also be excluded in the following, as a gradual extension would complicate things and would impose restrictions on the regulated entity which would not arise if all sectors were included at the start of the system. For example, a very high point of regulation in the supply chain would be associated with high transaction costs if the ETS would be expanded over time, as then again the use of the fuels would have to be tracked through the individual stages of the supply chain to the end consumer. In case of an immediate inclusion of all fuels, this tracking is only necessary to distinguish between the existing downstream EU ETS and the new fuel ETS.

Based on the design elements described in section 3.1.1.1 we choose specific design options for further analysis. In contrast to Section 3.1.1.2, the inclusion of all fossil fuels in an ETS does not leave many different design options as the inclusion of individual sectors or only parts of individual sectors is not an option. The main design questions are (i) whether the existing downstream ETS will be extended with a more upstream scheme to include emissions that are not yet regulated, (ii) whether an upstream ETS will be established alongside the existing EU ETS, with or without a linking to it, or (iii) whether the existing EU ETS will be reformed into an upstream

ETS that will regulate all fossil fuels. Based on this, we have defined the following design options, which will be analyzed below (see also Table 95).

- Option 0 - baseline: As in Section 3, Option 0 is used as the baseline scenario, i.e. the existing EU ETS is continued as it exists and the non-ETS sectors are covered by the ESR.
- Option 1a - full scope extension: In this scenario we assume that an EU-wide extension of the EU ETS will take place. This also covers the fossil fuel emissions from sectors, which have not yet been regulated. We further assume, that this scope extension implies that the sectors become fully regulated under the EU ETS and are no longer part of the ESR, so scope of the EU ETS and the ESR change significantly compared to today.
- Option 1b - full scope extension under existing ESR: Like in Option 1a, in this scenario we assume that an EU-wide scope extension of the EU ETS takes place. This also covers the fossil fuel emissions from sectors, which have not yet been regulated. In contrast to Option 1a, we assume that the ESR remains in place for the sectors newly covered under the EU ETS.
- Option 2 - separate ETS for all sectors which use fossil fuels and not yet been regulated under the existing EU ETS: In this scenario we assume that a new ETS is designed for all fossil fuels that have not yet been regulated under the existing EU ETS with the current EU ETS continuing to exist. The two emissions trading systems are linked to a certain extent, i.e. use of allowances from one system in the other system for compliance is possible but with upper limits. Whether the link is one-way or two-way is not yet specified.
- Option 3 - EU-wide upstream ETS replaces current EU ETS: In this option, an ETS covering all fossil fuels would be implemented, i.e. there will be no mix of upstream or downstream regulated entities, but the entities will be regulated uniformly at one point in the supply chain. In this case, the existing EU ETS will no longer exist, so there will be no administrative costs for compensation or ex-ante exemptions.

Table 95. General design options regarding scope of the new system and legal implementation in the context of existing EU legislation

Design Options	**Sectors**	**Flexibilities**	**ESR applies**	**Possibilities for extension**
Option 0 (baseline)	No EU-wide extension of the EU ETS, potential opt-in by individual MS	n/a	yes	---
Option 1a - full scope extension	Full EU-wide scope extension of the EU ETS to include all fossil fuels used in non-ETS sectors	n/a	no	---
Option 1b - full scope extension	Full EU-wide scope extension of	n/a	yes	Later extension to

Design Options	Sectors	Flexibilities	ESR applies	Possibilities for extension
	the EU ETS to include all fossil fuels used in non-ETS sectors			Option 1a possible
Option 2 - separate ETS for all fossil fuels used in non-ETS sectors	Separate ETS schemes for all fossil fuels used in non-ETS sectors	With (limited) linking between ETSs	yes	
Option 3 - new EU-wide upstream ETS	EU-wide upstream ETS replaces current EU-ETS	n/a	no	

Source: Fraunhofer ISI

The points discussed in 3.1.1.3 regarding price and market stability or the allocation of allowances also apply to the design options analysed in this section, although the assessment of such measures in this case must take account of the fact that not only two sectors (road transport and buildings) but several sectors are covered by the ETS.

Design option 3 would represent the biggest change to existing regulation, as the existing ETS would no longer exist and a new upstream ETS would be implemented. Whether such a design option is preferable to the mixed options 1 and 2, where downstream regulated and further upstream regulated installations exist, depends on certain factors. The coexistence of both approaches has the advantage that many emitters are directly regulated, which leads to stronger incentives to mitigate emissions. Furthermore, the existing system would require little or no restructuring, which would be an advantage in terms of administrative costs. On the other hand, a unified system such as design option 3 has the advantages that there are fewer regulated entities and that there would be little or no problems of double counting, both of which lead to lower administrative costs than in a system where both forms of ETS coexist. Both systems therefore offer advantages and disadvantages which should be analysed and weighed against each other. First considerations are presented on the following pages.

6.2.2 Emissions not covered under certain design options

6.2.2.1 Process Emissions

In the case of a purely upstream ETS, as in design option 3, the question is how to deal with process emissions, for example in the cement/lime, chemical, glass or iron and steel industries. Process emissions result from the chemical reaction of substances, which releases CO_2 or other greenhouse gases. These emissions are thus not directly related to the combustion of fossil fuels. Process emissions do not represent a minor amount of emissions, as a look at the EUTL Register shows. In the cement sector, for example, 119 million tonnes of CO_2 equivalent were reported for the year 2019. According to Ecofys, Fraunhofer ISI, Öko-Institut (2009a), about 55% of the emissions in the cement sector are due to calcination, which means that about 66 million tonnes CO_2 equivalent in the cement sector are process emissions. If lime production is included in the calculation, the total would be about 81 million tonnes

CO_2 equivalent. In the glass sector, process emissions depend heavily on the glass produced and can range between 10% and 26.4% according to Ecofys, Fraunhofer ISI, Öko-Institut (2009b). This means that of the reported emissions in the glass sector of 18 million tonnes CO_2 equivalent in 2019, between 2-5 million tonnes CO_2 equivalent are due to process emissions. Furthermore, process emissions also result for example from sintering in the iron and steel industry or kraft pulp making in the paper and pulp industry. Process emissions also play a major role in the chemical industry.

Overall, the EU Commission estimated process emissions in the EU ETS for the year 2017 at 262 Mt CO_2e (European Commission 2018), which corresponds to a share of about 15%. If this share is applied to the year 2019, this would mean 237 Mt CO_2e. This means that cement, lime and glass plants alone would be responsible for around 35% to 36% of process emissions in the EU ETS.

Table 96. Process emissions and number of regulated installations

Sector	Process Emissions[1]	Number of regulated installations
Production of Cement Clinker	66.5 Mt. CO_2e	280
Production of Lime or calcination of dolomite / magnesite	15.3 Mt. CO_2e	267
Manufacture of glass	1.8-4.7 Mt. CO_2e	379
Production of carbon black	1.6 Mt. CO_2e	18
Production of nitric acid	2.8 Mt. CO_2e	34
Production of adipic acid	0.1 Mt. CO_2e	3
Production of glyoxal and glyoxylid acid	0.01 Mt. CO_2e e	1
Production of Ammonia	19.8 Mt. CO_2e	29
Production of hydrogen and synthesis gas	8.9 Mt. CO_2e	42
Production of soda ash and sodium bicarbonate	2.4 Mt. CO_2e	14

[1] Emissions from chemicals contain steam emissions
Source: Fraunhofer ISI calculation based on EUTL data

Table 96 provides an overview of estimated process emissions and the number of regulated installations in the sectors with process emissions. As mentioned above, other sectors, such as iron and steel or pulp and paper, also have process emissions, but in these cases it is difficult to calculate the process emissions share, as it depends heavily on production methods and products. The above mentioned industries alone are responsible for about 120 Mt. CO_2e and comprise more than 1,000 plants. Given the importance of process emissions, we recommend for design option 3 that process emissions continue to be covered downstream. The MRV system already exists in the EU ETS and would therefore not cause any additional set-up costs.

6.2.2.2 Fugitive Emissions

As described in Section 6.1.4, fugitive emissions occur along the entire fossil fuel supply chain and especially during extraction and production. Fugitive emissions are therefore not a clearly identifiable point source of emissions, but arise from many smaller sources with low emissions. This makes regulation difficult, as many players are involved and it is not possible to identify a single player. In addition, monitoring would have to be carried out at many points in the supply chain, which would lead to very high MRV costs. Another problem in the case of natural gas is that the transporter is not the owner of the gas. So who should be regulated? The owner, who is not responsible for the fugitive emissions, or the transporter, who can ensure that there are less fugitive emissions but who does not own the product that causes the emissions? For this reason, targeted regulation of all fugitive emissions in an emissions trading scheme is only feasible at considerable expense.

In general, fugitive emissions can be divided into two categories. (i) extraction/mining, (ii) transport. For production and transport, the point of regulation plays a decisive role. For example, regulation at the point where natural gas is fed into the transmission grid would regulate the total quantity fed into the grid. Fugitive emissions that occur further down the supply chain would reduce the amount of gas, which would result in a larger amount of gas being regulated than is later sold. Although the difference does not generally correspond to the same level of greenhouse gas equivalents because fugitive emissions are largely methane and combustion usually releases mainly CO_2, it would create additional incentives to repair pipeline leaks and other emission sources. Thus, the further down the supply chain regulation is implemented, the shorter the distance to the end customer and thus the smaller the difference between the amounts of fossil fuels combusted by the end consumer and the regulated amount of fossil fuels and thus the lower the incentives to avoid fugitive emissions. A point of regulation high up in the supply chain would therefore create stronger incentives to avoid fugitive emissions along the supply chain than a regulation point further downstream. However, much of the emissions are created during extraction and mining, i.e. before any amount of fossil fuels can be tracked for the first time and thus before any possible point of regulation of a fuel emissions trading scheme. Nevertheless, it would be possible to regulate the fugitive emissions in the processing and mining process in an emissions trading system. Independently of the regulation of the fuels, the processors and miners of these fuels would then have to be regulated. However, this would require the development and implementation of a uniform MRV system.

6.2.3 Point of regulation

The principles for the decision of the regulated entity have already been discussed in section 4.2 and a detailed consideration of all entities based on the supply chains of the three main fuels has been carried out. In this section we discuss at which point in the supply chain fuel regulation would be favourable for the design options defined in section 6.2.2.1. In contrast to the scope extension variant covering buildings and road transport, it is not necessary to differentiate between individual sectors if all fossil fuels are fully included. However, the individual design options place different demands on the regulated entity in terms of knowledge about the end user of the fuel. For example, in those options where the existing EU ETS continues to exist, it is important to ensure that downstream regulated installations are not subject to double regulation. This would be the case if a plant operator regulated under the existing EU ETS buys fuels that are also regulated under the new system. In this case, it must be ensured that the downstream regulated installation either receives compensation or that the fuel supplied to this plant is exempted from the new system. In order to limit the administrative burden for the regulating authority and also for the regulated entities, upstream exemption should be sought wherever possible. A downstream exemption makes little sense, as it would then be possible to discontinue the downstream ETS completely (exception would be process emissions). Table 97 provides an overview of the knowledge that regulated entities must have about the use of their fuels in EU ETS installations for an ex ante exemption to be possible.

Table 97. Design options and necessary knowledge about the end user

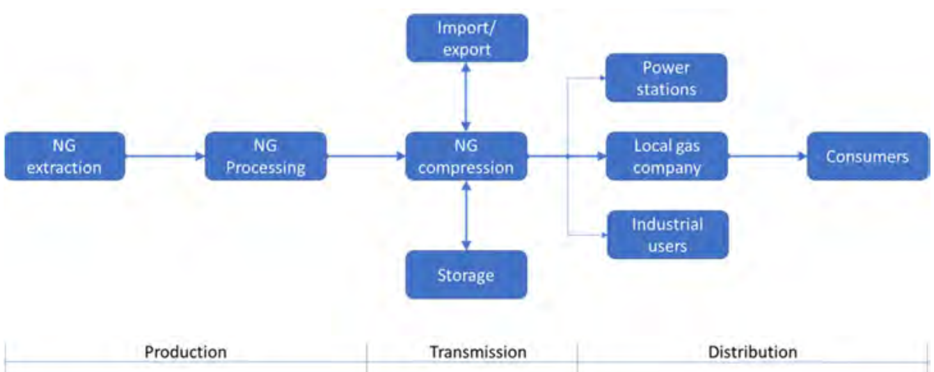
Design Options	Necessary knowledge about the end user
Option 0	MS individual
Option 1a	Need to identify the use in EU ETS installations
Option 1b	Need to identify the use in EU ETS installations
Option 2	Need to identify the use in EU ETS installations
Option 3	No requirements with regard to fuel tracking

Source: Fraunhofer ISI, own calculation

Gas products

As described in Section 6.1.1, due to the grid structure, the supply chain is not different from the chain described in sections 2 and 3. Figure 120 shows the same illustration of the supply chain in the gas market as used in the previous sections.

Figure 120. Supply chain of the gas market



For design options 1 and 2, the regulated entity must know the gas flowing to downstream regulated installations. This is not the case at the production level, as producers and importers feed the gas into the transmission grid and its further use remains unclear. Therefore, for Options 1 and 2 the point of regulation would be appropriate at the level of the TSOs. TSOs generally supply gas to regional distributors and to large industrial and energy companies. It can be assumed that only in a few cases downstream regulated installations are supplied by the distribution grid operators, which is why regulation at TSO level seems appropriate for these two options. TSOs know the customers they supply and therefore know which supplied installations are regulated downstream and which are not. Downstream regulated installations supplied by distribution grid operators would then have to be compensated. The problem described in 3.2.2.1 that TSOs are usually not the owners but only the transporters of the gas remains. Regulation of the gas owners at TSO level appears to be problematic due to the lack of clarity caused by the gas spot market in which gas traders, regional distributors, large customers and banks are active[235]. Although regulation of the owners seems possible if there are clear ownership structures for the offtake of gas from the TSO grid. In this case, regulation of the owner who initiates the offtake of gas from the TSO grid would be possible. However, it can be assumed that the number of regulated entities is not necessarily lower than in the case of regulation at DSO level, as many regional distributors also participate on the spot market. Furthermore, the TSOs would also be involved, although not regulated, as they would have to provide data on gas volumes. Regulation at TSO level therefore only seems appropriate if the TSO itself could be regulated. Whether the transporter of a product can be regulated in an emissions trading scheme remains to be legally examined. Should this be possible, the TSOs would be an appropriate point of regulation for the design options 1 and 2. Regulation at regional distribution level would also be possible and downstream regulated plants supplied by regional distributors would have to be compensated. In addition, installations that are connected to the TSO grid but are not regulated in the downstream ETS would have to be regulated. However, this should only be the case if these companies buy their gas independently on the spot market or from supra-regional gas traders. If the companies buy their gas from the regional distributor, which in this case supplies via the TSO grid and not via the DSO grid, it would not be a problem, as the regional distributor would be regulated in the new system. These companies, which are not regulated downstream but buy gas from the TSO grid, could therefore be forced to buy from regional distributors or be included in downstream emissions trading. Such an inclusion of individual installations does not seem to be the best solution to be pursued, but could be necessary due to the described problems of regulation at TSO level. As plants supplied with gas at TSO level are usually large, the owners of these plants are also of a certain size, so they should not be small companies for which inclusion in emissions trading would be relatively expensive.

In design option 3, the downstream ETS no longer exists, which means that the regulated entities do not need to know the gas flows to the downstream regulated installations. This in turn makes regulation at the level of producers and importers possible. Regulation at the point of transfer into the transmission grid appears to be an appropriate option. Such regulation at producer and importer level is also beneficial in terms of fugitive emissions. In this case, the amount of gas fed in would be regulated. Fugitive emissions result in the loss of gas along the supply chain, which means that the amount of gas fed in is usually greater than the amount taken out for consumption. Regulating the amount of gas fed into the grid creates an additional incentive to reduce fugitive emissions, as otherwise more gas is regulated than is ultimately sold.

As described in Section 3.2.2.1, it can be assumed that it is possible to pass on the price signal to the end customer at least in the short term. Regulation at the TSO or DSO level makes it likely that the price signal will be passed on due to competition, but competition from alternative heating systems such as heat pumps may give an incentive not to pass on the price signal if financially possible. It is unclear whether the price signal will be fully passed on even if regulation takes place at the level of importers and producers. Given the Eurostat energy balances, in 2018, 37% of the EU27 gas volumes were imported from Russia, 17% from Norway and 11% from Algeria. This means that, two thirds of the volumes consumed in the EU were imported from three countries. The extent to which the prices of those imports from these countries react to price signals is not clear. On the one hand, these countries are interested in continuing to sell their gas at the highest possible prices, but on the

[235] https://www.eex.com/de/handel/teilnehmerliste#/teilnehmerliste

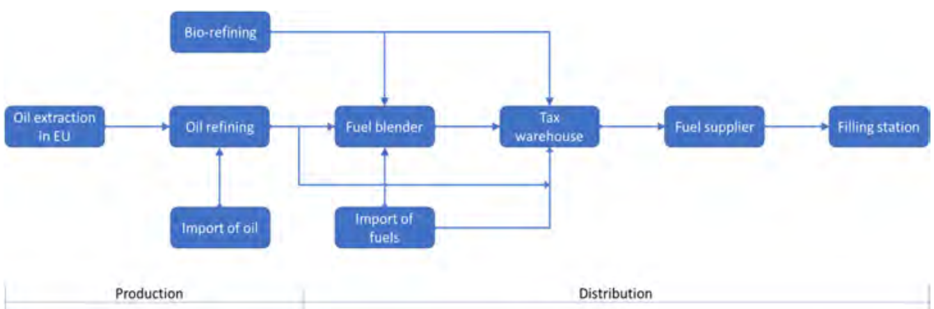
other hand, a high price signal would lead to end customers trying to switch to other fuels, which would reduce imports in the medium to long term, which is not in the interest of the seller. It is therefore unclear whether and how the sellers would react to the implementation of a price signal and whether this would reduce or eliminate the effect of the price signal.

Given the unclear situation regarding the pass-through of the price signal and the higher number of entities to be regulated at the level of producers and importers (433 extr./imp. and 56 proc.), regulation at the TSO level (58 companies) appears to be the most appropriate point of regulation for all three design options. However, it remains to be analysed whether such regulation is permissible at all on the basis of the ownership structure. Should this not be the case, the level of producers and importers would be appropriate for design option 3 and the regional distribution level for design options 1 and 2.

Mineral oil products

For the petroleum products market, refineries or tax warehouses were identified as possible regulated entities in the design options examined in Section 3.2.2.2. Figure 121 shows the supply chain for petroleum products, as already shown in the previous sections.

Figure 121. Supply chain of mineral oil products



Regulation upstream of refineries, i.e. regulation of crude oil, does not seem to make much sense, since crude oil is not only used to make products that later lead to greenhouse gas emissions when combusted, but also in other sectors, such as the chemical industry, which often use it to make plastics such as polyvinyl chloride, that is used for example in window frames, floor coverings or medical equipment such as hoses. Furthermore, crude oil is used in the textile industry or for pharmaceuticals and cosmetics. Even of the refined products, not all are intended for energetic use, e.g. lubricants or motor oils.

For design option 3, where the downstream ETS is not continued, refineries can easily be used as regulated entities. With regard to the identification of downstream regulated entities, which is important for options 1 and 2, it can be expected that the refineries are already familiar with a majority of the downstream regulated installations, since a large part of the energy sector and major industry is supplied directly by the refineries. Thus, an ex-ante exemption of supply flows to downstream regulated installations could already take place at the refinery level. In this case, downstream-regulated installations that are supplied by intermediaries would have to be compensated to avoid a double charge. The problem with imported and exported petroleum products described in 3.2.2.2 also arises with the options analysed in this Task and could be solved in the same way as in 3.2.2.2 by also regulating the importers of these products. The regulation of tax warehouses is also an option. This means that the ETS obligation always applies when the tax warehouse operator supplies products to non-tax warehouses. This is analogous to the energy tax and monitoring systems already exist for this, which simplifies implementation at this point. Also, tax warehouse operators may know the downstream regulated installations even better than the refineries, which could be another advantage. Since refineries produce taxable products and do not sell them only to tax warehouse operators, refineries are usually also classified as tax warehouses or operate a tax warehouse directly linked to the refinery. In other words, the existing monitoring system for tax warehouses could very probably also be used to regulate refineries. In this case, the refinery would have to regulate all petroleum products leaving the site and sold to market participants not regulated downstream.

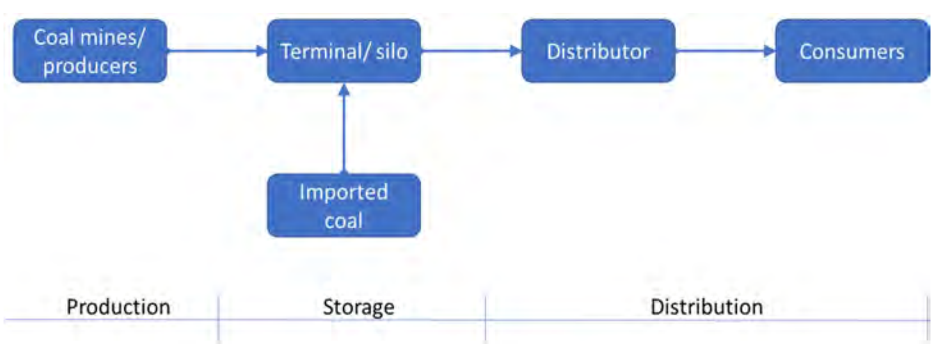
For the presented design options it can also be assumed that the price signal can be passed on to the end customer, so that the incentive effect to avoid emissions is ensured. However, the question arises whether, under certain circumstances, the energy sector or large industry could influence prices so that the price signal would be distorted in favour of large buyers. Regarding fugitive emissions, the regulation of refineries also seems somewhat more advantageous than the regulation of tax warehouses, since the further upstream the quantities are monitored, the more incentive exist to avoid fugitive emissions along the supply chain.

