Documentation

The EU-ETS price through 2030 and beyond: A closer look at drivers, models and assumptions

Input material and takeaways from a workshop in Brussels

30 November 2022

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The EU-ETS price through 2030 and beyond: A closer look at drivers, models and assumptions

Input material and take-aways from the Ariadne Workshop in Brussels, 30 November 2022

Authors: M. Pahle, J. Sitarz, S. Osorio (PIK), B. Görlach (Ecologic)

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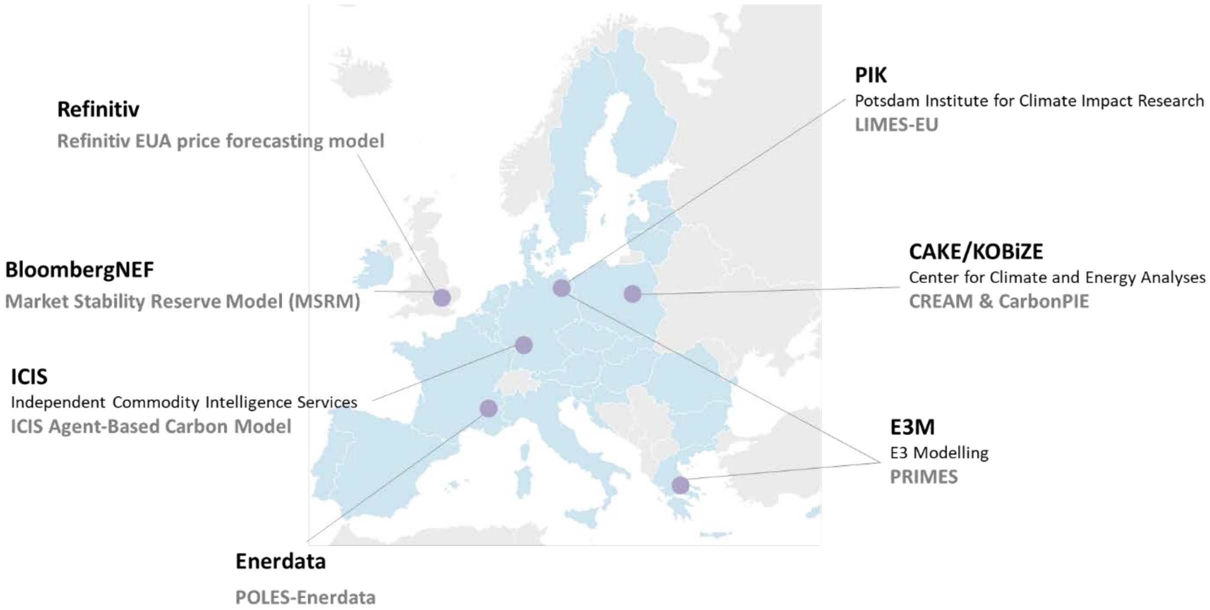
Workshop: goal and set-up

This document presents main takeaways and insights from a workshop organised by the Ariadne Project in Brussels on 30 November 2022. The workshop convened experts from seven organisations that operate carbon market models – academic institutions as well as carbon market analysts (see Figure 1).

Figure 1: Participating organizations and models



The goal of the workshop was to discuss in-depth the types of models, implementation details as well as core assumptions employed in the analysis of ETS prices targeted to inform the policy debate. More specifically, the workshop served to take stock of the diversity of approaches, discuss their pros and cons, and identify major sensitivities and arising developments affecting the price of EU Allowances (EUAs) through the end of this decade and beyond. In preparation of the workshop, all participants took part in a survey and provided a short model fact sheet, information about EUA in their default "Green Deal/FF55 COM" scenario, as well as an assessment of what they view as the main price drivers in 2025 and 2030. The completed questionnaires can be found in the Appendix I.

1. Survey results

Different modelling approaches to forecast the EU ETS prices

The survey unveiled that main characteristics and features differ across the models (see Table 1). That said, almost all of the models are (single agent) optimization models or rely on abatement cost curves. Additionally, all models comprise a simulation of the EU ETS, as well as the Market Stability Reserve (MSR). Moreover, depending on the model's main purpose, either perfect, or limited foresight is assumed. Herein, we see a tendency among organisations developing benchmark scenarios (i.e., computing the theoretically optimal prices to drive the energy transition) to assume foresight is perfect, whereas all market analysts, with a stronger focus on capturing market imperfections, assume limited foresight.