For design option 3, the regulation of refineries appears to be clearly beneficial, as the number of refineries is relatively small (87) compared to the number of tax warehouses (7,000), which would lead to less administrative burden. But, in addition to the 87 refineries, the 100 to 1,000 fuel importers would also have to be regulated. For design options 1 and 2, regulation at refinery level seems also beneficial, as the number of entities to be regulated is small and the majority of downstream regulated installations are likely to be known by refineries. However, if, unlikely, the additional administrative costs of compensation for double regulation are higher than the additional administrative costs that would be due to the much higher number of tax warehouses to be regulated, regulation of tax warehouses would be beneficial for design options 1 and 2.

Coal products

Figure 122 shows the supply chain for coal products, as already shown in the previous sections. In section 4.2.2.3, distribution to final customers was defined as the most appropriate point of regulation for extending the EU ETS to the buildings and road transport sectors.

Figure 122. Supply chain of the coal market



This was mainly due to the fact that in this case only the building sector was to be regulated. In the design options analysed in this section, all coal fuels should be regulated. So, this point of regulation does not make sense for any of the design options analysed in this task, since all fuels are to be regulated and the industry usually does not buy from regional distributors. For design option 3, where the downstream ETS would no longer exist, regulation at the level of coal mine operators seems appropriate. In addition to mine operators, the importers who bring coal from non-EU countries onto the EU market would also have to be regulated. For design options 1 and 2, where the downstream regulated installations should be known to the regulated entities, regulation at this level also seems to make sense, as, according to the EURACOAL association, the coal mine operators and producers know the largest customers, as they determine the coal quality specifications that they must meet and they buy directly from them and there are no intermediaries in between. It can therefore be assumed that only a very small number, if any, of downstream regulated installations do not receive their coal directly from the producers, mines or importers. All coal sold by the entities to be regulated (producers, mine operators and importers) to non-downstream regulated players must then be regulated. In cases where downstream regulated installations do not buy their coal directly from producers, mine operators or importers, they must be compensated. Regulation at the level of the storage operator or distributor makes no sense for the present design options, as not all coal passes through these elements of the supply chain.

With regard to the pass-through of the price signal, it is very likely that the price signal will be pass-through and there will be little strategic pricing. This is mainly due to the fact that many member states have already decided to phase out coal, so the market will collapse in the foreseeable future anyway. Coal mine operators and producers will therefore continue to try to sell their coal at cost-covering prices. In addition to this, consumers cannot do without coal in the very short term, which is why the price signal passed on would have little effect on coal sales in the short term. This constellation makes the pass-through of the price signal very likely.

Regulation at the level of mine operators is the only appropriate regulatory point for all three design options. In this case, 198 mine operators and about 500 importers would have to be regulated, which is a much smaller number than regulation at the distribution level as recommended for the building and road transport sector in section 4.2.2.3.

6.2.4 Emissions cap

Similar to the approach in section 4.3, different cap setting variants are shown for the design options to be analysed in this task. Again, we analyse three variants: a reduction of 40% below 1990 levels by 2030 as currently implemented under the 2030 climate and energy framework, a reduction of 50% below 1990 levels by 2030 and a reduction of 55% below 1990 levels by 2030. Depending on the design options, we need to define one or two caps (design option 2).

For calculation of the cap different approaches could be applied:

- Stick to current targets proportionally to today's definition of 2030 targets
- Cap 2: Define new targets based on equal reductions for ETS and non-ETS sectors

In all cases, the target is set as an absolute cap, relative target setting options are not further considered as they do not allow for reaching overall GHG targets with the sufficient amount of certainty.

6.2.4.1 A 40% GHG reduction target and current target setting rules

As a starting point for the analysis, we stick to the target currently defined for 2030 under the Climate and Energy Framework, as already stated in section 4.3. This means that the EU ETS sectors will have to reduce their emissions by 43% below 2005 levels and the ESR sectors will have to reduce their emissions by 30% below 2005 levels, resulting in an overall reduction of GHG emissions to 40% below 1990 levels. Depending on whether a design option foresees that newly regulated sectors in the ETS remain regulated under the ESR or exit the ESR, we define the target accordingly (see Table 98).

Table 98. Targets based on current target setting rules under the 2030 climate and energy framework [% below 2005]

	EU ETS	"new" ETS	ESR
Option 0	43%	---	30%
Option 1a	43%	---	30%
Option 1b	43%	---	30%
Option 2	43%	30%	30%
Option 3	43%	---	30%

Source: Fraunhofer ISI, own calculation

This target setting approach ensures that the current EU 40% target is met in all cases. As in section 4.3, for some of the design options analysed, total greenhouse gas emission reductions are higher than the overall 40% target when the ETS sectors become part of the EU ETS and thus have a higher reduction obligation. Table 99 gives total GHG levels and emission reductions below 1990 in the analysed scenarios. Design option 1a and 3 result in a total GHG emission reduction of 45% below 1990 levels due to the high amount of emissions becoming part of the EU ETS and thus facing a higher emission reduction target. In scenario 1b, the resulting GHG emission level is uncertain due to the double regulation of part of the emissions under the ESR and the EU ETS. Scenario 2 provides the same result as scenario 0, assuming that the separately established ETS has the same reduction targets as the ESR.

Table 99. Resulting GHG levels [Mt CO2e] and reductions below 1990 levels

	GHG levels	Reduction below 1990
Option 0	2,898	40%
Option 1a	2,680	45%
Option 1b	At most 2,898	At least 40%
Option 2	2,898	40%
Option 3	2,680	45%

Source: Fraunhofer ISI, own calculation

As in section 4.3, the alternative approach is also calculated in this section. This means that we assume all sectors stick to their current target setting rules. In case of ESR sectors becoming part of the EU ETS, we assume, that the new EU ETS target is calculated based on current EU ETS sectors' EU ETS target and current ESR sectors' ESR target. Table 100 gives the resulting targets for the EU ETS, the "new ETS" and the ESR under the different design options. In all scenarios, in which the current EU ETS is being extended to include new sectors, the target value under the new EU ETS decreases. However, the figure still remains significantly above the target for the ESR sectors with 37% below 2005 levels.

Table 100. Resulting EU ETS, "new ETS" and ESR targets by applying sectors-specific targets [% below 2005 levels]

	EU ETS	"new ETS"	ESR
Option 0	43%	---	30%
Option 1a	37%	---	30%
Option 1b	37%	---	30%
Option 2	43%	30%	30%
Option 3	37%	---	30%

Source: Fraunhofer ISI, own calculation

6.2.4.2 Keeping current proportionality for higher ambition levels

Also, for the design options considered in this section, as in section 4.3, calculations are made for higher levels of ambition while keeping the current proportionality. According figures are provided in Table 101. Emission reductions under the EU ETS would need to increase to 55% below 2005 in case of an overall emission reduction target of 50% below 1990 levels and to 62% below 2005 in case of an overall emission reduction target of 55% below 1990 levels. Targets under the ESR and for Option 2 in the newly created ETS systems would increase to 39% and 43% respectively.

Table 101. Targets based on emission reductions proportional to the 2030 climate and energy framework [% below 2005] for higher ambition levels of 50/55%

	50%			55%		
	EU ETS	"new" ETS	ESD	EU ETS	"new" ETS	ESD
Options 0, 1, 3	55%	---	39%	62%	---	43%
Option 2	55%	39%	39%	62%	43%	43%

Source: Fraunhofer ISI, own calculation

Table 102 analogous to Table 100 shows resulting 2030 targets for the EU ETS, the new ETS and the ESR for an integration of the new sectors into the EU ETS.

Table 102. Resulting EU ETS, "new ETS" and ESR targets by applying sectors-specific targets as defined in Table 101 for higher ambition levels [% below 2005 levels]

	50%			55%		
	EU ETS	"new ETS"	ESD	EU ETS	"new ETS"	ESD
Option 0	55%	---	39%	62%	---	43%
Option 1a	48%	---	39%	53%	---	43%
Option 1b	48%	---	39%	53%	---	43%
Option 2	55%	39%	39%	62%	43%	43%
Option 3	48%	---	39%	53%	---	43%

Source: Fraunhofer ISI, own calculation

6.2.4.3 Similar emission reduction requirements compared to todays' GHG levels

In this case we assume that the contributions of all sectors to emission reductions should be similar. As in section 4.3 we use relative abatement rates and again use two base years 2005 and 2017. Table 103 provides target splits for the different design options for two base years: 2005 (as currently used for measuring reduction targets in the EU climate and energy framework) and 2017 as the most recent historic base year available.

Table 103. Resulting emission reductions [below 2005 levels] for more ambitious overall GHG reduction targets of 50 and 55% below 1990 levels applying similar relative emission reduction requirements for different base years (2005 and 2017)

	50%			55%		
	EU ETS	**"new ETS"**	**ESR**	**EU ETS**	**"new ETS"**	**ESR**
2017 base year						
Option 0	51%	---	42%	56%	---	48%
Option 1a	49%	---	33%	54%	---	40%
Option 1b	49%	---	42%	54%	---	48%
Option 2	51%	46%	42%	56%	52%	48%
Option 3	49%	---	33%	54%	---	40%
2005 base year						
Option 0 - 3	46%	46%	46%	52%	52%	52%

Source: Fraunhofer ISI calculation

As in section 4.3, using most recent GHG emissions as base year for splitting the target results - in all design options - in significantly higher relative reduction figures for the EU ETS sectors compared to the ESR sectors. The large EU ETS options (design options 1 and 3) show slightly lower relative ambition levels for the EU ETS sectors compared to the other sectors as a large part of the sectors with limited reductions in the past moves to the EU ETS.

6.2.5 Robustness check of design options

6.2.5.1 Robustness criteria

Analogous to the robustness criteria in section 4, a number of robustness criteria are also analysed for the design elements considered in this section.

Table 104. Robustness criteria for first assessment of design options

Environmental criteria	**Indicators**
Current and future magnitude of sectoral emissions	Absolute and relative emissions per sub-sector today Current emission trend and emission projection for 2030
Availability of emission reduction measures	Technical abatement potential per sub-sector
Economic criteria	

Costs of emission reductions	Marginal abatement costs of the decarbonisation options per sub-sector
Administrative costs	Administrative costs and transaction costs
Social criteria	
Impact on individual spending on transport and heating fuels	Price impact on transport and heating fuels Spending on transport and heating fuels
Regulatory criteria	
EU competence and legal basis. Subsidiarity and proportionality principles	Compliance with EU Treaty regarding scope of measures (e.g. to cover intra-EU transport)
Implementation, compliance and enforcement measures	Measures proposed are implementable and enforceable Measures proposed comply with MRV rules Definition of penalties for entities not complying with MRV and surrendering obligations

Source: Fraunhofer ISI representation

6.2.5.2 Option 1a - full scope extension

In Option 1a, we assume that an EU-wide scope extension of the current EU ETS takes place to include all CO_2 emissions from fossil fuel combustion in the existing EU ETS. We further assume that this scope extension implies that the sectors become fully regulated under the EU ETS and are no longer part of the ESR, so scope of the EU ETS and the ESR change significantly compared to today.

Environmental criteria

Data sources and data processing

The environmental criterion "Current and future magnitude of sectoral emissions" is calculated for this section in a similar way to section 4. The data basis remains almost the same, only for the non-ETS industry the data from Enerdata shown in section 6.1.3 were used. The UNFCCC GHG inventories provide emission data by sector and sub-sector, the ETS emissions are taken from the ETS data viewer of EEA and the PRIMES EUCO3232.5 scenario provides data on emission projections. The reduction in the sectors road transport, railway, domestic navigation, buildings and agriculture were directly taken from the PRIMES data. For the other sectors considered, non-ETS industry, other transport and other sectors, the reductions applied to ESD in total were used, as the PRIMES data do not provide any information on this.

Table 104 provides reduction rates required to meet the 2030 EUCO3232.5 projections for the different sectors. To compensate for the low historic reduction rate between 2005 and 2017 (1.04%), an average reduction rate of 3.86% p.a. between 2017 and 2030 is required for the fuel use in agriculture sector even though the sector contributes to emission reductions only to a limited amount. Much higher rates are required for buildings (5.08% p.a. between 2017 and 2030 on average).

Table 105.Historic and required emission trends for underlying sectors

Sector	2005-17	2005-30	2017-30
EU ETS	-2.15%	-2.72%	-3.23%
Road transport	-0.14%	-1.08%	-1.93%
Railway	-2.52%	-1.35%	-0.26%
Domestic navigation	-1.86%	-0.78%	0.23%
Other Transportation	-2.76%	-2.14%	-1.56%
Buildings	-1.62%	-3.44%	-5.08%
Agriculture	-1,04%	-2.52%	-3.86%
Other sectors	-3.87%	-2.68%	-1.56%
Non-ETS industry	-7.25%	-4.33%	-1.56%

Source: Fraunhofer ISI calculations

Based on 2017 GHG emissions the coverage increases from 1,590 Mt CO_2e to about 2,830 Mt CO_2e, which represents an increase by 89%. In turn, emissions covered under the ESR decrease significantly from 2,252 Mt CO_2e to 832 Mt CO_2e, a decrease of about 63%. In total, the EU ETS in Option 1a covers 78% of all GHG emissions, while the ESR covers only 22%. This is a significant relocation between EU ETS and ESR compared to Option 0. In particular, ESR covers a relatively small part of emissions.

Using the EUCO3232.5 scenario, EU ETS emissions under Option 1a scope go down to about 2,011 Mt CO_2e by 2030, a reduction of 1,000 Mt CO_2e or 33% compared to 2017 levels in 13 years. As in the results in section 4, a comparison of the projections with historical reduction trends shows that much higher reductions are needed to achieve the targets projected in the EUCO scenario. Between 2005 and 2017, emissions under the scope of Option 1a of the EU ETS were reduced by 19%. By comparison, emissions under the EU ETS in Option 0 in the EUCO3232.5 scenario are projected to decrease by 35% between 2017 and 2030, so the extension of the scope leads to a slight decrease in the percentage emission reductions of the EU ETS.

Emissions under the ESR are projected to fall from 832 Mt in 2017 to roughly 686 Mt CO_2e in 2030, a reduction by 18% in a time frame of 13 years. In contrast, emissions in the remaining ESR sectors increased by about 6% between 2005 and 2017. While the projected emission reductions in the EUCO scenario for the scope of Option 1a of the EU ETS decrease, the emission reductions in the sectors remaining under the ESR decrease from 26% in baseline option 0 to 18% in option 1a.

Economic criteria

As in section 4, a relative assessment of administrative costs is carried out for the design options underlying this task. Again, we focus on the costs for the public sector and do not consider the costs for the private sector. We differentiate between four types of costs:

- negotiation costs
- one-time administrative costs

- regularly occurring administrative costs
- costs for disclosure and sanctioning

As in section 4, the design elements of coverage of the system and the linking with the EU ETS are considered. Again, other design elements may also be of high relevance in this context, e.g. the point of regulation, the avoidance of double counting as well as the allocation mechanism and the associated compensation regulations, but they are again not considered here because they are not sufficiently taken into account in the design options. It must be kept in mind, however, that these other design elements have strong, perhaps even stronger effects on the various cost types than the design elements considered here.

Negotiation costs: Since all design options analysed in this task aim to regulate the same additional sectors and emissions, it is not expected that there would be major differences between the design options in terms of negotiation costs. But it can be assumed that the negotiation costs will be quite high. Since, in addition to the circumstances already mentioned in section 4, the inclusion of two large sectors and the fact that in some countries the automotive industry has a strong lobby, other sectors will be included, which are small and probably less organised, but which must also be consulted and negotiated with.

One-time administrative costs: The large advantage of option 1a regarding one-time administrative costs is, that the infrastructure already existing for the EU ETS can also be used for the sectors to be newly included.

Regularly occurring administrative costs: The main factors influencing the regularly occurring administrative costs is the coverage. A higher number of regulated entities, as can be expected in case of the inclusion of all sectors that burn fossil fuels also results in high regularly occurring costs. Compared to the option with a pure upstream ETS, the costs are much higher in option 1a. It can be assumed that connection with the EU ETS has no significant impact on this type of costs.

Costs for disclosure and sanctioning: As for regularly occurring administrative cost, cost for disclosure and sanctioning are closely linked to the number of regulated entities and therefore particularly high in option 1a compared to the option of a pure upstream ETS.

Table 106 provides an overview of the assessment of the relative administrative costs of option 1a compared to other options.

Table 106. Relative assessment of administrative costs for design option 1a

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning
Coverage	++	o	++	++
Connection with the EU ETS	o	--	o	o

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

Social criteria

In aggregate, an EU-wide scope extension of the EU ETS, covering all GHG emissions from fossil fuels use previously not yet regulated is expected to have low effect on the population as a whole, but relatively higher (indirect) effect on specific households.

Overall, changes in other ETS sectors are likely to be broadly regressive (but small in size); larger impacts might be from changes in employment (i.e. if employment in some affected industries is particularly concentrated amongst the low-income deciles).

The primary indirect impacts, thus, would essentially be employment impacts, and would potentially bring about job cuts in sectors that are becoming subject to the ETS and initially have a large amount of low-skilled workers (of probably lower income households), more vulnerable to job cuts and less likely to get easily absorbed by other industries with different skills needs.

The other important issue to consider in case of an EU-wide scope extension including all fossil fuels relates to the redistribution of ETS revenue.

In the long run, redistributed revenue is normally designed to support the price of green technologies. In the shorter run, it can be used to shape the initial redistribution effects through a set of additional policy measures, for example:

- Providing more direct and indirect compensation and benefits to low-paid employees of the regulated entities
- Reducing employers' tax in sectors that have a lot of low-skilled workers
- Providing direct subsidies / giving grants to low-income households for green technologies, as they are the less likely to afford new/green technologies (like EVs)

Regulatory criteria

The option to extend the scope of the current EU ETS to include all CO_2 emissions from fossil fuel combustion in the existing EU ETS would require the adoption of new legislation amending, *inter alia*, **legislative acts** such as the ETS Directive 2003/87/EC, and the Effort Sharing Regulation (EU) 2018/842 and/or **non-legislative acts** such as the Monitoring and Reporting Regulation (EU) 2018/2066[236] and the Verification Regulation (EU) 2018/2067[237] and the Commission Regulation (EU) No 389/2013 establishing a Union Registry as amended in 2018 and 2019.

Since all measures required for this option have an emissions reduction objective, the analysis of the EU competence complies with the requirements to adopt an EU act under Article 192 TFEU.

The legislative acts under consideration will most likely comply with the principles of 'subsidiarity' and 'proportionality' established under Article 5 of the Treaty of the European Union (TEU)[238]. Emission reduction objectives cannot be sufficiently achieved by Member States in isolation and can be better achieved at Union level for reasons of scale or effects of the proposed action. Furthermore, an ETS covering all

[236] Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions amending Commission Regulation (EU) No 601/2012

[237] Commission Implementing Regulation (EU) 2018/2067 on the verification of data and on the accreditation of verifiers

[238] https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en

CO_2 emissions does not exceed what is necessary to achieve the intended objective. While the scope of the measures under this option might be considered broad, the 2040 zero-emissions objective justifies it from a subsidiarity and proportionality point of view. The main barriers to this option do not seem to be linked to the subsidiarity principle but rather to the effectiveness of this system in comparison to other EU measure that could regulate emission reductions as effectively as the ETS.

The legislation amending the above mentioned legislative acts should be accompanied by amendments to non-legislative acts developing aspects related to the functioning of the ETS such as the Commission Regulation (EU) No 389/2013 establishing a Union Registry as amended in 2018 and 2019.

Implementation, compliance and enforcement measures

The second set of regulatory criteria is linked to the compliance system required for the effectiveness of the ETS that would need to be applied to the new sectors. The ETS implementation is based on clear rules for Monitoring, Reporting and Verification (MRV) of emissions and the definition of enforcement measures to ensure implementation of the regulated entities' obligations and effective penalties for lack of compliance.

This option will require the amendment of non-legislative acts to ensure the applicability of the current Monitoring and Reporting Regulation (EU) 2018/2066[239] and the Verification Regulation (EU) 2018/2067[240] to the new sectors ensuring that a similar robust system for monitoring, reporting and verification (MRV) of emission is applied so that "one tonne emitted is one tonne reported". While this option seems to be based on upstream system, there is no reason to change the current compliance system requiring operators to monitor emissions based on a monitoring plan approved by the competent authority (CA), to report emissions every year to the competent authority and to surrender enough allowances to cover all its verified emissions.

Regulated entities would need to fulfil similarly effective requirements such as listing all the metering instruments and monitoring approaches, outlining the data flows and implemented control procedures in place as they are essential for competent authorities to approve monitoring plans. It is also important that regulated entities are subject to similar rules regarding the verification of emissions by independent, impartial and competent verifiers who are accredited by a national accreditation body and the use of a verification template designed to improve the quality of verification.[241] An upstream system approach facilitates that the current compliance rules for monitoring and reporting are feasible for the regulated entities.

The recently adopted guidance document by the Commission on EU ETS inspections aiming to remedy the problems of capacity of the authorities to check the verified reports might need to be adapted.