Table 1: Categorization of models along different features and methodological aspects

1. Type of model	EU ETS & MSR simulation *OR* agent-based model **(ICIS)**	Energy systems optimization model *OR* abatement curves
	> Detail and number of sectors represented > Dynamic (iterative approach) or static (one-directional information flow*)*	
2. Foresight	> **Perfect** foresight (benchmark approach) > Limited foresight of actors (1-10 years)	**PIK, CAKE, E3M** **Refinitiv, BNEF, ICIS, Enerdata**
3. Market imperfections	> Limited foresight > Banked EUA from non-compliance actors > Hedging by compliance actors	Refinitiv, BNEF, ICIS, Enerdata BNEF, Enerdata, ICIS Enerdata
4. Non-compliance actors		

Different models deliver convergent expectations about EUA price development in the medium term

The survey further unveiled a remarkable convergence between the different modelling approaches in the modelled price path towards the end of the 2020s (see Figure 2) in their respective default scenarios (see Table 2). Five out of six models presented yield a price estimate in the range of around 130 to 160 Euro in 2030, although their short-term predictions differ much more widely (between 56 and 111 Euro in 2025).

Figure 2: EUA prices in default "Green Deal/FF55 COM" scenarios [Notes: (a) Refinitiv and BloombergNEF prices are nominal; remaining prices are real and were harmonized to EUR2022 using EUROSTAT inflation rates. (b) E3M did not provide prices.]

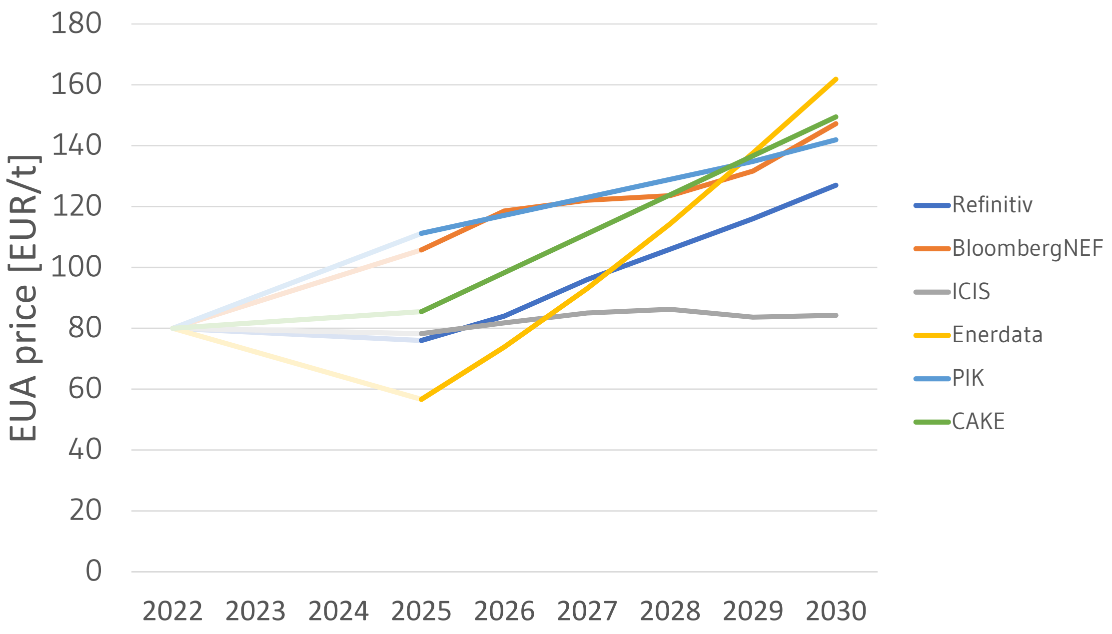


Table 2: Description of default "Green Deal/FF55 COM" scenarios

Modelling group	Scenario description
Refinitiv	+ ETS targets, MSR design from the FF55 package + **REPowerEU** sales of EUA considered
BloombergNEF	+ ETS targets, MSR design from the FF55 package + **REPowerEU** sales of EUA considered
ICIS	+ ETS targets, MSR design from the FF55 package + **RePowerEU** (reflected by frontloading of 250m allowances) + **Maritime sector**
Enerdata	+ ETS and ESR targets, MSR design from the FF55 package - RES and EE targets not strictly implemented
PIK	+ ETS, MSR design from the FF55 package - RePowerEU not considered
CAKE	+ ETS and ESR targets, MSR design from the FF55 package + **Maritime sector**, ETS2 (housing and transport) + CBAM

Main expected price drivers will continue to be ETS policy parameters and power sector, but industry sector will gain importance

Overall, ETS policy parameters, developments in the power sector and the behaviour of market participants are reported as the main factors driving modelled EUA prices (see Table 3). Over time this assessment remains relatively stable both within and between models. An important observation though is that the industry sector becomes more important by 2030 in three out of the seven models, while behaviour loses some importance. External factors are seen as relatively unimportant, except in one model.

Table 3: Three most important (expected) prices drivers in 2025 and 2030.

Drivers	2025	2030
Policy parameters (e.g., MSR)	BloombergNEF, ICIS, Enerdata, PIK, CAKE, E3M	Refinitiv, BloombergNEF, ICIS, Enerdata, PIK, CAKE, E3M
Power sector	Refinitiv, BloombergNEF, ICIS, Enerdata, PIK, CAKE, E3M	BloombergNEF, ICIS, Enerdata, PIK, CAKE, E3M
Behavior (e.g., hedging, speculation)	Refinitiv, BloombergNEF, ICIS, Enerdata, CAKE, E3M	Refinitiv, BloombergNEF, Enerdata, CAKE
Industry		Refinitiv, ICIS, E3M
External (e.g., interest rates, inflation, Geopolitical risks)	Refinitiv, PIK	PIK
New sectors and international transport		

Modelling group
- Refinitiv
- BloombergNEF
- ICIS
- Enerdata
- PIK
- CAKE
- E3M

2. Main takeaways and insights from workshop discussions

In the following a summary of the main takeaways and insights by the organizers [authors of this report] is provided. **This summary does not necessarily coincide with the views of the other participants.** Their individual main takeaways can be found in Appendix II; which contains the summary slides prepared for the back-to-back webinar.

Long-term convergence of most models implies stronger choice constraints and/or converging expectations as decarbonization progresses

This convergence was subject to discussion and one hypothesis about this long-term convergence that emerged is that there may be indeed fewer choices in the medium to long term than there are in the short-medium term. In this sense, the convergence of carbon prices can also be an expression of the convergence of expectations about future developments – or simply a case of group thinking.

This points to a counterintuitive possibility: normally, one would expect to have greater confidence in predictions of models about short term developments, as price drivers are better known and understood, whereas socio-economic uncertainties increase in the long term. Yet, as the carbon budget is shrinking, the path also becomes clearer – as all available options for decarbonisation will need to be implemented. In the medium term, there is still some discretion as to which options to realise first, and which later – in the long term, we need all of them. Also, in the medium to long term, backstop technologies are quite clear (renewables, eventually negative emission technologies), and their prices can be estimated with reasonable confidence. Important in that regard is that in all models ETS policy credibility is assumed, i.e. the pending implementation of a tighter ETS cap and stronger MSR operation (higher intake rate) will not be revoked in the future.

Overlapping policies are one key driver of projected prices – but implementation matters, not targets

Despite this convergence, there are also still considerable uncertainties that surround the price paths. One key assumption – that might also partly explain why the ICIS model arrives at a lower estimate – concerns the implementation of overlapping policies with an effect on the carbon price, particularly the expansion of renewables and energy efficiency. Here, what matters is not so much the ambition of targets – but rather the actual implementation; and implementation not in the sense of regulations adopted, but in the sense of renewable capacities deployed. The transmission channel from more ambitious energy targets to lower carbon prices is thus investment. Since many of the needed investments are capital intensive with a high share of upfront capex, they are particularly sensitive to assumptions about cost of capital / interest rates.

Overlapping policies not only have the effect of cushioning carbon prices – of late there have also been examples of overlapping policies that increase carbon prices by increasing emissions – in particular the drift back into coal triggered by national measures e.g. in Germany in response to the energy crisis and high gas prices.

Industrial emitters play a growing role in the carbon market, changing market dynamics – and modeller's understanding of them

As the power sector progresses on the pathway to decarbonisation and is expected to provide most reductions before 2030, emissions from industry will account for an increasingly larger share of EU ETS emissions, and therefore will also play a larger role in determining the ETS price. This has several implications for carbon market dynamics.

At current, there is already a trend towards falling industry emissions as emission-intensive industries reduce their production levels (at least in their European installations).

This trend may be accelerated (markedly) by the current gas price rise. If and when adopted, the Carbon Border Adjustment Mechanism (CBAM) could affect or even reverse this trend: if it succeeds to make industrial production in Europe more attractive, this would lead to a slower decline of industrial emissions in Europe – or even an increase. However, particularly the interaction between CBAM and market dynamics is not (yet) well understood.

Despite efforts to improve the data base, the market behaviour and the trading strategies by industrials are less well understood than those of the energy sector, and hence also their effect on carbon price dynamics. Rather than coal/gas or gas/renewables switch prices, industry demand is fundamentally driven by the marginal abatement cost of industrial installations and processes. Despite efforts to improve the data, these remain uncertain – also since many relevant investments are lumpy, installation-specific, depend on a wide range of industrial processes and products, and involve technologies that are not yet applied widely or are even far from commercial deployment.

(To what extent) does the carbon market factor in long-term scarcity?

There is some uncertainty as to how scarcity in the very long term (2040 and beyond, approaching climate neutrality) would be reflected in modelling results – how long into the future do the models allow us to look? Time horizons in the model differ (perfect foresight vs limited foresight) – but also in perfect foresight, the choice of the discount rate will determine just how much the far future would influence modelling results.

But while the time horizon of models is typically limited, many investment decisions easily surpass the time horizons of most models. Thus, the long run scarcity of emission allowances does enter into decision-making. Hence there is a need to bridge the short-term and the longer-term outlook, and for models to provide an estimate also of price expectations in 10-20 years from now.

The emerging "endgame" for the EU ETS and related prices are of course uncertain – but some key factors can be identified.