It is also likely that under this option the compliance system under the ETS Directive 2003/87/EC, will not change and the breach of the obligation to surrender an equivalent number of emission allowances, every year by 30 April, will entail the activation by competent authorities of effective, proportionate and dissuasive penalties to operators not complying with the rules. The current ETS Directive establishes under its Article 16(3) requires 100 € (+inflation) penalty to be paid for each tCO_2(e)

---

[239] Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions amending Commission Regulation (EU) No 601/2012

[240] Commission Implementing Regulation (EU) 2018/2067 on the verification of data and on the accreditation of verifiers

[241] Ibid.

emissions for which no allowance has been surrendered (without waiving the requirement to surrender the allowances). This penalty system ensures environmental integrity (i.e. effectiveness of the cap) and transparency by the publication of the since the name of the installations and aircraft operators which have failed to surrender sufficient allowances for covering their verified emissions (Article 16(2)). Other penalties "effective, proportionate and dissuasive" are left to the Member States discretion including in relation to obligations not stated in the ETS Directive but in the EU legislation regulating MRVA.

The current option would likely apply similar rules to the new sectors integrating the ETS.

The implementation of other legal acts might also have an impact on the compliance and enforcement of the ETS covering all fossil fuels. For example, any obligations linked to monitoring and reporting under the ETS might benefit from exiting tools like smart metering already introduced in buildings to support the implementation of the EED.

While the adoption of EEOS is specifically mandated within Article 7 of the EED, Member States may choose to implement alternative measures or a combination of both. In fact, the adoption of EEOS is not mandatory in itself and cannot be subject to enforcement measures; indeed a number of countries do not see them as a necessary policy within their national policy framework. However, some countries have designed EEOS that set incentive measures, including subsidies, to achieve energy savings in certain sectors such as vulnerable or low-income households or community-based initiatives. Those measures promote information on efficient energy use, how to reduce the energy bill or how to read smart meters. They promote also the use of other funding instruments to support the necessary investments such as cohesion funds or innovative funding mechanisms. Others promote skill development programmes and training experts. Those measures could interact with the implementation of the ETS covering all fossil fuels by supporting regulated entities to fulfil their obligations for monitoring emissions or training verifiers.

The ETS price might trigger the implementation of energy efficiency measures (e.g. retrofitting existing buildings, as mentioned in section 4.2). However, as energy savings planned under the EEOS have to be additional to those which are expected from existing EU efficiency policies, the objectives in the new designed EEOS will need to take into account the mandatory reduction of emissions under the ETS.

6.2.5.3 Option 1b - full scope extension under existing ESR

In option 1b, we assume that an EU-wide scope extension of the current EU ETS takes place to include all CO_2 emissions from fossil fuel combustion in the existing EU ETS. We further assume that, despite this extension of the scope, the sectors will also remain part of the ESR, so that the scope of the ESR will not change compared to today.

Environmental criteria

Analogue to option 1a, option 1b increases the coverage from 1,590 Mt CO_2e to about 2,830 Mt CO_2e. The emissions regulated by the ESR remain unchanged with 2,252 Mt CO_2e. In total, the EU ETS in option 1b covers 78% of all GHG emissions, while the ESR covers only 59%. Part of the emissions will therefore be double regulated by the EU ETS and the ESR.

There is no difference between option 1a and option 1b with regard to the development of the sectors regulated in the EU ETS until 2030. The emission reduction under the ESR is the same as in option 0, i.e. 26%, as its scope has not changed.

Economic criteria

Negotiation costs: Since in design option 1b the ESR will continue to apply to the additionally regulated sectors, there is less scope for negotiation on emission levels than in option 1a, which will reduce the costs of negotiation. However, it is very likely that the costs of negotiation would be higher than under option 0, as it is likely that certain design features such as MRV procedures, emission factors for certain fuels or exemptions such as carbon leakage will still be negotiated. No costs are expected for connection to the EU ETS.

One-time administrative costs: Like option 1a, option 1b can be built on existing infrastructure, so there are no one-time costs for additional coverage. However, the connection to the EU ETS has to be established, which will result in low costs.

Regularly occurring administrative costs: The costs of option 1b are likely to be very similar to those of option 1a and very high compared to other design options due to the high number of regulated entities. Costs for the connection with the EU ETS are not relevant.

Costs for disclosure and sanctioning: As the costs of disclosure and sanctioning are also highly dependent on the number of regulated entities, it can be assumed that they will also be quite high in terms of coverage in option 1b.

Table 107 provides an overview of the assessment of the relative administrative costs of Option 1b compared to other options.

Table 107.Relative assessment of administrative costs for design option 1b

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning
Coverage	+	o	++	++
Connection with the EU ETS	o	--	o	o

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

Social criteria

Social impacts under this options would in nature be similar to those discussed in option 1a. A key difference would be that the ESR remaining in place, essentially, would mean that double regulation applies for all of these sectors – as a consequence it is expected that regulated entities would presumably seek to pass on the increased costs of compliance to the consumers to an even larger extent than under option 1a. That is, if ESR remains in place for all sectors that are newly included in the EU ETS, the anticipated social impacts are more likely to manifest.

Regulatory criteria

Under this option, similar considerations to those raised under option 1a would be applicable. The only difference is that additional amendments to existing legislative acts would be required in order to ensure that Effort Sharing Regulation (EU)

2018/842 continues to apply to the new sectors and that a clear linking system is designed.

6.2.5.4 Option 2 - separate ETS for all fossil fuels used in non-ETS sectors

In option 2, we assume that the EU ETS will continue as it is and that a separate emissions trading scheme will be implemented for those fossil fuels that have not yet been regulated in the EU ETS. It is assumed that the ESR will continue to apply to the new ETS.

Environmental criteria

In option 2, the coverage of the EU ETS remains unchanged compared to option 0 at 1,590 Mt CO_2e and the ESR also remains unchanged at 2.252 Mt CO_2e. A new ETS covering emissions from the combustion of fossil fuels in the ESR sector is implemented. This new ETS covers 1,420 Mt CO_2e, which is about 37% of total emissions.

Using the EUCO3232.5 scenario, EU ETS and ESR change by 2030 in the same way as in the baseline option 0, i.e. EU ETS emissions fall by 35% from 1,590 to 1,037 Mt CO_2e and ESR emissions fall by 26% from 2,252 to 1,659 Mt CO_2e. Emissions in the new ETS fall by 31% from 1,420 Mt CO_2e to 973 Mt CO_2e in 2030. This means that emissions regulated under the new ETS will decrease faster than emissions regulated only in the ESR, as these emissions will only fall by about 18% in the same 12 years up to 2030.

Economic criteria

Negotiation costs: Design option 2 foresees the establishment of a new ETS alongside the existing ETS, while continuing to apply the ESR for that new ETS. This means that the costs of negotiation in terms of coverage should be comparable to those of option 1b. On the other hand, it is expected that this option will lead to high costs for the connection with the existing EU ETS, as it will be necessary to negotiate whether a link should be possible and if so, how exactly this should be designed. This in turn also affects the sectors currently regulated under the EU ETS, so a number of negotiating partners can be expected.

One-time administrative costs: Design option 2 foresees a completely new emissions trading scheme that cannot be built on existing infrastructure, and high one-off administrative costs are therefore likely. It remains to be waited to what extent it will be possible to build on the experiences of the EU ETS, which could reduce costs. If a link to the EU ETS is to be established, it must also be built into the infrastructure, which leads to administrative costs also for the connection with the EU ETS.

Regularly occurring administrative costs: Although the number of regulated entities in the new ETS is lower than the number of entities in option 1a or 1b, the sum of entities of the EU ETS and the new ETS is likely to be comparable. Therefore, it can be assumed that the ongoing administrative costs are also very high in option 2. If the new ETS is linked to the existing EU ETS, it can be assumed that costs will also be incurred in relation to this, but these will be rather moderate.

Costs for disclosure and sanctioning: As option 2 regulates a comparable number of entities in total as options 1a and 1b, it can be assumed that there is no difference between these options in terms of the costs of coverage. In the case of foreseen linking to the EU ETS, illegal use of this linking must be monitored and sanctioned, which in turn leads to costs.

Table 108 provides an overview of the assessment of the relative administrative costs of option 2 compared to other options.

Table 108.Relative assessment of administrative costs for design option 2

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning
Coverage	+	++	++	++
Connection with the EU ETS	++	+	-	-

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

Social criteria

Social impacts under this options would be quite similar to those discussed in option 1a and 1b.

Regulatory criteria

This option to develop an ETS separated from the current EU ETS covering all CO_2 emissions from fossil fuel combustion would require the adoption of new legislation amending, *inter alia*, **legislative acts** such as the ETS Directive 2003/87/EC, in order to ensure consistency of the systems. The framework would be similar to the one design to regulate aviation as a separated ETS. Furthermore, additional amendments will be required to ensure that the Effort Sharing Regulation (EU) 2018/842 is applicable to the sectors integrating a separated ETS including relevant linking provisions.

The amendments to relevant existing **non-legislative acts** such as the Monitoring and Reporting Regulation (EU) 2018/2066[242] and the Verification Regulation (EU) 2018/2067[243] and the Commission Regulation (EU) No 389/2013 establishing a Union Registry as amended in 2018 and 2019 would also be required. Specific provisions in the legislative acts empowering the Commission to adopt those act might be needed.

As mentioned under option 1a above, the main barriers to this option do not seem to be linked to the subsidiarity or proportionality principle but rather to the effectiveness of a separated ETS covering all CO_2 emissions from fossil fuel combustion in comparison to other EU measures that could regulate emission reductions as effectively as the ETS.

[242] Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions amending Commission Regulation (EU) No 601/2012

[243] Commission Implementing Regulation (EU) 2018/2067 on the verification of data and on the accreditation of verifiers

It is also likely that under this option the compliance system under the ETS Directive 2003/87/EC, will not change and the breach of the obligation to surrender an equivalent number of emission allowances, every year by 30 April, will entail the activation by competent authorities of effective, proportionate and dissuasive penalties to operators not complying with the rules as foreseen under Article 16(3) of the ETS Directive. This penalty system ensures environmental integrity (i.e. effectiveness of the cap) and transparency by the publication of the since the name of the installations and aircraft operators which have failed to surrender sufficient allowances for covering their verified emissions (Article 16(2)). Other penalties "effective, proportionate and dissuasive" are left to the Member States discretion including in relation to obligations not stated in the ETS Directive but in the EU legislation regulating MRVA.

This option will require the amendment of non-legislative acts to ensure the applicability of the current Monitoring and Reporting Regulation (EU) 2018/2066[244] and the Verification Regulation (EU) 2018/2067[245] to the new sectors covered by a separated ETS while ensuring that a similar robust system for monitoring, reporting and verification (MRV) of emission is applied so that "one tonne emitted is one tonne reported". It is likely that a similar system to the current compliance system will be applied requiring operators to monitor emissions based on a monitoring plan approved by the competent authority (CA); to report emissions every year to the competent authority and to surrender enough allowances to cover all its verified emissions.

It is also important that regulated entities are subject to similar rules regarding the verification of emissions by independent, impartial and competent verifiers who are accredited by a national accreditation body and the use of a verification template designed to improve the quality of verification.[246] As described under option 1a, interactions with EEOS might be useful to design support measures to promote the implementation of the monitoring and verification obligations derived from the ETS.

6.2.5.5 Option 3 - new EU-wide upstream ETS

In option 3, we assume that the existing EU ETS will not be continued, but that a pure upstream ETS will be implemented, regulating all fossil fuels. In this case, the ESR will only apply to emissions not covered by this new upstream ETS.

Environmental criteria

With regard to emissions covered by an ETS and those covered by the ESR, there is no difference between option 1a and option 3, assuming that process emissions, which have so far been regulated in the EU ETS and would not be covered in a purely upstream fuel emissions trading scheme, will continue to be regulated downstream. The difference between the two options concerns only the point of regulation, which is not relevant for the environmental criterion.

In figures, this means that as in option 1a, the ETS in option 3 covers 3,011 Mt CO_2e and these emissions will be reduced by 33% to 2,011 Mt CO_2e by 2030. The emissions covered by the ESR would be reduced from 832 Mt CO_2e to 686 Mt CO2e, a decrease of 18%.

[244] Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions amending Commission Regulation (EU) No 601/2012

[245] Commission Implementing Regulation (EU) 2018/2067 on the verification of data and on the accreditation of verifiers

[246] Ibid.

Economic criteria

Negotiation costs: The implementation of a new comprehensive upstream ETS in design option 3 does not necessarily mean that more or less parties need to negotiate with than in the other options, as the same sectors and emissions will be regulated in the end. In the case of downstream regulation of process emissions, it can be assumed that additional negotiations will be necessary, which tends to result in very high negotiating costs in terms of coverage. As no several parallel ETS is planned, no costs related to linking are expected.

One-time administrative costs: It is not clear whether the upstream ETS can be built on the existing infrastructure, but it may be possible, which would lead to low one-time administrative costs.

Regularly occurring administrative costs: It can be assumed that in option 3 the number of regulated entities is lower than in the other options (even if process emissions would continue to be regulated downstream), therefore the regularly occurring administrative costs are also expected to be lower than in the other options. In addition, the absence of a downstream ETS that also regulates fuels makes the MRV less complex, resulting in less administrative work.

Costs for disclosure and sanctioning: As with regularly occurring administrative costs, the number of regulated entities is also very important for the costs for disclosure and sanctioning, so it can be assumed that the costs in option 3 are lower than in the other options. Nor is it possible to take advantage of abuse in terms of ex-ante exemption or ex-post compensation, which would require less administrative effort.

Table 1 provides an overview of the assessment of the relative administrative costs of option 3 compared to other options.

Table 1: Relative assessment of administrative costs for design option 3

	Negotiation costs	One-time administrative costs	Regularly occurring administrative costs	Costs for disclosure and sanctioning
Coverage	++	--	--	--
Connection with the EU ETS	o	o	o	o

++: very high, +: high, o: no significant impact, -: low, --: very low

This table presents a relative assessment of the different design options within the design elements. A comparison between design elements or cost types is not possible.

Social criteria

Under a new EU-wide upstream inclusion of all fuels, all allowances would be auctioned. According to CE Delft (2014), all fossil fuel extractors, importers and TSOs (transmission system operators) are likely to pass on the costs along the supply chain, therefore, all economic sectors will face higher costs of fossil fuel use. This could affect sectors already at risk of carbon leakage[247] relatively more. However, there is presumably little impact on end consumers from a pricing measure that is imposed on businesses only.

The earlier CE Delft (2014) work estimated the relevant number of potentially regulated entities to be less than 3,000: including about 500 extractors, 1,000–1,500 importers and 1,000–1,500 installations with non-combustion emissions. This means that the operational administrative / transaction costs, related to MRV (monitoring, reporting and verification) of emissions and trading of allowances, would be significantly lower than in the current system, which comprises about 13,000 entities.

Overall, the administrative costs could be decreased in an upstream system due to the lower number of regulated entities, but the benefits would, to a large extent depend on the treatment of sectors exposed to carbon leakage.

Windfall profits would still occur because the free allowances are in essence a transfer to the receiving industries, and are not dependent on the productivity of the market players. Hence, the product prices would reflect the higher cost prices of fossil fuels, but not the revenues made from selling free allowances to upstream sectors.

The social impacts in the transport sector and in the buildings sector would be the same as the combination of the relevant inclusion design options discussed above.

Regulatory criteria

This option to develop a new EU ETS replacing the existing EU ETS which will be a pure upstream ETS regulating all fossil fuels would require the adoption of new legislation replacing the ETS Directive 2003/87/EC. The Effort Sharing Regulation (EU) 2018/842 will remain as it is applicable to emissions not covered by this new upstream ETS

The analysis of the regulatory criteria regarding competency and EU added value are consistent with other options. EU Competence remains and the subsidiarity or proportionality principles do not seem to be an issue. The main difficulty for this option could still be linked to the effectiveness of a different ETS covering all CO_2 emissions from fossil fuel combustion in comparison to other EU measures that could regulate those emission as effectively as the ETS.

As highlighted in the 2015 report on the evaluation of the EU ETS Directive the MRVA have increased the robustness of the system and improved the level playing field for participating industries[248]. It is therefore quite likely that similar non-legislative acts would be adopted which requires specific provisions under the new legislative acts, empowering the Commission to adopt non-legislative acts to design compliance and enforcement rules. The compliance rules for monitoring and reporting would need to be feasible for the regulated entities. The system to be designed will ensure a level playing field applicable to all sectors and maintain a robust system. In such upstream system, the regulated entities should be subject to rules regarding the verification of emissions by independent, impartial and competent verifiers who are accredited by a national accreditation body and the use of a verification template designed to improve the quality of verification. As described under option 1a, interaction with EEOS could be used to

[247] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1557732929383&uri=CELEX:32019D0708

[248] Evaluation of the EU ETS Directive, Ecologic and SQ Consult, 2015, https://www.ecologic.eu/sites/files/publication/2015/2614-04-review-of-eu-ets-evaluation.pdf

design measures supporting regulated entities to comply with the monitoring and verification obligations derived from the ETS or the training of expert verifiers.

A similar system to the Commission Regulation (EU) No 389/2013 establishing a Union Registry would need to be designed as the effectiveness and efficiency of an EU-wide registry in comparison to national ones has been proved. As granting allowances do not seem to be the best system for allocating emission permits, a system establishing a system for auctioning similar to the one regulated under Commission Delegated Regulation (EU) 2019/1868 amending Regulation (EU) No 1031/2010 on the auctioning of allowances for the period 2021 to 2030 might also be needed.

6.3 Question 5.3: Impact on existing Regulatory Framework

The main instruments that are of relevance have been described in section 5.2.1: these include vehicle CO_2 performance standards for passenger cars, light-duty vehicles and for heavy-duty vehicles, Renewable Energy Directive, Energy Tax Directive, and the Eurovignette Directive. The impact of an extended ETS on these main instruments is broadly similar, irrespective of whether carbon pricing is extended to buildings and transport, or whether it is extended to all fossil fuels. In this way, the conclusions of section 4.2.1 generally also apply if the EU ETS were extended to all fossil fuels. In addition, the impact on some other main parts of the EU Regulatory Framework is considered, which would be additionally affected by an EU ETS extended to all fossil fuels.

6.3.1 Vehicle CO_2 performance standards

The functioning of the instrument is described in section 5.2.1.1. The standards are credited there as a main driver of emission reductions in the transport sector – and yet an extended ETS can be a useful complement to these standards in many ways, and enhance their functioning.

- First, an extended ETS would tackle the rebound effect, as it controls total emissions rather than specific emissions: the performance standards themselves can lead to a situation where increased fuel efficiency creates an incentive to drive more. The ETS, as it controls total emissions would be suited to counteract this effect.
- Second, the ETS captures real-life emissions rather than standards achieved under testing conditions, thus addressing one deficiency of the performance standards.
- Third, by increasing fuel prices, the ETS would tend to increase demand for more fuel-efficient vehicles, which in turn makes it easier for car manufacturers to meet their efficiency objectives.
- And fourth, as elaborated in section 5.2.1.1, the ETS carbon price in and of itself is ill-suited to bring about the necessary technological leaps and the transformative change that the performance standards are geared towards – and indeed the carbon price would have to rise to levels of several hundred Euro to bring about the envisaged change.

Such transformative carbon prices could be the result of a stand-alone ETS that only covers the transport sector (or transport and buildings) (Option 2 – depending on how the link to the existing ETS is implemented). Yet they would hardly be feasible in the case of a broad, uniform ETS that spans across all major sectors, as would be the case for an ETS covering all fossil fuels (Options 1a, 1b and 3) – particularly since this price would also apply to businesses exposed to international competition. Therefore, if anything, the justification for having vehicle performance standard as a complement to the carbon price is stronger in case of an ETS extended to cover all fossil fuels.

6.3.2 Eurovignette Directive

Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures, also known as the Eurovignette Directive, sets the legal framework for charging heavy goods vehicles (i.e. trucks and lorries with a laden weight of more than 3.5 tons) for the use of certain roads. However, the Eurovignette Directive does not require Member States to charge HGVs for the use of roads, but merely determines the standards for those that want to do so. In practice, MS apply a wide variety of systems, from time-based to distance-based charging system, in some instances also reflecting the emissions performance (Euro class) of HGVs.

At a basic level, both the Eurovignette Directive and a possible upstream ETS covering all fuels would share the same basic goal: to better implement the polluter pays principle, in this case in the field of road transport (as noted in section 5.2.1 for the case of extending carbon pricing to the transport sector). Both make road transport with HGVs more expensive – yet importantly, they also address different cost components. The Eurovignette Directive is intended to not only cover the external costs of pollution (CO_2 and also other types of air pollution, noise etc.), but more importantly the cost of providing and maintaining road infrastructure, as well as the cost of congestion. Thus, at least in its present form, the Eurovignette Directive is predominantly concerned with infrastructure charging, thus implementing the user pays principle in addition to the polluter pays principle. The ongoing revision of the Eurovignette Directive, however, aims to change this situation, first by moving to distance-based instead of time-based charges, and by allowing MS to differentiate these distance-based road use charges based on the specific CO_2 emissions of the LGVs (rather than their Euro class, as currently applied in some Member States).[249]

In this way, the revised Eurovignette Directive (differentiated for CO_2 emissions) and an upstream ETS for all fossil fuels would overlap in their objective to capture the external costs of CO_2 emissions. The upstream ETS, however, would still be the most targeted tool to achieve this objective, as it imposes a carbon price per actual ton emitted, whereas a CO_2-adjusted road charge would effectively still impose a price per km travelled. Thus, the introduction of an upstream ETS for all fossil fuels would need to be considered in a subsequent revision of the Eurovignette Directive by eliminating the CO_2 differentiation; yet the instrument itself would remain necessary and justified as a tool to recover infrastructure cost and to internalise non-CO_2 externalities of road transport.

6.3.3 Renewable Energy Directive

Also, here, in general the findings laid out in section 5.2.1.2 (derived for the extension of carbon pricing to transport and buildings) also apply to the case of an ETS for all fossil fuels.