- In the 2030s, linkage to or merger with the ETS for buildings and road transport; future role of the MSR: will it remain operational or be replaced by another mechanism, e.g., carbon price floor?

- In the 2040s, increasing role for negative emissions technologies
- Need to support negative emissions technologies for the foreseeable future. Prices may fall – but ETS remains needed to pay for them.

Rising carbon prices in the long term can also be seen as underlining the credibility of climate policy, and the plausibility of decarbonisation strategies. They are a signal that the regulator’s commitment to a long-term carbon constraint is seen as credible by market participants, and that the EU ETS is considered as “here to stay”. This may explain why carbon prices remained low in the 2010s – despite the fact that, already then, the EU had a fairly ambitious mid-century reduction target: apparently this was not taken to plausibly and credibly translate into future scarcity of allowances.

Appendix I: Completed questionnaires

Questionnaire ETS workshop

Responding organisation	**BloombergNEF***

*For any questions please contact https://about.bnef.com/

Model fact sheet

Model (suite) name	Market Stability Reserve Model (MSRM) 1.18.2
Short description	The MSRM forecasts the EU ETS market balance and EUA prices given emissions forecasts, a marginal abatement cost curve, and user-defined rules for the Market Stability Reserve. The MSRM projects hedged holdings and allowances in circulation given price levels and abatement volume solved for in the previous year. It subsequently calculates the reserve injections or ejections and anticipates any upcoming scarcity using a market horizon. The pricing algorithm then minimizes the costs at which abatement is provided. Users can adjust assumptions for the key parameters of the Market Stability Reserve including start date, absorbed volume, injection/ejection rate, fixed or variable reserve ejections, and others. The model comes pre-configured with several key sets of MSR parameters as per official proposals, and users can save their combination of settings for later use. The model differentiates between operational abatement (such as fuel switching), which can be scaled down if prices fall below levels incentivizing its use, and permanent abatement (like investment-driven decisions) which, once implemented adjust the emissions trajectory.
Representation of foresight	Base case (default) assumes one full year of foresight and five ‘decay years’ of declining foresight. Optional: users can adjust the number of years of full and declining foresight.
Representation of non-compliance trading (NCT)	Assumes ‘speculative’ demand of 90 million EUAs per year.
Representation of market imperfections	Not represented

Philosophy regarding level of detail	We aim to keep the model concise and easy to use (run-time within a few minutes in Excel, assumptions and inputs updated biannually). The output of annual average prices is intended to give a sense of the EU ETS' long-term trajectory based on market balance, rather than to follow weekly or monthly price fluctuations. The adjustable parameters intend to give users an idea of how different variables might affect the EU ETS price trajectory to 2030.

EUA prices in default "Green Deal/FF55 COM" scenario

Short description of scenario	• Base case: Reform of the ETS according to FF55 COM proposal • REPowerEU according to Council of the European Union position

	2025	2026	2027	2028	2029	2030
EUA price [€/t]	105.75	118.53	122.07	123.57	131.68	147.22

Please provide base year and type of prices	• Base year: 2021 • Type: nominal [X] real [ ]

Note: For the workshop we will harmonize price data to EUR_{2022} using [Eurostat inflation rates EU 27]() (avg. of monthly reported figures).

	Average of inflation rate %	2015 real
2015	0.12	1.001167
2016	0.19	1.003086
2017	1.56	1.018717
2018	1.79	1.036969
2019	1.43	1.051746
2020	0.68	1.058933
2021	2.91	1.08973
2022	8.54	1.182841

Relevant price drivers

Please select the three most important drivers for prices in 2025, and in 2030. For the 2030 prices, please also provide the sensitivity range for the selected most important drivers.

	2025	2030	Range [EUR/t]
Policy parameters (excluding LRF adjustment) MSR thresholds, MSR withdrawal rate, MSR cancellations, Timing of supply (auctions, allocation, supply), Type of supply - allocation vs. auction, Use of revenues	☒	☒	+/- 15
Power sector Renewable targets, Power demand, Fuel prices, Coal/Fossil phase-out policies, Cost of new capacities, Grid costs and constraints, Expansion constraints/bottlenecks	☒	☒	+/- 10
Industry Abatement costs (Cost of substitute fuels, Costs of CO2, Technological learning), Industrial growth/deindustrialisation, Short-term demand response, Carbon contracts for difference	☐	☐	
New sectors and international transport Costs of substitute fuels, Short-term demand response, Behavioural trends (Flight shame, regionalisation)	☐	☐	
Behaviour Power sector hedging, Industry hedging/banking, Financial market participants, Speculation (Compliance player and financial player), Investment behaviour (e.g. adoption speed)	☒	☒	+/- 5
External Political signalling, Monetary policy (EUA as inflation hedge), Interest rates slowing down investments, Global climate negotiations (e.g., Article 6), Cost of carbon removals or offsets, Geopolitical risks and opportunities	☐	☐	

Please proved a short explanation for your choice of the most important drivers, focussing on the changes between 2025 and 2030.