One additional consideration is that, in the case of an ETS covering all fossil fuels, there would be less risk of a distortion if biofuels are specifically used to meet goals in the transport sector. In the alternative scenario of an ETS that extends to transport (or to transport and heating), the use of biofuels driven by the REDII goals for the transport sector would have the effect of lowering fossil emissions, and thus demand for allowances in the transport sector. For other sectors that remain outside the ETS, and which could also potentially use biofuels (e.g. agriculture), this would only have the effect of raising the price of biofuels – but there would be no incentive generated from the ETS to use biofuels in these sectors.

[249] Germany has recently announced plans to adopt its existing system of highway charging for HGVs to include a CO_2 component, see section 2.2.2.2

This changes for an ETS that covers all fossil fuels (1a, 1b, 2 and 3). In such a system, there is no fossil fuel combustion left outside the scope of the ETS, therefore all sectors (including e.g. agriculture) would therefore have an incentive to use more biofuels in order to avoid the carbon price component of fossil fuels. At the margin, this would therefore drive up demand for biofuels in sectors outside the scope of the current ETS plus transport and housing. For the transport sector, this would make it marginally more difficult to meet its biofuels objectives.

6.3.4 Energy Taxation Directive

In this instance, the analysis laid out in section 5.2.1.3 applies in full – as the discussion in this part applies to the provisions which the Energy Taxation Directive makes for transport fuels, which would be part of the ETS in either case.

As an additional consideration, the ETD (Art. 8, Annex 1 B) specifies derogations in the form of significantly reduced tax rates for motor fuels that are used for industrial and commercial purposes (in particular in agricultural, horticultural or piscicultural works, and in forestry; for stationary motors; for construction machinery and for vehicles intended for use off the public roadway). These uses benefit from significantly lower tax rates: the minimum tax applicable to diesel and kerosene in these uses is 0.021 Euro per litre, compared to the general minimum rate 0.302 Euro per litre for diesel and kerosene. Unlike the case where the ETS is merely extended to the transport sector, the fuels and uses specified in article 8 would also be affected by the upstream carbon price.

This does not create a legal conflict per se, as the minimum level specified in the ETD is a minimum level for taxation, and as such does not relate to the price signal set by an extended ETS. Thus, the expectation is that the single carbon price which the extended ETS sets for all fossil fuels and all uses would also apply to the fuels laid out in Article 8 of the ETD – anything else would undermine the economic efficiency of the system and defeat the intended goal of having one single carbon price for all fossil fuel uses.

Yet it does mean that the relative increase of the fuel price brought about by an extended ETS would be much more palpable for the uses specified in Article 8, as they start from a much lower base. It could also lead to renewed discussion about the justification of the derogations in Article 8, as the fuel uses specified therein would continue to benefit from lower overall fuel prices than other sectors, questioning the overall efficiency of the system. This might have an additional impact which leads to a legal change in the ETD regarding the derogation provisions.

6.3.5 Industrial Emissions Directive

The Industrial Emissions Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions), as successor to seven other Directives including the IPPC, Large Combustion Plant and Waste Incineration Directives, commits Member States to control and reduce the impact of a broad range of industrial emissions on the environment. The legal coexistence of the IED and its predecessors with the EU ETS has been resolved over the years.

There is one specific element of interaction between the IED and the EU ETS that would need to be resolved in case of an ETS expanded to include all fossil fuels. Article 9 of the IED specifies that, for greenhouse gas emissions from an installation that fall under the remit of the EU ETS Directive, the IED permit shall not include an emission limit value for that gas – i.e. the IED explicitly does not regulate greenhouse gas emissions from EU ETS installations. Furthermore, Article 9 (2) specifies that Member States may choose to exempt EU ETS installations from requirements relating to the energy efficiency of combustion units.

In the case of an ETS applied to all fossil fuels, these exemptions may need to be revisited. The current construction of referring to the coverage of the ETS Directive would only work if there is still a positive list of activities to which the EU ETS applies (as in option 1a or 1b). However, if industrial installations were covered by an upstream ETS (as in option 3, or possibly 2), while they would fall under the remit of the expanded ETS, they would not be identifiable as "ETS installations", as none of them would have reporting or other compliance obligations.

A second consideration is that the exemption in Article 9 of the IED applies to greenhouse gas emissions. However, an upstream ETS (as in option 3) would cover all fossil fuels and hence CO_2 emissions. The question remains how other, non-CO_2-GHGs would be addressed. One feasible way forward would be to exclude all emission limit values for CO_2 emissions from the IED, but – depending on how the system is implemented – retain them for non-CO_2 GHG emissions. For options 1a, 1b and possibly 2, it is plausible that they would also include non-CO_2-emissions from industry; hence the situation would be reconciled more easily. The IED permit would need to take into account the measures under the ETS to keep emissions under the ETS cap when setting the emission limit values.

6.3.6 EU Agricultural Policy

Next to small industrial installations, agriculture is the other main sector that would be affected if the ETS was expanded to all fossil fuels. For agriculture, the impact on the regulatory framework is relatively straightforward to assess in the sense that there is no relevant regulatory framework: there are no separate emission reduction targets for agriculture established in EU legislation. Existing climate protection efforts in the sector focus on nutrient management, animal feeding strategies, reduced emissions from organic soils, increase in carbon content of mineral soils, and above-ground biomass sequestration. The role of emissions from fossil fuel combustion is minor compared to other emission sources (CH_4, N_20, CO_2 from soil management) and sequestration potential. While there are options for Member States to support investments in more efficient tractors, machinery, and energy efficiency through the investment measure under Rural Development Programmes, the scale of this investment and savings made are also minor compared to the role of instruments targeting other GHG in the agricultural sector. In this sense, there are no positive or negative interactions of a carbon pricing tool with other climate-related policies in EU agricultural policy.

There is, however, an interaction with the partial tax exemption specified in Article 8 ETD for diesel and kerosene used, among others, in agriculture, horticulture, pisciculture and forestry, as discussed above. While the extension of the ETS to include all fossil fuels would not violate the letter of this exemption, it would run counter to its intention, and expose the fundamental conflict between economic efficiency (which suggests a single, uniform carbon price across all sectors) and the desire to avoid hardships to individual sectors and emitters.

6.3.7 Effort-Sharing Regulation

An extension of the ETS would have quite significant effects on both the functioning of the ESR, and its function in the broader context of EU climate policy.

As laid out in option 1a, **the extension of the EU ETS could coincide with reduced coverage of the ESR**. This would effectively reduce the coverage of the ESR to non-CO2 GHGs, and its function to that of a residual instrument. For the functioning of the ESR, this would suggest a very different dynamic: when limited to non-CO_2 GHGs, the scope of the instrument would be dominated by agriculture, forestry, land use and waste, with some contribution from industry. For most of these, emission trends are driven by factors that are outside the remit of climate policy, and outside the sphere of influence of Members States – i.e. by weather patterns, by developments in EU agricultural policy, by world market prices for agricultural produce and for recycled products. In this setting, the function of the flexibility mechanisms of the ESR, which allows Member States to trade emission allowances as a way of ensuring compliance with ESR targets, would largely be taken over by transactions between private entities: as the covered entities buy and sell allowances to and from entities in other European countries and surrender them to fulfil their compliance obligation, they would not only meet their own obligations, but would also ensure that the national registry has sufficient allowances to be in compliance. Thus, the role of the public administrator in this setting would be reduced to procure allowances to match the residual non-ETS emissions. Since these are, as argued above, largely driven by trends and developments (perceived to be) outside the control of the Member States, this trading activity would presumably be a retroactive matching of emissions and allowances, rather than a proactive management of emissions.

The alternative is presented with **option 1b, where coverage of the ESR is maintained at current levels, and at the same time expanding the coverage of the ETS.** This would thus depart from the current situation (where ETS and ESR are binary alternatives), and create an area of overlap where both the ESR and the ETS apply. This fundamental change in the architecture of EU climate policy, would suggest that the function of the ETS and the ESR would change: in this setting, the Member States would retain some amount of control over, and political responsibility for, emission trends in the ESR sectors, despite the fact that the ESR emitters are also part of a trading system. This control could then be used to set a long-term framework for emission reductions in the covered sectors, whereas the function of the ETS would rather be to leverage short-term optimisation potentials between the covered sectors. Alternatively, the ESR would leverage optimisation potentials in the covered sectors once the impact of the ETS emission reduction objective has been established.

7 References

7.1 Task 1 (Section 2)

Ackva 2018a: Sweden's Carbon Tax. Ackva, Johannes und Hoppe, Janna/Ecofys and adelphi. Available at: https://www.euki.de/wp-content/uploads/2018/11/fact-sheet-carbontax-se.pdf (date of access: 25.03.2020)

Ackva 2018b: Sweden's Carbon Tax. Ackva, Johannes und Hoppe, Janna/Adelphi Webstory for publication Sweden's Carbon Tax (see above). Available at: https://www.adelphi.de/en/publication/carbon-tax-sweden (date of access: 25.03.2020)

ADEME 2020: Bonus et malus écologiques en 2020, Website Agence de la transition écologique, Paris. Available at: https://www.ademe.fr/particuliers-eco-citoyens/financez-projet/vehicule/bonus-malus-ecologiques-2020 (date of access: 14.04.2020)

Agora Energiewende 2019: The french CO2 pricing policy: Learning form the yellow vest protests, Berlin. Available at: https://www.agora-energiewende.de/fileadmin2/Projekte/2018/CO2-Steuer_FR-DE_Paper/Agora-Energiewende_Paper_CO2_Steuer_EN.pdf (date of access: 06.04.2020)

Åkerfeldt and Hammar 2015: CO_2 Taxation in Sweden - Experiences of the Past and Future Challenges. Åkerfeldt, Susanne and Hammar, Henrik. Available at: https://www.un.org/esa/ffd/wp-content/uploads/2016/12/13STM_Article_CO2-tax_AkerfeldtHammar.pdf

Amendment to Catalan Climate Change Law, Law 9/2019. 2019: Modificación de la Ley 16-2017 de cambio climático de Cataluña. Available at: https://www.boe.es/eli/es-ct/l/2019/12/23/9 (date of access: 31.03.2020)

Andersson 2017: Cars, carbon taxes and CO_2 emissions. Andersson, Julius. Centre for Climate Change Economics and Policy / Grantham Research Institute on Climate Change and the Environment. Available at: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2017/03/Working-paper-212-Andersson_update_March2017.pdf (date of access: 25.03.2020)

Arimura, Toshi H., and Tatsuya Abe. 2020. 'The Impact of the Tokyo Emissions Trading Scheme on Office Buildings: What Factor Contributed to the Emission Reduction?' Environmental Economics and Policy Studies, March. https://doi.org/10.1007/s10018-020-00271-w.

Asen, E. 2019: Carbon taxes in Europe. Tax Foundation. Available at: https://taxfoundation.org/carbon-taxes-in-europe-2019/ (date of access: 31.03.2020).

Assemblée Nationale 2013: Résolution pour une fiscalité écologique au cœur d'un développement soutenable, Paris, 4 juin 2013. Available at: http://www.assemblee-nationale.fr/14/ta/ta0146.asp (date of access 06.04.2020)

Bach, Stefan, Niklas Isaak, Claudia Kemfer, and Uwe Kunert. 2019. 'CO2-Bepreisung Im Wärme- Und Verkehrssektor: Diskussion von Wirkungen Und Alternativen Entlastungsoptionen'. 140. Politikberatung Kompakt. Berlin: Deutsches Institut für Wirtschaftsforschung.

Bayer, Edith/ Cowart, Richard 2018: Small district heating systems key to improving Poland's air quality. Available at: https://energypost.eu/cleaning-up-poland-is-not-about-big-coal-but-small-heating/ (date of access: 16.04.2020)

Bohlin 1998: The Swedish Carbon Dioxide Tax: Effects on Biofuel Use and Carbon Dioxide Emissions. Bohlin, Folke. In: Biomass and Bioenergy Vol. 15, Nos 4/5, pp. 283-291/Elsevier Science Ltd. Available at: https://www.academia.edu/28163907/The_Swedish_carbon_dioxide_tax_effects_on_biofuel_use_and_carbon_dioxide_emissions (date of access: 09.04.2020)

Brundgage-Moore, Asha. 2019. 'The Tokyo Emissions Trading Scheme: Lessons from a Pioneering Jurisdiction'. New York: NYU Law Guarini Center on Environmental, Energy and Land Use Law.

Bundesministerium für Umwelt, Naturschutz und Nukleare Sicherheit (BMU). 2019a. 'Warum Eine Einbeziehung Des Verkehrssektors in Den Europäischen Emissionshandel Nicht Möglich Ist'. BMU. https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Emissionshandel/einbeziehung_verkehrssektor_emissionshandel_EU__ETS_bf.pdf.

Bundesministerium für Umwelt, Naturschutz und Nukleare Sicherheit (BMU). 2019b. 'Eckpunkte Zur Ausgestaltung Eines Nationalen Emissionshandels Für Wärme Und Verkehr'. Berlin: BMU. https://www.bmu.de/download/eckpunkte-zur-ausgestaltung-eines-nationalen-emissionshandels-fuer-waerme-und-verkehr/.

Bundesregierung. 2019. 'Eckpunkte Für Nationalen Emissionshandel CO2-Preis Für Wärme Und Verkehr'. Bundesregierung. https://www.bundesregierung.de/breg-de/aktuelles/co2-preis-fuer-waerme-und-verkehr-1682074.

Buñuel González, M. 2015: Implementing a carbon tax in Spain: how to overcome the fear of inflation? Green Growth Knowledge Platform (GGKP). Third Annual Conference, Venice.

Burger, Andreas, Benjamin Lünenbürger, and Christoph Kühleis. 2019. 'CO2-Bepreisung in Deutschland: Ein Überblick Über Die Handlungsoptionen Und Ihre Vor- Und Nachteile'. Dessau-Roßlau: Umweltbundesamt.

Businessinsider 2020: Ministerstwo Infrastruktury podniosło opłatę paliwową na 2020 r. Już po raz drugi. Available at: https://businessinsider.com.pl/motoryzacja/oplata-paliwowa-podwyzki-w-2020-roku/pzm516s (date of access: 16.04.2020)

California Executive Order S-21-09, available online via web archive of Center for Climate Strategies at http://www.climatestrategies.us/library/library/view/290 (accessed March 2020)

California Legislative Analyst's Office (LAO Gabriel Petek). 2020. Assessing California's Climate Policies—Electricity Generation. 6 January, 2020. Available online (accessed March 2020) at https://lao.ca.gov/Publications/Report/4131

California Legislative Analyst's Office (LAO). 2017. 'The 2017-18 Budget: Cap-and-Trade'" available at http://www.lao.ca.gov/Publications/Report/3553, accessed March 2020.

California Senate Bill 100, de Leon 2018: California Renewables Portfolio Standard Program: emissions of greenhouse gases. Bill text available online (accessed March 2020) at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100

CARB 2014a: "Information for Entities That Take Delivery of Fuel for Fuels Phased into the Cap-and-Trade Program Beginning on January 1, 2015." Archived guidance document for fuel distributors. Available online (accessed March 2020) at https://ww2.arb.ca.gov/mrr-data

CARB 2014b: "California's Cap-and-Trade Program: Fuel Facts." Published December 2014. Available online (accessed March 2020) at www.arb.ca.gov/cc/capandtrade/capandtrade.htm under "program overview" then "fuels under the cap".

CARB 2019: California Greenhouse Gas Emissions for 2000 to 2017 - Trends of Emissions and Other Indicators. Available for download (accessed March 2020) at https://ww2.arb.ca.gov/ghg-inventory-data

CARB 2019: Mandatory Greenhouse Gas Reporting 2018 Emissions Year Frequently Asked Questions. Published November 8, 2019. Available online (accessed March 2020) at https://ww2.arb.ca.gov/mrr-data

CARB 2020: PDF version of presentation entitled "LCFS basics" available for download at https://ww2.arb.ca.gov/resources/documents/lcfs-basics, accessed March 2020.

Carbon Pulse LCFS dossier, available online (subscription required) at https://carbon-pulse.com/50599/#California_Low_Carbon_Fuel_Standard_LCFS. Accessed March 2020

Carbon Pulse. 2020. 'NZ Market: NZUs Hit NZ$29 on Bullish Surge Following Move to Lift Fixed Price « Carbon Pulse'. 14 January 2020. https://carbon-pulse.com/90037/.

Carbon Pulse. 2020. "ETS harmonisation, integrity key to future TCI cap-and-trade system - stakeholders." Carbon Pulse, 2 March 2020. Available online (subscription only, accessed April 2020) at https://carbon-pulse.com/93378.

Catalan Climate Change Law, Law 16/2017. 2017/2019: Ley de Cambio Climático de Cataluña. Available at: https://www.boe.es/eli/es-ct/l/2017/08/01/16/con (date of access: 31.03.2020)

Climate Action Tracker. 2020. 'New Zealand | Climate Action Tracker'. 2020. https://climateactiontracker.org/countries/new-zealand/.

Comité pour l'économie verte 2018: Comment construire la fiscalié environmentale pour le quinquennat et après 2022? Available at: https://www.ecologique-solidaire.gouv.fr/sites/default/files/Comment%20construire%20la%20fiscalit%C3%A9%20environnementale%20pour%20le%20quinquennat%20et%20apr%C3%A8s%202022.pdf (date of access 07.04.2020)

Commission of Experts for the Reform of the Spanish Tax System 2014. Report. Comisión de expertos para la reforma del Sistema tributario Español. Informe. Madrid.

Commission présidée par Alain Quinet 2009: La valeur tutélaire du carbon. Available at: https://www.vie-publique.fr/sites/default/files/rapport/pdf/094000195.pdf (date of access: 07.04.2020)

COM (European Commission) 2018: In-depth analysis in support of the Commission Communication COM (2018) 773A: Clean Planet for all - A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy. Brussels, 28 November 2018. Available at: https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf (date of access: 05.03.2020)

Concawe 2019: A look into the role of e-fuels in the transport system in Europe (2030–2050). Available at: https://www.concawe.eu/wp-content/uploads/E-fuels-article.pdf (date of access: 09.03.2020).

Conseil d'analyse économique 2019: A Proposal for the Climate: Taxing Carbon not People. Available at: http://www.cae-eco.fr/IMG/pdf/cae-note050-env3.pdf (date of access: 07.04.2020)

Council of Europe, Council Directive, 2003, 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity [online] Brussels Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32003L0096:en:HTML (date of access: 10.04.2020)

CPUC 2019: California Renewables Portfolio Standard Annual Report, November 2019. Available online (accessed March 2020) at https://www.cpuc.ca.gov/RPS_Reports_Data/

De Perthuis, Ch.; Faure, A. 2018: Projet de loi de finances 2019: Taxe carbon, l'heure de verité, Policy Brief, Chaire Économie du Climat, Paris. Available at: https://www.chaireeconomieduclimat.org/wp-content/uploads/2018/11/2018-04-POLICY-BRIEF-2.pdf (date of access: 08.04.2020)

DeCicco and Truelove, 2017: "Carbon taxes and the affordability of gasoline." Report from the University of Michigan Energy Survey. Ann Arbor, MI: University of Michigan Energy Institute, September 2017

DEHSt 2011: Leitfaden: Teil 3a - Spezielle Zuteilungsregeln für anlagenübergreifende Wärmeströme. Available at: https://www.dehst.de/SharedDocs/downloads/DE/stationaere_anlagen/2013-2020/Leitfaden-3a.pdf?__blob=publicationFile&v=4 (date of access: 04.02.2020)

Deloitte 2016: The Energy Efficiency Act. New obligations for suppliers of electricity, heat and natural gas to end users. Available at: https://www2.deloitte.com/pl/en/pages/doradztwo-prawne/articles/alerty-prawne/the-energy-efficiency-act.html (date of access: 16.04.2020)

Diamant, et al, 2013: Exploring the Interaction Between California's Greenhouse Gas Emissions Cap-and-Trade Program and Complementary Emissions Reduction Policies. Electric Power Research Institute (EPRI) technical update March 2013 document number 3002000298. Technical Paper ,

Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32003L0087 (date of access: 31.03.2020)

Drews, S., van den Bergh, J., & Maestre Andres, S. 2019: ¿Aceptaríamos en España un impuesto al carbono? Available at: https://theconversation.com/aceptariamos-en-espana-un-impuesto-al-carbono-118218 (date of access: 31.03.2020)

Duran, M. L. 2015: El Impuesto sobre gases fluorados de efecto invernadero: reflexiones a los dos años de su aprobación. Universidad de Alcalá, Madrid.

ECF et al. 2012: Carbon taxation and fiscal consolidation: the potential of carbon pricing to reduce Europe's fiscal deficits. European Climate Foundation, Green Budget Europe, Vivid Economics, London. Available at: https://www.vivideconomics.com/wp-content/uploads/2019/05/Carbon_taxation_and_fiscal_consolidation_Polish-1.pdf (date of access: 21.04.2020)

Edenhofer, Ottmar, Christian Flachsland, Matthias Kalkuhl, Brigitte Knopf, and Michael Pahle. 2019. 'Optionen Für Eine CO2-Preisreform'. Berlin: Mercator Research Institute on Global Commons and Climate Change (MCC).

Edenhofer, Ottmar, Matthias Kalkuhl, and Axel Ockenfels. 2020. 'Das Klimaschutzprogramm Der Bundesregierung: Eine Wende Der Deutschen Klimapolitik?' Perspektiven Der Wirtschaftspolitik, February. https://doi.org/10.1515/pwp-2020-0001.

EDF et al, 2015: "California" in publication series The World's Carbon Markets: A Case Study Guide to Emissions Trading. Washington, DC: Environmental Defense Fund et al. Version updated April 2015 (more recent updates exist)

El Economista (2016). Los impuestos medioambientales se abren paso en nuestro país. Available at: https://www.eleconomista.es/especial-medio-ambiente/noticias/9488142/10/18/Los-impuestos-medioambientales-se-abren-paso-en-nuestro-pais.html (date of access: 18.04.2020)

El Economista (2020). El Gobierno abre la puerta a subir el impuesto al diésel Available at: https://www.eleconomista.es/politica/noticias/10306859/01/20/El-Gobierno-abre-la-puerta-a-aplicar-el-impuesto-al-diesel.html (date of access: 20.04.2020)

Energy Information Agency (EIA) State profile and energy estimates, profile analysis California. Last updated January 2020 (accessed March 2020) available online at https://www.eia.gov/state/analysis.php?sid=CA

ENSPOL n.d.: Energy Savings Policies. Poland. Available at: http://www.article7eed.eu/index.php/poland (date of access: 16.04.2020)

Environmental Defense Fund, International Emissions Trading Association, and CDC Climat. 2015. 'Tokyo: An Emissions Trading Case Study'. The World's Carbon Markets: A Case Study Guide to Emissions Trading. EDF, CDC Climat & IETA.

Environmental Protection Agency. 2019. '2018 New Zealand Emissions Trading Scheme Report'. Wellington: Environmental Protection Agency. https://www.epa.govt.nz/assets/Uploads/Documents/Emissions-Trading-Scheme/Reports/Annual-Reports/b450975461/2018-ETS-Annual-Report.pdf.

Environmental Protection Agency. 2020. 'Industries in the Emissions Trading Scheme | EPA'. 2020. https://epa.govt.nz/industry-areas/emissions-trading-scheme/industries-in-the-emissions-trading-scheme/.

Ericsson 2009: Introduction and development of the Swedish district heating systems Critical factors and lessons learned. Available at: https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/res-h_policy_introduction_and_development_of_swedish_dh_systms_en.pdf (date of access: 29.03.2020)

EU Building Stock Observatory 2016: Topic 1: Building Stock Characteristics. Available at: https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/eu-bso (date of access: 05.03.2020)

European Commission DG Climate Action 2020: EU Emissions Trading System (EU ETS). Available at: https://ec.europa.eu/clima/policies/ets_en (date of access: 28.03.2020)

European Commission, n.d.: A European Strategy for low-emission mobility. Available at: https://ec.europa.eu/clima/policies/transport_en (date of access: 31.03.2020)

European Commission: 2019 Taxation: Commission refers Poland to Court, Brussels. Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_19_6311 (date of access: 10.04.2020)

European Commission Directorate General CLIMA 2020: Personal communication – Member State specific historic activity level of district heating, on 27.03.2020.

European Environment Agency (EEA) 2019a: Greenhouse gas - data viewer on greenhouse gas emissions and removals, sent by countries to UNFCCC and the EU Greenhouse Gas Monitoring Mechanism, emission source 1.A.3.b. Available at: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer (date of access: 05.03.2020)

European Environment Agency (EEA) 2019b: Annual European Union greenhouse gas inventory 1990–2017 and inventory report 2019. European Environment Agency, Brussels. Available at: https://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2019 (date of access: 10.04.2020)

European Environment Agency (EEA) 2020: Carbon intensity from electricity generation. Available at: https://www.eea.europa.eu/data-and-maps/daviz/sds/co2-emission-intensity-from-electricity-generation-2/@@view (date of access: 09.03.2020)

European Parliament, 2006 Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC (date of access: 10.04.2020)

European Parliament, 2012, Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (date of access: 10.04.2020)

Eurostat 2020: Greenhouse Gas Emissions per Capita. Available at: https://ec.europa.eu/eurostat/databrowser/view/t2020_rd300/default/table?lang=en (date of access: 30.03.2020)

Eurostat 2019a: Sustainable Development Report in the European Union – Monitoring report on progress towards the SDGs in an EU context – 2019 edition. Available at: https://ec.europa.eu/eurostat/web/products-statistical-books/-/KS-02-19-165 (date of access: 09.03.2020)

Eurostat 2019b: Energy consumption in households. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_consumption_in_households#Energy_consumption_in_households_by_type_of_end-use (date of access: 09.03.2020)

Eurostat 2020a: Complete energy balances. Data code: nrg_bal_c. Last update: 24-02-2020.

Eurostat 2020b: Stock of vehicles. Data code: road_eqs_carpda, road_eqs_busmot, road_eqs_lormot.

Eurostat 2020c: Commuting between regions. Available at: https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/DDN-20200324-1 (date of access: 05.03.2020)

Eurostat 2020d: Population. Data code: TPS00001

Eurostat 2020e: Greenhouse Gas Emissions per Capita. Available at: https://ec.europa.eu/eurostat/databrowser/view/t2020_rd300/default/table?lang=en (date of access: 30.03.2020)

Forum Energii 2019: Clean Heat 2030. Strategy for heating. Available at: https://forum-energii.eu/public/upload/articles/files/strategia dla cieplownictwa_en_net.pdf (date of access: 16.04.2020)

Fraunhofer Institut für System- und Innovationsforschung (ISI) 2019: Erstellung von Anwendungsbilanzen für die Jahre 2018 bis 2020 für die Sektoren Industrie und GHD; Studie für die Arbeitsgemeinschaft Energiebilanzen e.V. (AGEB) – Entwurf. Karlsruhe, 27. September 2019

Gestha 2019. Ministry of Finance Technicians' Union: Gestha propone gravar las emisiones contaminantes para recaudar más de 10.000 millones de euros al año. Available at: http://www.gestha.es/index.php?seccion=actualidad&num=637 (date of access 18.04.2020)

Gloriant, S. 2018: Une évaluation quantifiée de la "taxe carbone" francaise. Chaire Économie du Climat, Paris. Available at: https://www.chaireeconomieduclimat.org/wp-content/uploads/2018/10/ID57.pdf (date of access: 08.04.2020)

Governement Offices of Sweden 2018: Sweden's Draft Integrated National Energy and Climate Plan. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/sweden_draftnecp.pdf (date of access: 28.03.2020)

Government Bill 2019: A unified policy for the climate - climate policy action plan (2019/20: 65) (in Swedish). Available at: https://www.regeringen.se/4afbe4/contentassets/61f93d2abb184289a0c81c75395207b6/en-samlad-politik-for-klimatet--klimatpolitisk-handlingsplan-prop.-20192065 (date of access: 09.04.2020)

Government of Catalonia. 2019: The Government makes changes to the vehicle carbon dioxide emission tax. Available at: https://web.gencat.cat/en/actualitat/detall/El-Govern-modifica-limpost-sobre-les-emissions-de-dioxid-de-carboni-dels-vehicles (date of access: 31.03.2020)

Government Offices of Sweden 2019: Climate Policy Action Plan Facts (in Swedish). Available at: https://www.regeringen.se/4af76e/contentassets/fe520eab3a954eb39084aced9490b14c/klimatpolitiska-handlingsplanen-fakta-pm.pdf (date of access: 26.03.2020)

Government Offices of Sweden 2020: Sweden's Carbon Tax. Available at: https://www.government.se/government-policy/taxes-and-tariffs/swedens-carbon-tax/ (date of access: 23.03.2020)

Govt 2019: Oblicz i zapłać opłatę paliwową. Government of the Republic of Poland. Available at: https://www.biznes.gov.pl/pl/firma/podatki-i-ksiegowosc/chce-rozliczac-akcyze/proc_1630-oplata-paliwowa (date of access: 16.04.2020)

GreenStreem, 2015: Inclusion of the heating sector in the EU ETS. Avalable at: https://energia.fi/files/995/gs_ets_heating_presentation_2015_0.pdf (date of access: 16.04.2020)

Gullers Grupp Rapport 2018: The public's views on climate 2018 - A quantitative survey of the Swedish public's views on climate solutions. Available at: http://www.swedishepa.se/upload/miljoarbete-i-samhallet/miljoarbete-i-sverige/klimat/attitydundersokning/Public-views-on-climate-2018.pdf (date of access: 26.03.2020)

Hafstead and Picciano, 2017: "Calculating Various Fuel Prices under a Carbon Tax" Resources for the Future, blog post from November 28, 2017 available online (accessed March 2020) at https://www.resourcesmag.org/common-resources/calculating-various-fuel-prices-under-a-carbon-tax/

Hammar and Åkerfeldt 2011: CO_2 Taxation in Sweden -20 Years of Experience and Looking Ahead. Hammar, Henrik and Åkerfeldt, Susanne. Available at: https://www.globalutmaning.se/wp-content/uploads/sites/8/2011/10/Swedish_Carbon_Tax_Akerfedlt-Hammar.pdf (date of access: 25.03.2020)

Harthan, Ralph O., Julia Repenning, Ruth Blank, Hannes Böttcher, and Veit Bürger. 2020. 'Treibhausgasminderungswirkung Des Klimaschutzprogramms 2030 (Kurzbericht)'. 12/2020. Climate Change. Dessau-Roßlau: Umweltbundesamt.

Hein, Fabian, Frank Peter, and Patrick Graichen. 2020. 'Auswirkungen Der Corona-Krise Auf Die Klimabilanz Deutschlands: Eine Abschätzung Der Emissionen 2020'. Berlin: Agora Energiewende.

Hsia-Kiung, Reyna, and O'Connor, 2014: "Carbon Market California - a comprehensive analysis of the golden state's cap-and-trade program. Year one, 2012-2013." Environmental Defense Fund

I4CE 2019: Panorama of explicit carbon pricing instruments around the world. Institute for Climate Economics, Paris. Available at: https://www.i4ce.org/wp-core/wp-content/uploads/2016/10/16-10-07-Panorama-des-prix-explicites-du-carbone-VANG-Final.pdf (date of access: 21.03.2020)

Ibs, 2018: Coal transition in Poland. Options for a fair and feasible transition for the Polish coal sector. Institute for Structural Research. Available at: https://climatestrategies.org/wp-content/uploads/2019/08/Coaltransitions_finalreport_Poland_2018.pdf (date of access: 16.04.2020)

IC4E 2018: La composante carbone en France: fonctionnement, revenus et exonerations, Institute for Climate Economics, Paris. Available at: https://www.i4ce.org/wp-core/wp-content/uploads/2018/10/Contribution-Climat-Energie-en-France_VF4.pdf (date of access: 07.04.2020)

IC4E, Terra Nova 2019: Climat et fiscalité: trois scénarios pour sortir de l'impasse, Institute for Climate Economics, Terra Nova, Paris. Available at: https://www.i4ce.org/download/climat-et-fiscalite-trois-scenarios-pour-sortir-de-limpasse/# (date of access: 13.04.2020)

ICAP, 2020: EU Emissions Trading System (EU ETS). International Carbon Action Partnership. Available at: https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems[]=43 (date of access: 16.04.2020)

ICAP. 2020. 'Japan - Tokyo Cap-and-Trade Program'. ETS Detailed Information. Berlin: International Carbon Action Partnership.

ICAP. 2020. 'New Zealand Emissions Trading Scheme'. ETS Detailed Information. International Carbon Action Partnership. https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=48.

IDDRI 2019: Après le gel de la taxe carbone, quelles priorités pour la transition écologique? IDDRI, Paris. Available at: https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Propositions/201901-PB0119%20taxe%20carbone_0_0.pdf (date of access: 13.04.2020).

IEA 2019: Energy Policies of IEA Countries – Sweden 2019. International Energy Agency (IEA). Available at: https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/Energy_Policies_of_IEA_Countries_Sweden_2019_Review.pdf (date of access: 24.03.2020)

IEA 2019: White Certificates. Poland. International Energy Agency. Available at: https://www.iea.org/policies/551-white-certificates (date of access: 16.04.2020)

Isaacs, NP, M Camilleri, L Burrough, A Pollard, K Saville-Smith, R Fraser, P Roussow, and J Jowett. 2010. 'Energy Use in New Zealand Household: Final Report on the Household Energy End-Use Project (HEEP)'. BRANZ Study Report 221. Judgeford, New Zealand: BRANZ Ltd. https://www.branz.co.nz/cms_show_download.php?id=a9f5f2812c5d7d3d53fdaba15f2c14d591749353.

IPPC 2006: Guidelines for Greenhouse Gas Inventories. Available at: https://www.ipcc.ch/report/2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/ (date of access: 09.03.2020)

Jofra Sora, M., Meyer, E., Puig Ventosa, I., Calaf Forn, M. 2014: Los impuestos energéticos en España: situaciones y propuestas. Fundació ent and Green Budget Europe.Law 18/2014 Adoption of urgent measures for growth, competitiveness and efficiency: Ley 18/2014 de Aprobación de medidas urgentes para el crecimiento, la competitividad y la eficiencia. Available at: https://www.boe.es/eli/es/l/2014/10/15/18 (date of access: 18.04.2020)

Johansson 2000: Economic Instruments in Practice 1: Carbon Tax in Sweden. Available at: http://www.oecd.org/science/inno/2108273.pdf (date of access: 30.03.2020)

Kemmler, Andreas, Almut Kirchner, Alex Auf der Maur, and Florian Ess. 2020. 'Energiewirtschaftliche Projektionen Und Folgeabschätzungen 2030/2050 - Dokumentation von Referenzszenario Und Szenario Mit Klimaschutzprogramm 2030'. Köln, Karlsruhe: Prognos AG; Fraunhofer-ISI; GWS, iinas.

Kerr, Suzi, and Vicki Duscha. 2014. 'Going to the Source: Using an Upstream Point of Regulation for Energy in a National Chinese Emissions Trading System'. Energy & Environment 25 (3–4): 593–611. https://doi.org/10.1260/0958-305X.25.3-4.593.

Knopf, Brigitte. 2020. 'Das Deutsche Klima-Finanzpaket'. MCC Common Economics Blog (blog). 7 January 2020. https://blog.mcc-berlin.net/post/article/das-deutsche-klima-finanzpaket-im-ueberblick.html.

KOBIZE, 2019: Poland's National Inventory Report 2019. The National Centre for Emissions Management. Available at: https://www.kobize.pl/uploads/materialy/materialy_do_pobrania/krajowa_inwentaryzacja_emisji/NIR_POL_2019_23.05.2019.pdf (date of access: 16.04.2020)

Kossoy, Alexandre/ Peszko, Grzegorz/ Oppermann, Klaus/ Prytz, Nicolai/ Klein, Noémie/ Blok, Kornelis/ Lam, Long/ Wong, Lindee/ Borkent, Bram 2015: State and Trends of Carbon Pricing 2015 (September). World Bank, Washington, DC. Available at: http://documents.worldbank.org/curated/en/636161467995665933/pdf/99533-REVISED-PUB-P153405-Box393205B.pdf (date of access: 16.04.2020)

Kronsell 2011: Interview study on the conditions for a Swedish climate transition – preliminary results (in Swedish). Annica Kronsell, Roger Hildingsson and Jamil Khan//Climate Research Programme LETS 2050 at Lund University. Available at:

http://www.lth.se/fileadmin/lets2050/Rapporter_o_Abstracts/120508_Intervjurapport_final.pdf (date of access: 09.04.2020)

Larsen and Herndon. 2018. "RGGI expansion: The Road Ahead." Rhodium Group. 3 January, 2018. Available online (accessed April 2020) at https://rhg.com/research/rggi-expansion-road-ahead/

Law 16/2013 of measures in the field of environmental taxation and other tax and financial measures: Ley 16/2013 de medidas en materia de fiscalidad medioambiental y otras medidas tributarias y financieras. Available at: https://www.boe.es/buscar/doc.php?id=BOE-A-2013-11331 (date of access: 31/03/2020)

Law 34/2007 Air quality and protection of the atmosphere: Calidad del aire y protección de la atmósfera. Available at: https://www.boe.es/eli/es/l/2007/11/15/34 (date of access: 31.03.2020)

Law 38/1992 on Special Taxes: Ley 38/1992 de Impuestos Especiales. Available at: https://www.boe.es/eli/es/l/1992/12/28/38 (date of access: 18.04.2020)

Leining, Catherine, and Suzi Kerr. 2016. 'Lessons Learned from the New Zealand Emissions Trading Scheme'. Motu Working Paper 16–06. Motu Economics and Public Policy. http://motu-www.motu.org.nz/wpapers/16_06.pdf.

Leining, Catherine, and Suzi Kerr. 2018. 'A Guide to the New Zealand Emissions Trading Scheme'. Motu Economics and Public Policy Research. https://motu.nz/assets/Documents/our-work/environment-and-agriculture/climate-change-mitigation/emissions-trading/ETS-Explanation-August-2018.pdf.

Leining, Catherine, Suzi Kerr, Ruben Lubowsi, Jeff Swartz, and Stefano De Clara. 2016. 'New Zealand: An Emissions Trading Case Study'. Case Studies - World Carbon Markets. IETA. https://www.ieta.org/resources/Resources/Case_Studies_Worlds_Carbon_Markets/2016/New_Zealand_Case_Study_2016.pdf.

Leprich, Uwe. 2019. 'Umsetzung Einer Wirtschaftsverträglichen CO2-Bepreisung in Deutschland Für Den ETS-Und Den Nicht-ETS-Bereich'. Saarbrücken, Berlin: Cum Ratione GmbH.

Löschel, Andreas, Georg Erdmann, Frithjof Staiß, and Hans-Joachim Ziesing. 2018. 'Expertenkommission Zum Monitoring-Prozess „Energie Der Zukunft" Stellungnahme Zum Sechsten Monitoringbericht Der Bundesregierung Für Das Berichtsjahr 2016'. Berlin, Münster, Stuttgart.

Löschel, Andreas, Georg Erdmann, Frithjof Staiß, and Hans-Joachim Ziesing. 2019. 'Expertenkommission Zum Monitoring-Prozess „Energie Der Zukunft" Stellungnahme Zum Zweiten Fortschrittsbericht Der Bundesregierung Für Das Berichtsjahr 2017'. Berlin, Münster, Stuttgart.

MacGregor, Casimir, David Dowdell, Roman Jaques, Lee Bint, and Brian Berg. 2018. 'The Built Environment and Climate Change: A Review of Research, Challenges and the Future'. SR403. BRANZ Study Report. Judgeford, New Zealand: BRANZ Ltd. https://www.branz.co.nz/cms_show_download.php?id=3c09f0a2df9f7586cbdbedbf15605ff800045d02.

Manthey, N. 2019: Catalonia introduces carbon tax for polluting vehicles, electrive.com Industry Service for Electric Mobility. Available at: https://www.electrive.com/2019/11/01/catalonia-introduces-carbon-tax-for-polluting-vehicles/ (date of access: 31.03.2020)

Martinsson and Fridahl 2018: The Swedish Carbon Tax 1991–2017 (in Swedish). Martinsson, Gustav and Fridahl, Mathias/Fores Policy Brief 2018:3, Forum för reformer och entreprenörskap, Stockholm. Available at: https://fores.se/wp-content/uploads/2018/03/Fores_Policy-Brief_2018_3.pdf (date of access: 28.03.2020)

MBIE. 2017. 'New Zealand Energy Sector Greenhouse Gas Emissions: 2015 Calendar Year Edition'. Ministry of Business, Innovation & Employment. https://www.mbie.govt.nz/assets/687c7abf5a/nz-energy-greenhouse-gas-emissions-2015.pdf.

MBIE. 2020a. 'New Zealand Energy Sector Greenhouse Gas Emissions: Annual Emissions Data Table'. Ministry of Business, Innovation and Employment. https://www.mbie.govt.nz/assets/Data-Files/Energy/annual-emissions-data-table.xlsx.

MBIE. 2020b. 'Weekly Fuel Price Monitoring'. Wellington, New Zealand: MBIE. https://www.mbie.govt.nz/assets/Data-Files/Energy/Weekly-fuel-price-monitoring/weekly-table.csv.

ME 2019: Nowe rozporządzenie w sprawie przeprowadzania egzaminu zawodowego i egzaminu potwierdzającego kwalifikacje w zawodzie. Ministry of Education. Available at: https://www.gov.pl/web/edukacja/nowe-rozporzadzenie-w-sprawie-przeprowadzania-egzaminu-zawodowego-i-egzaminu-potwierdzajacego-kwalifikacje-w-zawodzie (date of access: 16.04.2020)

Meinecke 2019: Collection and assessment of climate change policies in the context of the European Semester Country Report: France, Internal Report commissioned by DG CLIMA, ICF, eclareon and Ecologic Institute.

MI 2019: Projekt Strategii Zrównoważonego Rozwoju Transportu do 2030 roku. Ministry of Infrastructure. Available at: https://www.gov.pl/web/infrastruktura/projekt-strategii-zrownowazonego-rozwoju-transportu-do-2030-roku2 (date of access: 16.04.2020)

MI 2020: Notice of the Minister of Infrastructure of 7 November 2019 on the amount of the fuel surcharge rate for 2020. Available at: http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WMP20200000211/O/M20200211.pdf (date of access: 10.04.2020)

Ministère de l'écologie, de l'énergie, du développement durable et de la mer, Ministère de l'économie, de l'industrie et de l'emploi 2009: Rapport de la conférence des experts et de la table ronde sur la contribution Climat et Énergie – présidées par Michel Rocard, ancien Premier ministre. 28 July 2009. Available at: www.ladocumentationfrancaise.fr/rapportspublics/ (date of access: 06.04.2020)

Ministère de la Transition écologique et solidaire 2017: Fiscalité carbone, 21 September 2017. Available at: https://www.ecologique-solidaire.gouv.fr/fiscalite-carbone (date of access: 08.04.2020)

Ministère de la Transition écologique et solidaire 2018: Stratégie Française pour l'ènergie et le Climat, 11.2018. Available at: https://www.ecologique-solidaire.gouv.fr/sites/default/files/2018.11.27_MTES_dp_PPE_SNBC_stategiefrancaiseenergieclimat.pdf (date of access: 14.04.2020).