Policy parameters: This encapsulates several important price-driving variables. On the supply-side, the linear reduction factor will determine the overall supply in the market to 2030, which will also be affected by the MSR. Given that our model expects an undersupplied market balance towards 2030, this balance will likely have a large bearing on the price. Furthermore, the timing of supply will also shape the price trajectory throughout the decade. For example, the reshuffling of allowance supply as set out in the REPowerEU plans yields a 2030 average price 136EUR/t in our most bearish scenario (European Commission proposal), compared to 166EUR/t in the most bullish, Parliament plan scenario.

Power sector: The power sector has a large impact on EUA prices for 2025 and 2030 on the demand side, because it makes up the largest share of emissions in the EU ETS, the least free allocation, and the most available abatement options (which is the price-setting mechanism in MSRM). Our marginal abatement cost curve shows a large amount of renewable capacity coming online gradually between 2025 and 2030, which impacts the prices in both years.

Behaviour: Hedging is also an important component of our model. So far, we have seen utilities/power sector players taking part in EUA hedging, and expect this to be increasingly adopted by industrials in the latter half of the decade as their free allocation starts to get phased out.

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Questionnaire ETS workshop

Responding organisation	**Centre for Climate and Energy Analyses (CAKE/KOBiZE)**

Model fact sheet

Model (suite) name	**CREAM** & **CarbonPIE** – Carbon Regulation Emission Assessment Model (CGE model) & Carbon Policy Implementation Evaluation Tool (EU ETS simulation model)
Short description	For the analysis of changes in the EU ETS and the economy we applied two models: *Carbon Policy Implementation Evaluation Tool (CarbonPIE)* – is a EU ETS simulation model, which map the supply of emission allowances, while keeping the details related to the functioning of the EU ETS induding MSR and finds balance between the supply and demand for allowances. The demand for allowances is set for specific hedging needs, which are determined by the market position of EU ETS participants. Demand reflects the behaviour of market participants who receive part of allocation free of charge and who can also buy, sell or bank emission allowances, depending on their market position and needs. Model estimates the level of required emissions reduction, surplus of allowances and final auction pool after MSR. The information on the resulting emissions is then transferred to the Computable General Equilibrium (CGE) Carbon Regulation Emission Assessment Model (CREAM). *Carbon Regulation Emission Assessment Model (CREAM)* – is the global, multi-sector Computable General Equilibrium (CGE). The model distinguishes 16 regions (including EU-27 region and rest of the world), 31 sectors (including energy-intensive sectors), of which 10 include sectors belonging to the EU ETS, such as: oil refining (oil), ferrous metals production (fem), non-ferrous metals production (nem), chemical industry (che), paper production (pap), non-metallic mineral industry (nmm), aviation (air), electricity production (based on fuels: carbon (cof), oil (oil), gas (gas)). The model also distinguishes 8 electricity production technologies, including 4 renewable energy technologies and generation based on nuclear fuels, and three electricity production technologies based on fossil fuels. Additionally, the model distinguishes detailed data on GHG emissions like CO_2 emissions from combustion by fuel types: coal, oil products and gas, as well as process emissions, like N_2O (nitrous oxide), CH_4 (methane) and F-gases (fluorinated gases). The CREAM database is built

	on the basis of input-output (IO) tables, published by Joint Research Centre, (Baseline GECO). The CREAM model endogenously determines the marginal cost of GHG emission reduction.
Representation of foresight	Limited foresight
Representation of non-compliance trading (NCT)	Default: Not represented Optional: Indirectly represented (due to the high price of the EUA, offsets can be enabled)
Representation of market imperfections	Not represented (benchmark approach)
Philosophy regarding level of detail	A distinguishing feature of the tools box give us possibility to model climate policies in a broad perspective, including: Emissions trading schemes for GHG gases and the price of emission permits. Carbon border adjustment mechanism in the EU and the impact of the gradual decrease of free allocation of emission allowances, and others posible change in climate polices and its influence on ETS price.

EUA prices in default "Green Deal/FF55 COM" scenario

Short description of scenario	• „Fit for 55" – In this scenario the future EU ETS legislation is taken into account – planned EU ETS Directive and MSR decision amendment in line with the „Fit for 55" package. The supply of emission allowances reflects reduction target in the EU ETS equal 61% in 2030 vs. 2005 (with marine sector extension). In addition the scenario assumes "one off reduction of the cap", MSR parameters are changing, and others. Beside the simulations takes into account climate-related policies such as CBAM and linked with CBAM phasing out of free allocation, inclusion of maritime in the EU ETS, an additional ETS for housing and transport in the EU (BRT ETS), as well as higher emission reduction targets for non-ETS sectors.