Ministère de la Transition écologique et solidaire 2019: Chiffres clés du climat France, Europe et Monde. Available at: https://www.statistiques.developpement-durable.gouv.fr/sites/default/files/2019-11/datalab-62-chiffres-cles-du-climat-france-europe-monde-edition2020-novembre2019_0.pdf (date of access: 07.04.2020)

Ministère de la Transition écologique et solidaire 2020a: Dispositif des certificats d'économies d'énergie, 6 April 2020. Available at: https://www.ecologique-solidaire.gouv.fr/dispositif-des-certificats-deconomies-denergie (date of access: 09.04.2020)

Ministère de la Transition écologique et solidaire 2020b: Fiscalité des énergies, 28 January 2020. Available at: https://www.ecologique-solidaire.gouv.fr/fiscalite-des-energies (date of access: 07.04.2020)

Ministry for Ecological Transition and the Demographic Challenge, 2020. National Energy and Climate Plan: Plan Nacional Integrado de Energia y Clima. Available at: https://www.idae.es/en/node/13613 (date of access: 06.04.2020)

Ministry for Ecological Transition and the Demographic Challenge, n.d.: Sectores Difusos. Situación actual y objetivos. Available at: https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/definicion-difusos.aspx (date of access: 31.03.2020)

Ministry for the Environment (NZ). 2009a. 'Climate Change (Unique Emissions Factors) Regulations 2009'. 15. Emissions Trading Bulleting. Ministry for the Environment. https://www.mfe.govt.nz/sites/default/files/Emissions-trading-bulletin-15%20%281%29.pdf.

Ministry for the Environment (NZ). 2009b. 'Explanatory Note: Climate Change (Liquid Fossil Fuels) Regulations 2008'. ME 951. Wellington: Ministry for the Environment. https://www.mfe.govt.nz/sites/default/files/Emissions-trading-bulletin-9.pdf.

Ministry for the Environment (NZ). 2016. 'The New Zealand Emissions Trading Scheme Evaluation 2016'. Wellington: Ministry for the Environment. https://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/ets-evaluation-report.pdf.

Ministry for the Environment (NZ). 2017. 'Regulatory Impact Statement: Improving the NZ ETS Framework for Unit Supply'. https://www.mfe.govt.nz/more/briefings-cabinet-papers-and-related-material-search/regulatory-impact-statements/regulatory.

Ministry for the Environment (NZ). 2019. 'New Zealand's Fourth Biennial Report under the United Nations Framework Convention on Climate Change'. Ministry for the Environment. https://www.mfe.govt.nz/publications/climate-change/new-zealands-fourth-biennial-report-under-united-nations-framework.

Ministry for the Environment (NZ). 2019a. 'New Zealand's Fourth Biennial Report under the United Nations Framework Convention on Climate Change'. Ministry for the Environment. https://www.mfe.govt.nz/publications/climate-change/new-zealands-fourth-biennial-report-under-united-nations-framework.

Ministry for the Environment (NZ). 2019b. 'Reforming the New Zealand Emissions Trading Scheme: Proposed Settings – Consultation Document'. Wellington: Ministry for the Environment. https://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/reforming-the-ets-proposed-settings-consultation.pdf.

Montes Nebreda, A. 2019: Working paper: Imposición al carbon, derecho comparado y propuesta para España. Universidad Complutense de Madrid. Instituto de Estudios Fiscales.

MoSA 2019: Poland's National Energy and Climate Plan for years 2021-2030. Ministry of State Assets.Available at: https://www.gov.pl/web/aktywapanstwowe/krajowy-plan-na-rzecz-energii-i-klimatu (date of access: 10.04.2020)

Nationale Akademie der Wissenschaften Leopoldina, acatech - Deutsche Akademie der Technikwissenschaften, and Union der Deutschen Akademien der Wissenschaften. 2019. 'Über Eine CO2-Bepreisung Zur Sektorenkopplung: Ein Neues Marktdesign Für Die Energiewende (2019)'. Halle (Saale): Nationale Akademie der Wissenschaften Leopoldina.

New Zealand Productivity Commission. 2018. 'Low-Emissions Economy: Final Report'. www.productivity.govt.nz/low-emissions.

NIK 2020: How the Polish state supports energy efficiency. Najwyższa Izba Kontroli (Supreme Audit Office). Available at: https://www.nik.gov.pl/en/do_druku/typ,0,id,4016.html?referer=https://www.nik.gov.pl/en/news/how-the-polish-state-supports-energy-efficiency.html (date of access: 16.04.2020)

Nilsson et al. 2013: In the Light of the Future – Steering towards Zero Emissions in 2050 (in Swedish). Lars J Nilsson, Jamil Khan, Fredrik NG Andersson, Mikael Klintman, Roger Hildingsson, Annica Kronsell, Fredrik Pettersson, Henrik Pålsson, Nora Smedby/Climate Research Programme LETS 2050 at Lund University. Available at: https://www.lth.se/fileadmin/lets2050/Rapporter_o_Abstracts/130522_I_Ljuset_av_LETS_2050_webb.pdf (date of access: 28.03.2020)

North Carolina Clean Energy Technology Center, 2020: Database of State Incentives for Renewables & Efficiency (DSIRE). Accessed March 2020 at https://www.dsireusa.org/

OECD 2016: Environmentally related taxes. Taxes on energy use. Organisation for Economic Cooperation and Development. Available at: https://www.oecd.org/tax/tax-policy/environmental-tax-profile-poland.pdf (date of access: 21.03. 2020)

OECD 2018: Taxing Energy Use 2018. Poland. Organisation for Economic Cooperation and Development. Available at: https://www.oecd.org/tax/tax-policy/taxing-energy-use-2018-poland.pdf (date of access: 21.04.2020)

OECD 2018: Taxing Energy Use Sweden. Organisation for Economic Co-operation and Development (OECD). Available at: https://www.oecd.org/tax/tax-policy/taxing-energy-use-2018-sweden.pdf (date of access: 29.03.2020)

OECD 2019: Taxing Energy Use 2019 – Using Taxes for Climate Action. Organisation for Economic Co-operation and Development (OECD). Available at: https://read.oecd-ilibrary.org/taxation/taxing-energy-use-2019_058ca239-en#page1 (date of access: 24.03.2020)

OECD 2019: Taxing Energy Use 2019: Country Note – Sweden. Organisation for Economic Co-operation and Development (OECD). Available at: https://www.oecd.org/tax/tax-policy/taxing-energy-use-sweden.pdf (date of access: 24.03.2020), the note complements the OECD report: Taxing Energy Use 2019 – Using Taxes for Climate Action, see above. (date of access: 24.03.2020)

OECD 2019: Taxing Energy Use 2019. Country Note – Poland. Organisation for Economic Cooperation and Development, Paris. Available at: https://www.oecd.org/tax/tax-policy/taxing-energy-use-poland.pdf (date of access: 21.03. 2020)

OECD 2019a: Taxing Energy Use 2019. Organisation for Economic Cooperation and Development. Available at: http://www.oecd.org/tax/taxing-energy-use-efde7a25-en.htm (date of access: 16.04.2020)

OECD 2020: Les effets conjugués des prix de l'énergie et de la taxe carbone sur la performance économique et environnementale des entreprises françaises du secteur manufacturier, Organisation for Economic Co-operation and Development, Pais. Availabe at: https://www.oecd-ilibrary.org/docserver/b8ca827a-fr.pdf?expires=1586183257&id=id&accname=guest&checksum=2097FB90018E4B54BF86AD43E1D658E8 (date of access: 06.04.2020)

OECD. 2015: Environmental Performance Reviews: Spain 2015.

OECD. 2018: Taxing Energy Use 2018. Spain.

OECD. 2019: Taxing Energy Use 2019: Country Note – Spain.

Partnership for Market Readiness (PMR) and International Carbon Action Partnership (ICAP): 2016. Emissions Trading in Practice: a Handbook on Design and Implementation. World Bank, Washington, DC.

Partnership for Market Readiness (PMR) and International Carbon Action Partnership (ICAP). 2016. Emissions Trading in Practice: a Handbook on Design and Implementation. World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO

Pettigrew, S. 2020: Spanish Carbon Pricing the Lowest in the EU. Spain News Brief and Action Alert. Climate Scorecard. Available at: https://www.climatescorecard.org/2020/03/spanish-carbon-pricing-the-lowest-in-the-eu/ (date of access: 31.03.2020)

Phillips and Mitchell. 2020. "Trump weakens fuel economy standards, rolling back key U.S. effort against climate change." Los Angeles Times, 31 March, 2020. Available online (accessed April 2020) at https://www.latimes.com/politics/story/2020-03-31/trump-rolls-back-fuel-economy-standards

REAF (Registro de Economistas Asesores Fiscales) 2019: La fiscalidad ambiental en España: Situación actual y tendencias. Consejo General economistas.

RGGI, Inc. 2019. CO2 Emissions from Electricity Generation and Imports in the Regional Greenhouse Gas Initiative: 2017 Monitoring Report. Published November 8, 2019, available online (accessed April 2020) at https://www.rggi.org/allowance-tracking/emissions

Ricardo Energy and Environment 2018. Sweden Energy and Carbon Tax Policy. Available at: https://es.catapult.org.uk/wp-content/uploads/2018/10/Sweden-Case-Study-FINAL.pdf (date of access: 09.04.2020)

Roca, R. 2018: El Gobierno suspende el impuesto de generación y el céntimo verde durante seis meses: la factura caerá un 4% aproximadamente. Available at: https://elperiodicodelaenergia.com/el-gobierno-suspende-el-impuesto-de-generacion-y-el-centimo-verde-durante-seis-meses-la-factura-caera-un-4-aproximadamente/ (date of access: 18.04.2020)

Royal Decree 1085/2015 Promotion of Biofuels: Promoción de Biocombustibles. Available at: https://www.boe.es/eli/es/rd/2015/12/04/1085 (date of access: 31.03.2020)

Royal Decree 15/2018 Urgent measures for energy transition and consumer protection: Medidas urgentes para la transición energética y la protección de los consumidores. Available at: https://www.boe.es/eli/es/rdl/2018/10/05/15 (date of access: 18.04.2020)

Royal Decree 235/2013 Basic procedure for the certification of the energy performance of buildings: Procedimiento básico para la certificaión de la eficiencia energética de los edificios. Available at: https://www.boe.es/eli/es/rd/2013/04/05/235 (date of access: 31.03.2020)

Royal Decree 732/2019 Amendment to the Building Code: Modificación del Código Técnico de la Edificación. Available at: https://www.boe.es/eli/es/rd/2019/12/20/732 (date of access: 31.03.2020)

Rudolph, Sven, and Takeshi Kawakatsu. 2012. 'Tokyo's Greenhouse Gas Emissions Trading Scheme: A Model for Sustainable Megacity Carbon Markets?' 201225. MAGKS Papers on Economics. Marburg: Philipps-Universität Marburg, Faculty of Business Administration and Economics, Department of Economics.

Sachverständigenrat für Umweltfragen (SRU). 2017. 'Umsteuern erforderlich: Klimaschutz im Verkehrssektor'. Berlin.

Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (SVR). 2019. 'Aufbruch Zu Einer Neuen Klimapolitik: Sondergutachten 2019'. Wiesbaden: Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (SVR).

Sastre, S. 2016: Tax on fluorinated greenhouse gases in Spain. Institute for European Environmental Policy.

Scharin 2018: The Swedish CO_2 Tax –an Overview. Scharin, Henrik and Wallström, Jenny/Anthesis Enveco AB. Available at: http://www.enveco.se/wp-content/uploads/2018/03/Anthesis-Enveco-rapport-2018-3.-The-Swedish-CO2-tax-an-overview.pdf (date of access: 26.03.2020)

Schiebe 2019: Should every country on earth copy Sweden's carbon tax? Schiebe, Thorbjörn. Available at: https://www.carbonpricingleadership.org/blogs/2019/10/18/should-every-country-on-earth-copy-swedens-carbon-tax (date of access: 28.03.2020)

Segarra, 2018: "California's Economy Is Now Bigger Than All of the U.K." in Fortune online, published 5 May, 2018. Available (accessed March 2020) at https://fortune.com/2018/05/05/california-fifth-biggest-economy-passes-united-kingdom/

Sejm 1994: Act on toll roads and the National Road Fund (Ustawa o autostradach płatnych oraz o Krajowym Funduszu Drogowym). *Sejm of the Republic of Poland*. Available at: 24bis.pl, 2019: https://tvn24bis.pl/moto,99/oplata-paliwowa-w-2020-roku-o-ile-wzrosnie,996813.html (date of access: 21.03. 2020)

Sejm 2004: Excise Duty Act. Sejm of the Republic of Poland. Available at: http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20090030011/U/D20090011Lj.pdf (date of access: 10.04.2020)

Sejm 2011: Energy Efficiency Act. Sejm of the Republic of Poland. Available at: http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20160000831/U/D20160831Lj.pdf (date of access 10.04.2020).

Shtrestha, Priyanka 2019: Poland taken to EU Court for not removing coal and gas tax exemptions. Available at: https://www.energylivenews.com/2019/11/27/poland-taken-to-eu-court-for-not-removing-coal-and-gas-tax-exemptions/ (date of access: 16.04.2020)

Skatteverket (Swedish Tax Agency) 2020a: Tax Exemption for Biofuels (in Swedish). Available at: https://www.skatteverket.se/foretagochorganisationer/skatter/punktskatter/energiskatter/energiskatterpabranslen/skattebefrielseforbiodrivmedel.4.2b543913a42158acf800021393.html (date of access: 10.04.2020)

Skatteverket (Swedish Tax Agency) 2020b: Tax on Air Travel (in Swedish). Available at: https://www.skatteverket.se/servicelankar/otherlanguages/inenglish/businessesandemployers/payingtaxesbusinesses/taxonairtravel.4.41f1c61d16193087d7f5348.html (date of access: 26.03.2020)

Skatteverket (Swedish Tax Agency) 2020c: Tax Exemption for Agriculture, Forestry and Aquaculture (in Swedish). https://www.skatteverket.se/foretagochorganisationer/skatter/punktskatter/energiskatter/verksamhetermedlagreskatt/jordbrukskogsbrukvattenbruk/bransle.4.15532c7b1442f256baebbb2.html. (date of access: 10.04.2020)

Skoczkowski, Tadeusz / Węglarz, Arkadiusz n.d.: White Certificate Scheme in Poland. Available at: http://enspol.eu/sites/default/files/White%20Certificate%20Scheme%20in%20Poland_KAPE.pdf (date of access: 16.04.2020)

Stefaniak, Ewa 2017: Can energy efficiency be market-based? Available at: https://innopaths.eu/2017/12/13/can-energy-efficiency-be-market-based/ (date of access: 16.04.2020)

Swedish Climate Policy Council 2019: 2019 – Report of the Climate Policy Council (in Swedish). Available at: https://www.klimatpolitiskaradet.se/wp-content/uploads/2019/09/kprrapport190426.pdf (date of access: 27.03.2020)

Swedish Climate Policy Council 2020: 2020 – Report of the Climate Policy Council (in Swedish). Available at: https://www.klimatpolitiskaradet.se/wp-content/uploads/2020/03/klimatpolitiskaradetrapport2020.pdf (date of access: 09.04.2020)

Swedish Energy Agency 2017: Carbon Tax –Determining the Tax Rate - Swedish Experiences. Raab, Ulrika/Swedish Energy Agency. Available at: https://www.thepmr.org/system/files/documents/Sweden%20PMR%20Technical%20Workshop%20on%20Carbon%20Tax%2022%20March%202017.pdf (date of access: 27.03.2020)

Swedish Energy Agency et al. 2020: Control Station for the Strategic Plan of the transformation to a fossil free transport sector (in Swedish). Swedish Energy Agency, Swedish Housing Agency, Swedish Environmental Protection Agency, Traffic Analysis, Swedish Transport Administration and Swedish Transport Agency. Available at https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=163536 (date of access: 10.04.2020)

Swedish Environmental Protection Agency 2020a: Sweden's Climate Act and Climate Policy Framework. Available at: http://www.swedishepa.se/Environmental-objectives-and-cooperation/Swedish-environmental-work/Work-areas/Climate/Climate-Act-and-Climate-policy-framework-/ (date of access: 27.03.2020)

Swedish Environmental Protection Agency 2020b: Territorial greenhouse gas emissions and uptake (in Swedish). Available at: https://www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Vaxthusgaser-territoriella-utslapp-och-upptag/ (date of access: 27.03.2020)

Swedish Environmental Protection Agency 2020c: Greenhouse gas emissions from domestic transport (in Swedish). Available at: https://www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Vaxthusgaser-utslapp-fran-inrikes-transporter/ (date of access: 30.03.2020)

Swedish Environmental Protection Agency 2020d: Greenhouse gas emissions from ETS and non-ETS sectors (in Swedish). Available at: https://www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Vaxthusgaser-utslapp-handlande-o-icke-handlande-sektorn/ (date of access: 30.03.2020)

Swedish Environmental Protection Agency 2020e: Greenhouse gas emissions from heating of homes and premises (in Swedish). Available at: https://www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Vaxthusgaser-utslapp-fran-uppvarmning-av-bostader-och-lokaler/ (date of access: 09.04.2020)

Swedish Ministry of Finance 2017: How to Design a Cost-Effective Carbon Tax on Motor Fuels and be in line with EU state aid rules. Åkerfeldt, Susanne/Swedish Ministry of Finance/Government Offices of Sweden, Presentation. Available at: https://www.government.se/492fd9/contentassets/18ed243e60ca4b7fa05b36804ec64beb/170925-aakerfeldt-carbon-tax-on-motor-fuels-gcet-tucson.pdf (date of access: 08.04.2020)

Swedish Ministry of Finance 2018: Lessons Learned from 25 Years of Carbon Taxation in Sweden. Åkerfeldt, Susanne and Waluszewski, Daniel/Swedish Ministry of Finance/Government Offices of Sweden, Presentation. Available at: https://www.government.se/48e9fb/contentassets/18ed243e60ca4b7fa05b36804ec64beb/lessons-learned-from-25-years-of-carbon-taxation-in-sweden.pdf#mce_temp_url# (date of access: 26.03.2020)

Swedish Ministry of Finance 2020: Carbon Taxation in Sweden. Åkerfeldt, Susanne and Waluszewski, Daniel/Swedish Ministry of Finance, Presentation. Available at: https://www.government.se/492a01/contentassets/419eb2cafa93423c891c09cb9914801b/200224-carbon-tax-sweden---general-info.pdf (date of access: 23.03.2020)

Swedish Parliament (Sveriges Riksdag) (1994, last updated 2019): Energy Tax Act (SFS 1994:1776). Available at: https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-19941776-om-skatt-pa-energi_sfs-1994-1776 (date of access: 10.04.2020)

Swedish Parliament (Sveriges Riksdag) 2004 (last updated 2019): Regulation on Emissions Trading. Available at: https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20041205-om-handel-med_sfs-2004-1205 (date of access: 06.04.2020)

Tax Agency (2020). Database: Informes Mensuales de Recaudación Tributaria. Available at: https://www.agenciatributaria.es/AEAT.internet/Inicio/La_Agencia_Tributaria/Memorias_y_estadisticas_tributarias/Estadisticas/Recaudacion_tributaria/Informes_mensuales_de_Recaudacion_Tributaria/2020/2020.shtml

Tax Foundation 2019: Carbon Taxes in Europe. Available at: https://taxfoundation.org/carbon-taxes-in-europe-2019/ (date of access: 23.03.2020)

Tax Foundation 2019: Carbon Taxes in Europe. Washington DC. Available at: https://taxfoundation.org/carbon-taxes-in-europe-2019/ (date of access: 21.03.2020)

TCI. 2019a. Public Webinar, 17 December 2019: "Cap-and-Invest Modelling Results." Slide 4/49. Available for download (accessed April 2020) at https://www.transportationandclimate.org/main-menu/tcis-regional-policy-design-process-2019#Framework

TCI. 2019b. Draft Memorandum of Understanding of the Transportation and Climate Initiative - For Stakeholder Input. Published 17 December 2019. Available for download online (accessed April 2020) at https://www.transportationandclimate.org/main-menu/tcis-regional-policy-design-process-2019

Terra Nova 2017: Accélérer la décarbonation :vers un prix minimum du CO_2 pour l'électricité en Europe de l'Ouest, Terra Nova, Paris. Available at: file:///I:/ecologic-intern/projects/01_ongoing_projects/2616-04_DGC_ETS%20Extension/03%20Project/France/Literature/Terra-Nova_2017_Note_Prix-minimum-CO2_30082017.pdf (date of access: 14.04.2020)

Third Way 2020 Carbon Pricing: One Piece of the Climate Puzzle Brussels. Available at: https://thirdway.imgix.net/pdfs/override/Carbon-Pricing_-One-Piece-of-the-Climate-Puzzle-–-Third-Way.pdf (date of access: 22.03.2020)

Trafikverket 2020 (Swedish Transport Agency): Biofuels and energy efficient vehicles reduced emissions in 2019 (in Swedish). Available at: https://www.trafikverket.se/contentassets/ec275e93ccf0441b83d8088ff781b72a/pm-vagtrafikens-utslapp-200224.pdf

(replaces Trafikverket 2019)Transport & Environment 2018: Emission reduction strategies for the transport sector in Poland. The report produced under the framework of the EUKI project. Available at: https://www.transportenvironment.org/sites/te/files/publications/2019_01_PL_EUKI_report_FINAL_0.pdf (date of access: 16.04.2020)

UN Stats, 2017: International Recommendations for Energy Statistics (IRES) - Statistical paper. Department of Economic and Social Affairs of the United Nations Secretariat. Series M No. 93. ST/ESA/STAT/SER.M/93

US Environmental Protection Agency and Dept. of Transportation, 2010: Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule. Available online (accessed March 2020) at https://www.nhtsa.gov/corporate-average-fuel-economy/documents-associated-mys-2012-2016-rulemaking

Utsläppshandel (Emissions Trading) 2018: Korta fakta om utsläppshandel (Brief Facts about Emissions Trading). Available at: http://www.utslappshandel.se/sv/Utslappshandel/topmeny/om-utslappshandel/ (date of access: 31.03.2020)

Vito 2005: Energy saving policies and energy efficiency obligation scheme. Report on existing and planned EEOs in the EU – France, ENSPOL project. Available at: http://www.article7eed.eu/images/pdf/Existing%20and%20planned%20EEOs%20in%20France.pdf (date of access: 09.04.2020)

Wakabayashi, Masayo, and Osamu Kimura. 2018. 'The Impact of the Tokyo Metropolitan Emissions Trading Scheme on Reducing Greenhouse Gas Emissions: Findings from a Facility-Based Study'. Climate Policy 18 (8): 1028–43. https://doi.org/10.1080/14693062.2018.1437018.

Watson, 2019: "How High are Other Nations' Gas Taxes?" Blog post of Tax Foundation, 2 May, 2019. Available online (accessed March 2020) at https://taxfoundation.org/oecd-gas-tax/

WB 2019: Carbon Pricing Dashboard, last updated Aug. 1, 2019. World Bank. Available at: https://carbonpricingdashboard.worldbank.org/map_data (date of access: 16.04.2020)

World Bank 2019: State and Trends of Carbon Pricing 2019. Available at: https://openknowledge.worldbank.org/handle/10986/31755 (date of access: 26.03.2020)

World Bank. 2019: Carbon Pricing Dashboard. Available at: https://carbonpricingdashboard.worldbank.org/map_data (date of access: 31.03.2020)

World Economic Forum 2019: Global Competitiveness Report 2019: How to end a lost decade of productivity growth. Available at: https://www.weforum.org/reports/how-to-end-a-decade-of-lost-productivity-growth. (date of access: 23.03.2020)

WysokieNapięcie.pl 2020: PLN 2 billion went to the government fund instead of companies. Available at: https://wysokienapiecie.pl/28126-biale-certyfikaty-2-mld-zlotych-trafilo-do-nfosigw-zamiast-do-przedsiebiorcow/ (date of access: 10.04.2020)

7.2 Task 2 (Section 3)

Bio-Based Industries Consortium 2019: Biorefineries in Europe 2017. Available at: https://biconsortium.eu/news/mapping-european-biorefineries (date of access: 27.03.2020)

Buildings Performance Institute Europe, 2016, Financing building energy performance improvement in Poland; Status report. http://bpie.eu/wp-content/uploads/2016/01/BPIE_Financing-building-energy-in-Poland_EN.pdf (date of access: 15.04.2020)

Burke 2016: Thee price and income elasticities of natural gas demand: International evidence. P.J. Burke, H. Yang, Energy Economics 59., pp 466–474. Available at: https://www.sciencedirect.com/science/article/pii/S0140988316302420

CE Delft 2014: Emissions trading for transport and the built environment. Analysis of the options to include transport and the built environment in the EU ETS.

CEB 2019: Energy Poverty in Europe – How Energy Efficiency and Renewables Can Help. Council of Europe Development Bank, Paris, Available at: https://coebank.org/media/documents/CEB_Study_Energy_Poverty_in_Europe.pdf (date of access: 26.03.2020)

Charlier 2019: Fuel poverty and residential energy demand: how fuel-poor households react to energy price fluctuations. Dorothée Charlier, Sondès Kahouli, Energy Journal, International Association for Energy

Dunkerley 2014: Road traffic demand elasticities: A rapid evidence assessment. RAND Europe report for the UK Department for Transport. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/395119/road-traffic-demand-elasticities.pdf

Economics, Available at: https://halshs.archives-ouvertes.fr/halshs-01957771/document (date of access: 26.03.2020)

Complete energy balances, Eurostat, nrg_bal_c, Available at: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_bal_c&lang=en (date of access: 03.04.2020)

Concawe 2019: EU refinery capacity. Available at: https://www.concawe.eu/refineries-map/ (date of access: 26.03.2020)

DECC 2016: Gas price elasticities: the impact of gas prices on domestic consumption – a discussion of available evidence. UK Department of Energy and Climate Change, London, Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/532539/Annex_D_Gas_price_elasticities.pdf (date of access: 26.03.2020)

Delsaut 2014: The Effect of Fuel Price on Demands for Road and Rail Travel: An Application to the French Case. Marianne Delsaut, Transportation Research Procedia, Available at: https://www.sciencedirect.com/science/article/pii/S2352146514000192 (date of access: 26.03.2020)

entsog 2019: Transmission capacity map 2019. Available at: https://www.entsog.eu/maps#transmission-capacity-map-2019 (date of access: 31.03.2020)

ECFD 2020: European Confederation of Fuel Distributors. Available at: http://www.fuel-distributors.eu/about-us/ (date of access: 04.04.2020)

Europages (B2B marketplace): Bonded warehouses in the EU. Available at: https://www.europages.co.uk/companies/Warehouses%20and%20bonded%20warehouses/bonded%20warehouses.html (date of access: 25.03.2020)

Europages (B2B marketplace): Solid fuel distributors in the EU. Available at: https://www.europages.co.uk/companies/solid%20fuel.html (date of access: 31.03.2020)

European Environment Agency, 2020, National emissions reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism, Available at: https://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-unfccc-and-to-the-eu-greenhouse-gas-monitoring-mechanism-15#tab-european-data (date of access: 11.04.2020)

Eurostat 2019: Total number of companies that either produce natural gas by national production or bring natural gas into the country by import. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_market_indicators&oldid=464176#Natural_gas_market_-_import_.26_production_.28IMPRO.29 (date of access: 30.03.2020)

Eurostat 2019: Number of retailers selling natural gas to final customers. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_market_indicators&oldid=464176#Natural_gas_market_-_retail (date of access: 30.03.2020)

Eurostat 2019: Extraction of crude petroleum and natural gas. Annual enterprise statistics by size class for special aggregates of activities (NACE Rev. 2). Available at: https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do (date of access: 26.03.2020)

Eurostat 2019: EU energy in figures. Statistical pocketbook 2019. Available at: https://ec.europa.eu/energy/data-analysis/energy-statistical-pocketbook_en?redir=1 (date of access: 07.04.2020)

Eurostat 2020: Mining of coal and lignite. Annual detailed enterprise statistics for industry (NACE Rev. 2). Available at: https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do (date of access: 31.03.2020)

FuelsEurope 2018: Number of petrol stations in Europe. Available at: https://www.fuelseurope.eu/wp-content/uploads/2018/08/FUELSEUROPE-_Graph_2018-52.pdf?utm_medium=website&utm_source=archdaily.com (date of access: 26.03.2020)

Gómez et al, 2006, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*; Volume 2: Energy; Chapter 2 – Stationary Combustion. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (date of access: 11.04.2020)

Hössinger 2017: Estimating the price elasticity of fuel demand with stated preferences derived from a situational approach. Reinhard Hössinger, Christoph Link, Axel Sonntag, Juliane Stark, Transportation Research Part A: Policy and Practice, Available at: https://www.sciencedirect.com/science/article/pii/S096585641630636X (date of access: 26.03.2020)

Hyland 2015: Firm-level Estimates of Fuel Substitution: An Application to Carbon Pricing. Marie Hyland, Stefanie Haller, ESRI Working Paper, Dublin, Available at: https://www.econstor.eu/bitstream/10419/129422/1/837457629.pdf (date of access: 26.03.2020)

IPCC 2018, Transport. https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter8.pdf (accessed: 25/3/2020)

JRC 2018: EU coal regions: opportunities and challenges ahead. EUR 29292 EN. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112593/kjna29292enn.pdf (date of access: 24.03.2020)

Kenneth S. Kurani, Automobile Buyer Decisions about Fuel Economy and Fuel Efficiency (2004). United States Department of Energy and Energy Foundation. file:///C:/Users/13434/Downloads/2004+09+Turrentine+Kurani+automobile+buyer+decisions+about+fuel+economy.pdf (accessed: 25/3/2020)

Kompass (B2B portal): Coal import enterprises. Available at: https://gb.kompass.com/searchCompanies/facet?value=exporter&label=undefined&filterType=exporter&searchType=SUPPLIER&checked=false (date of access: 07.04.2020)

Labandeira 2017: A meta-analysis on the price elasticity of energy demand. Xavier Labandeira, José M. Labeagac, Xiral López-Oteroa, Energy Policy, Available at: http://www.pubmanitoba.ca/v1/proceedings-decisions/appl-current/pubs/2017%20mh%20gra/irs%20to%20iec/mh-daymark%20(load)%20i-12%20-attachment3%20-%20labandeira.pdf (date of access: 26.03.2020)

Real Prospects for Energy Efficiency in the United States (2010). Chapter: 3 Energy Efficiency in Transportation. https://www.nap.edu/read/12621/chapter/5#124 (accessed: 25/3/2020)

Sager 2019: The global consumer incidence of carbon pricing: evidence from trade. Lutz Sager, London School of Economics, London, Available at: http://docs.lutzsager.de/Sager_JMP.pdf (date of access: 26.03.2020)

Schade 2015: Analyse der Effekte niedriger Ölpreise auf aktuelle Verkehrsszenarien. Wolfgang Schade, M-Five, Fraunhofer ISI, Stiftung Mercator, Karlsruhe, Available at: https://www.stiftung-mercator.de/media/downloads/3_Publikationen/M_Five_ISI_Analyse_Effekte_niedriger_Oelpreise_Verkehrszenarien.pdf (date of access: 26.03.2020)

Schulte 2016: Price and Income Elasticities of Residential Energy Demand in Germany. Isabella Schulte, Peter Heindl, ZEW, Available at: http://ftp.zew.de/pub/zew-docs/dp/dp16052.pdf (date of access: 26.03.2020)

Sterner 2012: Distributional effects of taxing transport fuel. Energy Policy (41), pp 75-83. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0301421510001758

Thomas 2018: Drivers of recent energy consumption trends across sectors in EU28. Samuel Thomas, Samuel Thomas Consulting, Available at: https://ec.europa.eu/energy/sites/ener/files/energy_consumption_trends_workshop_report-september_2018.pdf (date of access: 26.03.2020)

Transport and Environment 2016. A Study on Oil Dependency in the EU. Available at: https://www.camecon.com/wp-content/uploads/2016/11/Study-on-EU-oil-dependency-v1.4_Final.pdf (date of access: 01/04/2020)

Waldron et al, 2006, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*; Volume 2: Energy; Chapter 3 – Mobile Combustion. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (date of access: 11.04.2020)

7.3 Task 3 (Section 4)

Accounting for Carbon (2015): Monitoring, Reporting and Verifying Emissions in the Climate Economy. Valentin Bellassen (INRA), Nicolas Stephan (CDC Climat), Ian Cochran (CDC Climat), Jean-Pierre Chang (Citepa), Mariana Deheza (CDC Climat), Guillaume Jacquier (Citepa), Marion Afriat (CDC Climat), Emilie Alberola (CDC Climat), Caspar Chiquet (South Pole Carbon), Romain Morel (CDC Climat), Chris Dimopoulos (National Physical Laboratory), Igor Shishlov (CDC Climat), Claudine Foucherot (CDC Climat), Alexandra Barker (National Physical Laboratory), Roderick Robinson (National Physical Laboratory), Cambridge university press

Achtnicht, M. (2019): Road transport and its potential inclusion in the EU ETS. Achtnicht, M., von Graevenitz, K., Koesler, S., Löschel, A., Schoeman, B.. and Reanos, M. A. T., in: E. Gawel et al. The European Dimension of Germany's Energy Transition - Opportunities and Conflicts.

Application of the European union emissions trading directive - Analysis of national responses under Article 21 of the EU ETS Directive in 2018, European Commission, SQ Consult, UBA Vienna, 22 May 2019. Available at: https://op.europa.eu/en/publication-detail/-/publication/4c3f7bf0-7d08-11e9-9f05-01aa75ed71a1/language-en/format-PDF/source-search

Bader, Pascal (2000): Europäische Treibhauspolitik mit handelbaren Emissionsrechten. Empfehlungen für die Umsetzung der Kyoto-Verpflichtung vor dem Hintergrund

US-amerikanischer Lizenzierungserfahrungen. Zugl.: Augsburg, Univ., Diss., 1999. Berlin: Duncker & Humblot (Studien zu Umweltökonomie und Umweltpolitik, 6).

CAT 2019: Zero Carbon Britain. Rising to the Climate Emergency. Allen, Paul, James, Philip/ Center for Alternative Technology, Powys (UK). Available at: https://www.cat.org.uk/info-resources/zero-carbon-britain/research-reports/zero-carbon-britain-rising-to-the-climate-emergency/ (date of access: 14.04.2020)

CE Delft 2014: Emissions trading for transport and the built environment. Analysis of the options to include transport and the built environment in the EU ETS. CE Delft, SQ Consult, Cambridge Econometrics, Delft (Netherlands).

cep 2015: Erweitert den Emissionshandel! Effektive und effiziente Reduktion von Treibhausgasen im Straßenverkehr. cepInput by Nima Nader & Götz Reichert. Available at: https://www.cep.eu/Studien/cepInput_ETS-Erweiterung/cepInput_ETS-Erweiterung.pdf (date of access:17.04.2020)

COUNCIL DIRECTIVE (EU) 2015/652 of 20 April 2015 laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels

COMMISSION IMPLEMENTING REGULATION (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012

COMMISSION IMPLEMENTING REGULATION (EU) 2018/2067 of 19 December 2018 on the verification of data and on the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council

Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814

Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC (Text with EEA relevance)

Duscha 2014: Personal Carbon Trading Systeme: Konzepte und Schlussfolgerungen für Deutschland. Vicki Duscha/ Umweltbundesamt, Dessau-Rosslau (Germany). Available at: https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_04_2014_komplett_21.5.2014.pdf (date of access: 28.04.2020)

Duscha 2019: GHG-neutral EU 2050 - a scenario of an EU with net-zero greenhouse gas emissions and its implications. Duscha, Vicki, Wachsmuth, Jakob, Eckstein, Johannes, Pfluger, Benjamin/Umweltbundesamt, Dessau-Rosslau (Germany). Available at: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-11-26_cc_40-2019_ghg_neutral_eu2050_0.pdf (date of access: 14.04.2020)

European Commission 2018: In-Depth Analysis in support of the Commission Communication COM (2018) 773. A Clean Planet for all. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy. European Commission, Brussels (Belgium). Available at: https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf (date of access: 14.04.2020)

EU ETS handbook, European Commission, 2015

Guidance Document, European Commission - The Monitoring and Reporting Regulation – General guidance for installations - MRR Guidance document No. 1, Updated Version of 27 November 2017

Fawcett, Rosenow, Bertoldi 2019: Energy efficiency obligation schemes: their future in the EU. Tina Fawcett, Jan Rosenow and Paolo Bertoldi. Energy Efficiency 12, 57-71(2019). Available at: https://link.springer.com/article/10.1007/s12053-018-9657-1 (date of access: 24.04.2020)

FOES 2016: Straßenverkehr im Emissionshandel - Ohne Nutzen für den Klimaschutz. Eine kritische Betrachtung der Integration des Straßenverkehrs in den bestehenden europäischen Emissionshandel. Forum Ökologisch-Soziale Marktwirtschaft. Available at: https://foes.de/publikationen/2016/2016-06-FOES-ETS-Strassenverkehr.pdf (date of access: 17.04.2020)

Greenstream 2017: Sectoral expansion of the EU ETS - inclusion of road transport and heating. Available at: https://greenstream.net/references/sectoral-expansion-of-the-eu-ets-inclusion-of-road-transport-and-heating/ (date of access: 29.05.2020)

Heindl, Peter (2017): The impact of administrative transaction costs in the EU emissions trading system. In: *Climate Policy* 17 (3), S. 314–329. DOI: 10.1080/14693062.2015.1110108.

Hermann 2014: Ausweitung des Emissionshandels auf Kleinemittenten im Gebäude- und Verkehrssektor: Gestaltung und Konzepte für einen Plicy mix. Endbericht zu Arbeitspaket 1 und Arbeitspaket 2 des UFOPLAN-Vorhabens "Ausweitung des Emissionshandels auf neue Sektoren und Kleinemittenten (z.B. Gebäudebereich). Hermann, Hauke; Cludius, Johanna, Förster, Hannah, Matthes, Felix C.; Schumacher, Katja, Buchholz, Georg, Behnisch, markus, Berman, Johann, Duscha, Vicki, Marth, Hans. Climate Change 03/2014. Available at: https://www.umweltbundesamt.de/publikationen/ausweitung-des-emissionshandels-auf-kleinemittenten (date of access: 24.04.2020)

I4CE, Enerdata, IFPen, November 2015, Extending the EU ETS to the road transport sector. Available at: https://www.i4ce.org/wp-core/wp-content/uploads/2016/06/rapport-I4CE-chapitre-4.pdf

ICAP International Carbon Action Partnership, 2019: Emissions Trading Worldwide, Status Report. Available at: https://icapcarbonaction.com/en/?option=com_attach&task=download&id=625

International Bank for Reconstruction and Development / The World Bank, ICAP, 2016: Emissions Trading System in practice: a handbook on design and implementation. Available at: http://documents.worldbank.org/curated/en/353821475849138788/Emissions-trading-in-practice-a-handbook-on-design-and-implementation

IPCC 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Pean, R. Pidcock, S. Connors, J.B.R.

Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonney, T. Maycokc, M. Tignor, and T. Waterfield (eds.). Available at: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf/ (date of access: 17.04.2020)

IPCC Guidelines for National Greenhouse Gas Inventories, 2006

Kluschke 2019: Market diffusion of alternative fuels and powertrains in heavy-duty vehicles: A literature review. Kluschke, P., Gnann, T., Plötz, P. and Wietschel, M. Energy Reports Volume 5, November 2019, 1010-1024. Available at: https://www.sciencedirect.com/science/article/pii/S2352484719301167?via%3Dihub (date of access: 27.07.2020)

Ligterink, N.E., TNO 2016 R10700. Dutch market fuel composition for GHG emissions. 2016

Matthes 2019: Ein Emissionshandelssystem für die nicht vom EU ETS erfassten Bereiche: Praktische Umsetzungsthemen und zeitliche Erfordernisse. Dr. Felix Chr. Matthes, erstellt im Auftrag von Agora Energiewende. Available at: https://www.agora-energiewende.de/veroeffentlichungen/ein-emissionshandelssystem-fuer-die-nicht-vom-eu-ets-erfassten-bereiche/ (date of access: 17.04.2020)

Monitoring, reporting and verifying emissions in the climate economy, 25 March 2015, Valentin Bellassen (INRA), Nicolas Stephan (CDC Climat), Ian Cochran (CDC Climat), Jean-Pierre Chang (Citepa), Mariana Deheza (CDC Climat), Guillaume Jacquier (Citepa), Marion Afriat (CDC Climat), Emilie Alberola (CDC Climat), Caspar Chiquet (South Pole Carbon), Romain Morel (CDC Climat), Chris Dimopoulos (National Physical Laboratory), Igor Shishlov (CDC Climat), Claudine Foucherot (CDC Climat), Alexandra Barker (National Physical Laboratory), Roderick Robinson (National Physical Laboratory), nature climate change, VOL 5, April 2015

Plötz 2018: Alternative drive trains and fuels in road freight transport - recommendations for action in Germany. Plötz, P., Gnann, T., Wietschel, M., Kluschke, P., Doll, C., Hacker, F., Blanck, R., Kühnel, S., Johrens, J., Helms, H., Lambrecht, U. and Dünnebeil, F. Available at http://publica.fraunhofer.de/eprints/urn_nbn_de_0011-n-5213061.pdf (date of access: 27.04.2020)

Quality and greenhouse gas intensities of transport fuels in the EU in 2017, Monitoring under the Fuel Quality Directive in 2017 (2018 reporting), EEA Report No 05/2019. Available at: https://www.eea.europa.eu/publications/quality-and-greenhouse-gas-intensities-1

REGULATION (EU) No 525/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC

Tokyo Cap-and-Trade Program - Japan’s first mandatory emissions trading scheme: March 2010, Bureau of the Environment Tokyo Metropolitan Government

Umweltbundesamt 2014: Treibhausgasneutrales Deutschland im Jahr 2050, Dessau-Rosslau (Germany). Available at: https://www.umweltbundesamt.de/publikationen/treibhausgasneutrales-deutschland-im-jahr-2050-0 (date of access: 14.04.2020)

World Bank Group, Partnership for Market Readiness, April 2016: Greenhouse Gas Data Management - Building Systems for Corporate/Facility-Level Reporting.

Available at: https://www.worldbank.org/en/topic/environment/publication/greenhouse-gas-data-management-building-systems-for-corporatefacility-level-reporting

7.4 Task 5 (Section 6)

Arpagaus, Cordin (2019): Hochtemperatur-Wärmepumpen. Marktübersicht, Stand der Technik und Anwendungspotenziale. Neuerscheinung. Available online at https://www.content-select.com/index.php?id=bib_view&ean=9783800745517.

Beyond zero emissions (2018): Zero Carbon Industry Plan, Electrifying Industry. BZE. Available online at https://bze.org.au/research/manufacturing-industrial-processes/electrifying-industry/, checked on 5/28/2020.

Boothroyd, I. M.; Almond, S.; Qassim, S. M.; Worrall, F.; Davies, R. J. (2016): Fugitive emissions of methane from abandoned, decommissioned oil and gas wells. In The Science of the total environment 547, pp. 461–469. DOI: 10.1016/j.scitotenv.2015.12.096.

CE Delft (2014): Emissions trading for transport and the built environment. Analysis of the options to include transport and the built environment in the EU ETS. With assistance of Cambridge Econometrics SQ Consult. Edited by CE Delft. Delft.