	2025	**2030**
EUA price [€/t]	85	149

Please provide base year and type of prices	- Base year: 2020 for CarbonPIE and for CREAM the I/O tables are prepared separately for the 2025, 2030 by JRC EC on the bases of GTAP 10 (base year is 2014) and external PRIMES 2020 projections. - Type: nominal [] real [X]

Note: For the workshop we will harmonize price data to EUR_{2022} using [*Eurostat inflation rates EU 27*]() *(avg. of monthly reported figures).*

	Average of inflation rate %	**2015 real**
2015	0.12	1.001167
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Relevant price drivers

Please select the <u>three most important drivers</u> for prices in 2025, and in 2030. For the 2030 prices, please also provide the sensitivity range for the selected most important drivers.

<table>
<tr><th></th><th>2025</th><th>2030</th><th>Range [EUR/t]</th></tr>
<tr><td>Policy parameters (excluding LRF adjustment)
MSR thresholds, MSR withdrawal rate, MSR cancellations, Timing of supply (auctions, allocation, supply), Type of supply - allocation vs. auction, Use of revenues</td><td>☒</td><td>☒</td><td>
<table>
<tr><th>MSR scen.</th><th>2025</th><th>2030</th></tr>
<tr><td>without MSR</td><td>37</td><td>107</td></tr>
<tr><td>12 intake rate</td><td>63</td><td>143</td></tr>
<tr><td>fit for 55</td><td>85</td><td>149</td></tr>
<tr><td>no rebasing</td><td>66</td><td>156</td></tr>
<tr><td>dynamic MSR</td><td>67</td><td>184</td></tr>
<tr><td>upper threshold</td><td>89</td><td>271</td></tr>
</table>
</td></tr>
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<table>
<tr><td>Power sector
Renewable targets, Power demand, Fuel prices, Coal/Fossil phase-out policies, Cost of new capacities, Grid costs and constraints, Expansion constraints/bottlenecks</td><td>☒</td><td>☒</td><td></td></tr>
<tr><td>Industry
Abatement costs (Cost of substitute fuels, Costs of CO2, Technological learning), Industrial growth/deindustrialisation, Short-term demand response, Carbon contracts for difference</td><td>☐</td><td>☐</td><td></td></tr>
<tr><td>New sectors and international transport
Costs of substitute fuels, Short-term demand response, Behavioural trends (Flight shame, regionalisation)</td><td>☐</td><td>☐</td><td></td></tr>
<tr><td>Behaviour
Power sector hedging, Industry hedging/banking, Financial market participants, Speculation (Compliance player and financial player), Investment behaviour (e.g. adoption speed)</td><td>☒</td><td>☒</td><td><table><tr><th>Hedging/banking</th><th>2025</th><th>2030</th></tr><tr><td>fit for 55 high</td><td>111</td><td>216</td></tr><tr><td>fit for 55 low</td><td>47</td><td>121</td></tr><tr><td>fit for 55</td><td>85</td><td>149</td></tr></table></td></tr>
<tr><td>External
Political signalling, Monetary policy (EUA as inflation hedge), Interest rates slowing down investments, Global climate negotiations (e.g., Article 6), Cost of carbon removals or offsets, Geopolitical risks and opportunities</td><td>☐</td><td>☐</td><td></td></tr>
</table>

Please proved a short explanation for your choice of the most important drivers, focussing on the changes between 2025 and 2030.

1. Extension of the current MSR 24% intake rate until 2030 would result in a much faster tightening of supply by increasing EUA transfers to MSR and accelerating emissions reduction by 2025. This combined with a strengthened LRF and one-off reduction of the cap in 2024 would imply an extremely tight supply in 2025 which could result in a higher EUA price in 2025. However, when the surplus is between the new thresholds introduced in the Fit for 55 package (1096-833 million), the intake rate drops below 24% easing the path of EUA price increases until 2030. CAKE analysis shows that the change of the upper MSR threshold is of great importance for the results. Lowering e.g. this upper threshold from 833 to 600 million could result in achieving the highest level of emission reduction in all scenarios but at the expense of fewer allowances available at auction pool, more allowances to be invalidated in the MSR and extremely high EUA prices (almost EUR 270 in 2030).

2. A wide range of unforeseen external events can have implications on MSR and EU ETS functioning (also on EUA prices). This could include unexpected changes in economic activity, fuel or low-carbon technology costs or the additional climate and energy policies used in the EU or on Member States level to help reach the EU ETS targets (so called overlapping climate policies). The above elements

could change demand for allowances and have a big impact on TNAC and additional transfers to/from MSR and consequently on EUA prices.

3. Energy producers are the largest group of entities in the EU ETS, as they generate around 50% of the emissions in the EU ETS. As the only sector in the EU ETS, the energy sector does not receive allowances for free and 100% of emissions must be surrender by allowances purchased in the market. That is why, since the beginning of the EU ETS, utilities have been the most active market players. Moreover energy producers may buy allowances up to 4 years within the "hedging needs". Taking this into consideration changing pattern and strategy in hedging behaviour would have a big impact on prices.