Ecofys, Fraunhofer ISI, Öko-Institut (2009a): Methodology for the free allocation of emission allowances in the EU ETS post 2012. Sector report for the cement industry, by order of the European Commission. Available online at https://ec.europa.eu/clima/sites/clima/files/ets/allowances/docs/bm_study-cement_en.pdf, checked on 5/28/2020.

Ecofys, Fraunhofer ISI, Öko-Institut (2009b): Methodology for the free allocation of emission allowances in the EU ETS post 2012. Sector report for the glass industry, by order of the European Commission. Available online at https://ec.europa.eu/clima/sites/clima/files/ets/allowances/docs/bm_study-glass_en.pdf, checked on 5/28/2020.

Element Energy (2019): Assessment of Options to Reduce Emissions from Fossil Fuel Production and Fugitive Emissions. Edited by Element Energy Limited. Cambridge. Available online at https://www.theccc.org.uk/publication/assessment-of-options-to-reduce-emissions-from-fossil-fuel-production-and-fugitive-emissions/, checked on 5/28/2020.

EPA (2017): Abandoned Coal Mine Methane Opportunities Database. Edited by US Environmental Protection Agency. Washington, DC. Available online at https://www.epa.gov/sites/production/files/2016-03/documents/amm_opportunities_database.pdf, checked on 5/28/2020.

European Commission (2018): Application of the European Union Emissions trading Directive, Analysis of national responses under Article 21 of the EU ETS Directive in 2018. Edited by European Commission. Available online at https://op.europa.eu/en/publication-detail/-/publication/4c3f7bf0-7d08-11e9-9f05-01aa75ed71a1, checked on 5/28/2020.

European Commission (2019): Best Available Techniques Guidance Document on upstream hydrocarbon exploration and production. Edited by European Commission. Available online at https://ec.europa.eu/environment/integration/energy/pdf/hydrocarbons_guidance_doc.pdf, checked on 5/28/2020.

Fraunhofer ISI (2019): Erstellung von Anwendungsbilanzen für die Jahre 2018 bis 2020 für die Sektoren Industrie und GHD, Studie für die Arbeitsgemeinschaft

Energiebilanzen e.V. (AGEB) - Entwurf. Available online at https://ag-energiebilanzen.de/8-0-Anwendungsbilanzen.html, checked on 5/28/2020.

IEA (2017): World Energy Outlook 2017. A world in transformation. Edited by IEA. Available online at https://www.iea.org/reports/world-energy-outlook-2017, checked on 5/28/2020.

Ipieca (2015): Exploring methane emissions. Edited by Ipieca. Available online at https://www.ipieca.org/resources/fact-sheet/exploring-methane-emissions/, checked on 5/28/2020.

Kang, Mary; Kanno, Cynthia M.; Reid, Matthew C.; Zhang, Xin; Mauzerall, Denise L.; Celia, Michael A. et al. (2014): Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania. In Proceedings of the National Academy of Sciences of the United States of America 111 (51), pp. 18173–18177. DOI: 10.1073/pnas.1408315111.

Kochhan et al. (2017): An Overview of Costs for Vehicle Components, Fuels, Greenhouse Gas Emissions and Total Cost of Ownership. Update 2017. Available online at https://steps.ucdavis.edu/wp-content/uploads/2018/02/FRIES-MICHAEL-An-Overview-of-Costs-for-Vehicle-Components-Fuels-Greenhouse-Gas-Emissions-and-Total-Cost-of-Ownership-Update-2017-.pdf, checked on 5/28/2020.

Laconde (2018): Fugitive emissions: a blind spot in the fight against climate change. Edited by Climate Chance (Energy). Available online at https://www.climate-chance.org/en/card/fugitive-emissions-blind-spot-fight-against-climate-change/, checked on 5/28/2020.

Lechtenböhmer, Stefan; Nilsson, Lars J.; Åhman, Max; Schneider, Clemens (2016): Decarbonising the energy intensive basic materials industry through electrification – Implications for future EU electricity demand. In Energy 115, pp. 1623–1631. DOI: 10.1016/j.energy.2016.07.110.

Lips, Markus (2017): Length of Operational Life and Its Impact on Life-Cycle Costs of a Tractor in Switzerland. In Agriculture 7 (8), p. 68. DOI: 10.3390/agriculture7080068.

Luh, Sandro; Budinis, Sara; Giarola, Sara; Schmidt, Thomas J.; Hawkes, Adam (2020): Long-term development of the industrial sector – Case study about electrification, fuel switching, and CCS in the USA. In Computers & Chemical Engineering 133, p. 106602. DOI: 10.1016/j.compchemeng.2019.106602.

McKinsey & Company (2019): Harnessing momentum for electrification in heavy machinery and equipment. Edited by McKinsey & Company. Available online at https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/harnessing-momentum-for-electrification-in-heavy-machinery-and-equipment, checked on 5/28/2020.

McKinsey & Company (2020): Agriculture and climate change. Reducing emissions through improved farming practices. Edited by McKinsey & Company. Available online at https://www.mckinsey.com/industries/agriculture/our-insights/reducing-agriculture-emissions-through-improved-farming-practices, checked on 5/28/2020.

Methane guiding Principles (2019): Reducing Methane Emissions: Best Practice Guide. Available online at https://methaneguidingprinciples.org/wp-content/uploads/2019/11/NSR05896-Reducing-Methane-Emissions-Brochure-AWv5_WEB.pdf, checked on 5/28/2020.

REHFELDT, MATTHIAS (2020): FUEL SWITCHING AS CONTRIBUTION TO THE DECARBONISATION OF THE. [S.l.]: FRAUNHOFER VERLAG.

UNECE & GMI (2019): Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector. Monitoring, Reporting and Verification (MRV) and Mitigation. Edited by UNECE. Available online at https://www.unece.org/fileadmin/DAM/energy/images/CMM/CMM_CE/BPG_Methane_final_draft_190912.pdf, checked on 5/28/2020.

8 Appendix A – Task 2.1c variation between GHG inventories and bottom-up CO2 estimates

	Residential Buildings		
Total CO_2 ($MtCO_2$)	Energy Balances	GHG Inventories	%Difference
EU-27	313.91	324.76	3%
Austria	6.72	6.85	2%
Belgium	15.86	14.93	-6%
Bulgaria	0.86	0.83	-3%
Croatia	1.55	1.57	1%
Cyprus	0.35	0.36	3%
Czech Republic	8.30	8.76	5%
Denmark	2.13	1.89	-13%
Estonia	0.16	0.18	7%
Finland	1.18	1.20	2%
France	42.36	46.43	9%
Germany	87.69	91.81	4%
Greece	4.69	4.70	0%
Hungary	7.77	7.94	2%
Ireland	5.64	5.60	-1%
Italy	46.49	47.76	3%
Latvia	0.46	0.46	1%
Lithuania	0.75	0.75	0%
Luxembourg	1.12	1.10	-1%
Malta	0.04	0.04	1%
Netherlands	16.28	16.50	1%
Poland	36.17	35.69	-1%
Portugal	1.74	1.73	-1%
Romania	6.59	6.53	-1%
Slovakia	2.87	3.09	7%
Slovenia	0.68	0.68	-1%
Spain	14.75	16.77	12%
Sweden	0.71	0.62	-15%

	Commercial Buildings		
Total CO_2 ($MtCO_2$)	Energy Balances	GHG Inventories	%Difference
EU-27	140.01	141.20	1%
Austria	1.47	1.18	-25%
Belgium	6.84	5.47	-25%
Bulgaria	0.34	0.34	-1%
Croatia	0.63	0.63	0%
Cyprus	0.11	0.09	-20%
Czech Republic	3.15	2.97	-6%
Denmark	0.65	0.72	9%
Estonia	0.26	0.10	-173%
Finland	0.91	1.02	11%
France	25.62	28.59	10%
Germany	44.13	38.11	-16%
Greece	0.71	0.71	0%
Hungary	2.86	3.07	7%
Ireland	1.93	1.96	2%
Italy	16.97	23.24	27%
Latvia	0.36	0.39	8%
Lithuania	0.33	0.33	0%
Luxembourg	0.56	0.58	4%
Malta	0.09	0.16	44%
Netherlands	7.97	7.62	-4%
Poland	7.42	7.33	-1%
Portugal	1.00	1.16	13%
Romania	2.18	2.17	-1%
Slovakia	1.69	1.60	-6%
Slovenia	0.32	0.36	12%
Spain	10.67	10.57	-1%
Sweden	0.85	0.75	-14%

	Road Transport		
Total CO_2 ($MtCO_2$)	Energy Balances	GHG Inventories	%Difference
EU-27	765.50	772.80	-1%
Austria	23.32	23.24	0%
Belgium	24.60	24.87	-1%
Bulgaria	8.68	8.84	-2%
Croatia	6.34	6.34	0%
Cyprus	1.98	2.07	-4%
Czech Republic	18.22	18.08	1%
Denmark	11.47	12.01	-5%
Estonia	2.34	2.33	1%
Finland	10.67	10.69	0%
France	121.32	126.04	-4%
Germany	157.54	160.08	-2%
Greece	14.36	14.53	-1%
Hungary	12.61	12.69	-1%
Ireland	11.44	11.37	1%
Italy	91.91	91.39	1%
Latvia	3.05	3.09	-1%
Lithuania	5.45	5.44	0%
Luxembourg	5.61	5.58	1%
Malta	0.56	0.56	1%
Netherlands	29.47	29.67	-1%
Poland	60.42	61.15	-1%
Portugal	16.01	16.17	-1%
Romania	16.92	17.07	-1%
Slovakia	7.29	7.15	2%
Slovenia	5.74	5.44	6%
Spain	81.94	81.55	0%
Sweden	16.23	15.34	6%

9 Appendix B – Todays (2017) and 2030 emission coverage for different design options for EU27 (Mt CO2e)

Design options	2017 EU ETS	2017 "new ETS"	2017 ESR	2030 EU ETS	2030 "new ETS"	2030 ESR
Option 0	1,590 (41%)	---	2,252 (59%)	1,037 (38%)	---	1,659 (62%)
Option 1a	2,829 (74%)	---	1,013 (26%)	1,931 (72%)	---	765 (28%)
Option 1b	2,829 (74%)	---	2,252 (59%)	1,931 (72%)	---	1,659 (62%)
Option 1c	2,026 (53%)	---	1,817 (47%)	1,367 (51%)	---	1,329 (49%)
Option 2a	2,363 (62%)	---	1,479 (38%)	1,644 (61%)	---	1,052 (39%)
Option 2b	2,056 (54%)	---	1,786 (46%)	1,325 (49%)	---	1,371 (51%)
Option 3a	1,590 (41%)	1,239 (32%)	2,252 (59%)	1,037 (38%)	894 (33%)	1,659 (62%)
Option 3b	1,590 (41%)	435 (11%)	2,252 (59%)	1,037 (38%)	329 (12%)	1,659 (62%)
Option 3c	1,590 (41%)	773/466 (20/12%)	2,252 (59%)	1,037 (38%)	606/288 (22/11%)	1,659 (62%)

Source: Fraunhofer ISI calculations based on EUCO3232.5, GHG inventories and EEA data viewer

10 Appendix C – Energy tax for gas and coal in each MS

Table 109.Energy tax on natural gas in EU Member States

	Type	Level per GJ	VAT	Purpose	Regulated entity
Austria	Excise duty	1.66€	20%	Business and non-business heating, propellant	Supplier (in specific cases the consumer)
Belgium	Excise duty + federal contribution	0.4351€ (reduced level for companies that are regulated by other environmental legislation)	21%	Business and non-business heating	Distributor at the moment of delivery from the distributor to the final consumer
Bulgaria	Excise duty	≈ 0.30-0.43€*	20%	Business heating, propellant	Person who releases for consumption
Croatia	Excise duty	0.15-0.30€	25%	Business and non-business heating	Person who releases for consumption
Cyprus	Excise duty	2.60€	19%	Business and non-business heating, propellant	Person who releases for consumption
Czech Republic	Excise duty	≈ 0.33-2.86€*	21%	Business and non-business heating, propellant	Person who releases for consumption
Denmark	Excise duty + CO_2 tax	≈ 9-12€*	25%	Business and non-business heating, propellant	Person who releases for consumption
Estonia	Excise duty	1.07€ (LNG1.16€)	20%	Business and non-business heating, propellant	Handlers on liquefied gas and network operators of natural gas

Finland	Excise duty	5.74€	24%	Business and non-business heating, propellant	Operators of natural gas networks, authorised warehousekeepers and registered users who have acquired natural gas free of tax but have used it for taxable purposes
France	Excise duty	1.61-2.35€	20% certain uses exempted from VAT but not the main uses	Business and non-business heating, propellant	Person who releases for consumption
Germany	Excise duty	1.14-3.86€	19%	Business and non-business heating, propellant	Person who releases for consumption
Greece	Excise duty	0.3-1.5€ (depending on the level of consumption)	6% (reduced from standard 24)	Business and non-business heating	Person who releases for consumption
Hungary	Excise duty	≈ 0.5-2.58€*	27%	Business heating, propellant	Trader, user or producer
Ireland	Excise duty	1.03-2.60€	13.5%	Business and non-business heating, propellant	Suppliers of natural gas
Italy	Excise duty	0.09-4.73€ (depending on the level of consumption)	10-22% (depending on the level of consumption)	Business and non-business heating, propellant	Subjects who invoice to the final consumers or subjects that extract natural gas for own use
Latvia	Excise duty	0.15-2.68€	21%	Business and non-business heating, propellant	Person who releases for consumption

Lithuania	Excise duty	0.15-6.56€	21% certain uses exempted from VAT but not the main uses	Business and non-business heating, propellant	Authorised warehouse keepers, registered consignees, registered consignors, importers and, in cases established by the law - other persons must calculate and pay excise duties
Luxembourg	Excise duty	0.05-1.08€	8% certain uses exempted from VAT but not the main uses (reduced from standard 14)	Business and non-business heating	Person who releases for consumption
Malta	Excise duty	0.84€	18% (only use for heating)	Business and non-business heating	Person who releases for consumption
Netherlands	Excise duty	1.07-11.67€ (depending on the level of consumption)	21%	Business and non-business heating, propellant	Distributor
Poland	Excise duty	≈ 0.29€	23%	Business and non-business heating	Person who releases for consumption
Portugal	Excise duty	1.64-2.48€	23%	Business and non-business heating, propellant	Person who releases for consumption
Romania	Excise duty	≈ 0.18-2.78€*	19%	Business and non-business heating, propellant	Taxpayers are economic operators that provide products directly to the final beneficiaries
Slovakia	Excise duty	0.37-2.6€	20%	Business and non-	End user suppliers or natural gas

				business heating, propellant	consumers who produce or trade natural gas
Slovenia	Excise duty + surcharge on energy end-use efficiency + surcharge for the promotion of electricity generation from renewable energy sources and high-efficiency cogeneration + CO_2 tax	1.85-3.74€	22% certain uses exempted from VAT but not the main uses	Business and non-business heating, propellant	Person who releases for consumption
Spain	Excise duty	0.15-1.15€	21%	Business and non-business heating, propellant	Person who releases for consumption
Sweden	Excise duty + CO_2 tax	≈ 5.90-8.20€* (no CO_2 tax for companies under the ETS)	25%	Business and non-business heating, propellant	Authorised warehousekeepers and registered traders are the main tax payers

* depending on exchange rate and end use

Source: Taxes in Europe Database v3

Table 110.Energy tax on coal products in EU Member States

	Type	**Level per GJ**	**VAT**	**Purpose**	**Regulated entity**
Austria	Excise duty	1.70€	20%	Business and non-business heating	Supplier (in specific cases the consumer)
Belgium	Excise duty	0.3715€ (reduced level for agriculture)	12% (reduced from standard 21)	Business and non-business heating	Levied at the moment of delivery to the retailer.

Bulgaria	Excise duty	≈ 0.30€*	20%	Business and non-business heating	Person who releases for consumption
Croatia	Excise duty	≈ 0.30€*	25%	Business and non-business heating	Person who releases for consumption
Cyprus	Excise duty	0.31€	19%	Business and non-business heating	Person who releases for consumption
Czech Republic	Excise duty	≈ 0.33€*	21%	Business and non-business heating	Person who releases for consumption
Denmark	Excise duty + CO_2 tax	≈ 9.84€* (reduced level for agriculture)	25%	Business and non-business heating	Person who releases for consumption
Estonia	Excise duty	0.93€	20%	Business and non-business heating	Producers of heat from solid fuel
Finland	Excise duty	6.38€	24%	Business and non-business heating	Warehousekeeper, registered or non-registered trader or importers
France	Excise duty	4.06€	20%	Business and non-business heating	Person who releases for consumption
Germany	Excise duty	0.33€	19%	Business and non-business heating	Person who releases for consumption
Greece	Excise duty	0.3€	24%	Business and non-business heating	Person who releases for consumption

Hungary	Excise duty	≈ 0.24€*	27%	Business and non-business heating	Trader, user or producer
Ireland	Excise duty	1.89€	13.5%	Business and non-business heating	Suppliers of solid fuels
Italy	Excise duty	0.38-0.47€	22%	Business and non-business heating	Authorised warehousekeeper or registered consignee or importer
Latvia	Excise duty	0.76€	21%	Business and non-business heating	Person who releases for consumption
Lithuania	Excise duty	0.15-0.30€	21%	Business and non-business heating	Authorised warehouse keepers, registered consignees, registered consignors, importers and, in cases established by the law - other persons must calculate and pay excise duties
Luxembourg	Excise duty	5.00€	14%	Business heating	Person who releases for consumption
Malta	Excise duty	0.30€	18%	Business and non-business heating	Person who releases for consumption
Netherlands	Excise duty	0.48€	21%	Business and non-business heating	The licensee of a coal establishment (generally the producer or warehousekeeper) or the one who has coal or coal products on hand that have not yet been taxed.

Poland	Excise duty	≈ 0.29€	23%	Business and non-business heating	Person who releases for consumption
Portugal	Excise duty	1.83-2.15€	23%	Business and non-business heating	Person who releases for consumption
Romania	Excise duty	≈ 0.16-0.32€*	19%	Business and non-business heating	Taxpayers, the producers or the economic operators which carry out intra-Community acquisitions or import such products
Slovakia	Excise duty	0.31€	20%	Business and non-business heating	End user suppliers or coal consumers who produce or trade coal
Slovenia	Excise duty + surcharge on energy end-use efficiency + surcharge for the promotion of electricity generation from renewable energy sources and high-efficiency cogeneration + CO_2 tax	2.34€	22%	Business and non-business heating	Person who releases for consumption
Spain	Excise duty	0.15-0.65€	21%	Business and non-business heating	Producer or extractor, importer or intra-community acquirer and resellers entrepreneurs
Sweden	Excise duty + CO_2 tax	≈ 0.6-10.71€* (no CO_2 tax for	25%	Business and non-	Authorised warehousekeepers and registered

		companies under the ETS)		business heating	traders are the main tax payers

* depending on exchange rate

Source: Taxes in Europe Database v3

11 Appendix D – Technical recommendations for the road transport sector

For passenger cars, energy savings can be achieved through switching to electric vehicles, and technical measures, such as improving aerodynamics, motor efficiency, light-weighting, etc. Table 111 presents a list of technical and operational measures for Light Duty Vehicles (LDV) and Heavy-Duty Vehicles (HDV). Due to the interaction between the technical measures, and difference in costs, for the three vehicle categories, the individual technical measures have been aggregated to overarching improvement levels, which have been modelled separately:

- Passenger transport: Improved vehicle efficiency of 3%, 4% and 6%.
- Light duty vehicle: Improved vehicle efficiency of 3%, 4% and 6%
- Heavy duty vehicle: Improved vehicle efficiency of 15%, 20%, 25%, 30% and 32.35%.

Table 111. Specific measures contributing to improvement of LDV and HDV efficiency

Measure	Energy saving potential	End-user cost	Source
Low rolling resistance tyres	2-4%	no addinional costs	CE Delft (2014)
TPMS (tyre pressure management system)	0.5-2.5%	€450-€1000	CE Delft (2014)
Frequently aligning axes and wheels	0-4.5%	€ 700	CE Delft (2014)
Installing nets on top of open empty containers	3.5-5.5%	labor costs	CE Delft (2014)
Side-shields for trailers	2.7-6%	€ 3,250	CE Delft (2014)
Aerodynamic wheel covers	0.5-1.5%	€125 per axis	CE Delft (2014)
ICT: fuel management systems	1-8%	€ 3,500	CE Delft (2014)
Improved aerodynamics	Up to 3-5% of energy use	n/a	IEA (2018)
Lower rolling resistance tyres	10% to 30% reduction of rolling resistance and about 3-5% of total energy use	n/a	IEA (2018)
Reducing idling	Up to 2.5%	n/a	IEA (2018)
Route optimization	5%-10% intra-city, 1% long haul	n/a	IEA (2018)
High Capacity Vehicles (HCVs)	Up to 20%, primarily in long haul, risk of rebound	n/a	IEA (2018)
Driver training and feedback	3% to 10%	n/a	IEA (2018)

Measure	Energy saving potential	End-user cost	Source
Platooning	5% to 15%	n/a	IEA (2018)
Last mile delivery optimization	5% to 10%, depends on degree of implementation	n/a	IEA (2018)
Supply chain collaboration/co-loading	Up to 15%	n/a	IEA (2018)
Matching cargo and vehicles via IT	5% to 10% in urban areas	n/a	IEA (2018)
Urban consolidation centres	20%-50% in urban centres (all measures combined, including vehicle techs)	n/a	IEA (2018)
Physical internet	Up to 20%	n/a	IEA (2018)

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

– by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

– at the following standard number: +32 22999696, or

– by email via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from: https://op.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: http://eur-lex.europa.eu

Open data from the EU

The EU Open Data Portal (http://data.europa.eu/euodp/en) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

Publications Office
of the European Union