4. Industry sectors typically use saved allowances from previous years to surrender current emission (e.g. banking EUA to the next year) or to borrow allowances from future allocation and surrender current emissions. As a result, the trading channel is not fully utilised - some gains from trade are not realised and freely allocated allowances are not available to other traders. This may change soon as a free allocation phase-out (eg. CBAM sectors) and rising EUA price levels will call for more trading proactivity and larger hedging needs.

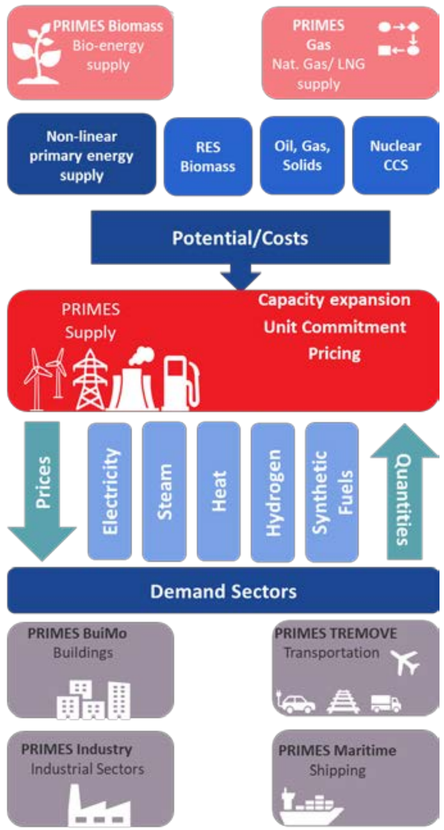
5. Long-term speculators (e.g. pension funds that invest for a very long period of 10-15 years) theoretically can buy most of the allowances from the market and keep them in their accounts for the long term period having a big imact on EUA prices. This could also have an impact on future tightening of EUA's supply. The problem could be also a growing market activity of ETFs which are opened to individual investors. Theoretically, later it may turn into the so-called „buying mania" and lead to the formation of a price bubble, which (as history shows) most often "bursts" with the participation of individual investors.

Questionnaire ETS workshop

Responding organisation	**E3Modelling**

Model fact sheet

Model (suite) name	PRIMES
Short description	The PRIMES (Price-Induced Market Equilibrium System) is a large-scale applied energy system model that provides detailed projections of energy demand, supply, prices and investment to the future, covering the entire energy system including emissions. The distinctive feature of PRIMES is the combination of behavioural modelling (following a micro-economic foundation) with engineering aspects, covering all energy sectors and markets. The model has a detailed representation of policy instruments related to energy markets and climate, including market drivers, standards, and targets by sector or overall (over the entire system). It handles multiple policy objectives, such as GHG emission

	reductions, energy efficiency and renewable energy targets, and also provides a pan-European simulation of internal markets for electricity and gas. PRIMES offers the possibility of handling market distortions, barriers to rational decisions, behaviours, as well as and market coordination issues and includes a complete accounting of costs (CAPEX and OPEX) and investment expenditure on infrastructure needs. PRIMES is designed to analyse complex interactions within the energy system in a multiple agent – multiple markets framework. Decisions by agents are formulated based on a microeconomic foundation (utility maximization, cost minimization and market equilibrium) embedding engineering constraints, behavioural elements and an explicit representation of technologies and vintages and optionally perfect or imperfect foresight for the modelling of investments in all sectors. PRIMES is well-placed to simulate medium and long-term transformations of the energy system (rather than short-term ones) and includes non-linear formulation of potentials by type (resources, sites, acceptability etc.) and technology learning 
Representation of foresight	Depends on module: perfect foresight in two timesteps for power generation and perfect foresight for industry
Representation of non-compliance trading (NCT)	No
Representation of market imperfections	Perceived/Hidden costs are included for decision making processes at various level; however ETS is assumed to be a perfectly functioning market. Actor behaviours represented through

Philosophy regarding level of detail	All energy balance sectors, plus subsectors for industry.

EUA prices in default "Green Deal/FF55 COM" scenario

Short description of scenario	• Latest publicly available scenario with ETS price formulation is the scenarios underlying the Fit for 55 impact assessments; the scenarios includes proposals for all the Fit for 55 proposals, but not the high fuel prices or RePower policies and measures.

	2025	**2026**	**2027**	**2028**	**2029**	**2030**
EUA price [€/t]	…	…	…	…	…	…

Scenarios	Carbon price "current" ETS sectors		Carbon price "new" ETS sectors	
	2025	2030	2025	2030
REF2020	27	30	0	0
REG	31	42	0	0
MIX	35	48	35	48
MIX-CP	35	52	53	80

Source: EC Impact Assessment for ETS Directive (SWD(2021) 601 final), Table 36

Please provide base year and type of prices	• Base year: 2015 • Type: nominal [x] real […]

Note: For the workshop we will harmonize price data to EUR_{2022} using Eurostat inflation rates EU 27 (avg. of monthly reported figures).

	Average of inflation rate %	2015 real
2015	0.12	1.001167
2016	0.19	1.003086
2017	1.56	1.018717
2018	1.79	1.036969
2019	1.43	1.051746
2020	0.68	1.058933
2021	2.91	1.08973
2022	8.54	1.182841

Relevant price drivers

Please select the three most important drivers for prices in 2025, and in 2030. For the 2030 prices, please also provide the sensitivity range for the selected most important drivers.

	2025	2030	Range [EUR/t]
Policy parameters (excluding LRF adjustment) MSR thresholds, MSR withdrawal rate, MSR cancellations, Timing of supply (auctions, allocation, supply), Type of supply - allocation vs. auction, Use of revenues	☒	☒	+/- …
Power sector Renewable targets, Power demand, Fuel prices, Coal/Fossil phase-out policies, Cost of new capacities, Grid costs and constraints, Expansion constraints/bottlenecks	☒	☒	
Industry Abatement costs (Cost of substitute fuels, Costs of CO2, Technological learning), Industrial growth/deindustrialisation, Short-term demand response, Carbon contracts for difference	☐	☒	
New sectors and international transport Costs of substitute fuels, Short-term demand response, Behavioural trends (Flight shame, regionalisation)	☐	☐	

Behaviour Power sector hedging, Industry hedging/banking, Financial market participants, Speculation (Compliance player and financial player), Investment behaviour (e.g. adoption speed)	☒	☐	
External Political signalling, Monetary policy (EUA as inflation hedge), Interest rates slowing down investments, Global climate negotiations (e.g., Article 6), Cost of carbon removals or offsets, Geopolitical risks and opportunities	☐	☐	

Please proved a short explanation for your choice of the most important drivers, focussing on the changes between 2025 and 2030.

Crucial in longer term scenario projections as considered in PRIMES are the underlying policies

Questionnaire ETS workshop

Responding organisation	Enerdata

Model fact sheet

Model (suite) name	POLES-Enerdata (Enerdata's version of the POLES model)
Short description	The POLES-Enerdata model is originally an energy system model, which enable to derive endogenous full energy balances for contrasted scenarios, up to 2050. It has been complemented by a module enabling to model the EU ETS market. POLES[1] (Prospective Outlook on Long-term Energy Systems) is a recognized multi-issue, partial equilibrium energy model that relies on national energy balances combined with economic, policy and technological scenarios to withdraw energy production, consumption and greenhouse gas (GHG) emission projections up to 2050, with yearly results. POLES-Enerdata covers the world energy systems, with details for individual countries or regions. Each EU27 Member State is modelled individually. Its EU ETS market modelling methodology enables to project the EU ETS price based on allowances supply and demand equilibrium. The module relies on: • endogenous variables characterizing the state of the market (e.g. allowances in circulation, allowances in circulation as perceived by the MSR criteria, allowances banked by industrials, allowances hedged by utilities, MSR stock, etc.) • an optimization process, enabling to compute through multiple runs of the model, the CO_2 price leading to a supply-demand equilibrium for allowances, on a yearly basis. The optimization process works as follows. For each year between 2021 and 2050, iteratively, a rolling carbon budget period is defined on which the supply-demand equilibrium for allowances will need to be respected. The horizon of this

[1] The POLES model has been initially developed by IEPE (Institute for Economics and Energy Policy), now GAEL lab (Grenoble Applied Economics Lab).

	period can be chosen between 3 to 10 years, and corresponds to the represented period of anticipation of agents. On each rolling budget period, the carbon price is calculated using an optimization method and impacts the ETS emissions in order to comply with a constrained budget. The budget to comply with is composed of several components: the cumulated ETS cap on the period, the effect of the MSR anticipated over this period (whether allowances will be removed or added to the market), the surplus of allowances available on the market at the initial year. The methodology also models the impact of banking and hedging of allowances. Sensitivities can be done on several assumptions or parameters of the methodology, including for instance the cap, the parameters of the MSR, etc.
Representation of foresight	Limited foresight by actors, with an adjustable anticipation period
Representation of non-compliance trading (NCT)	Represented using an exogenous additional EUA demand, including EUA banked by industrials and financial actors. Hedging by power utilities is also represented as an endogenous additional demand, relying on simple exogenous assumptions of hedge ratios.
Representation of market imperfections	Some imperfections represented: banked EUA from industrials & financial actors, limited anticipation of actors (rolling compliance period). The model assumes no political interventions on price.
Philosophy regarding level of detail	The focus of the model is to capture structural trends, with a price calculated at a yearly basis, up to 2040 and beyond. The methodology relies on an actual energy system model, enabling to endogenously capture interactions between various objectives, including interactions with sectors outside the ETS (RES, EE, ESR objectives for instance). The representation of precise market behaviours is however less developed that what exists in more trading-type of models. There is no infra-annual resolution. For each country, the model includes a description at sectoral level, with more detailed description in power sector where over 20 technologies are explicitly modelled.

EUA prices in default "Green Deal/FF55 COM" scenario

Short description of scenario	Scenario with ETS and ESR targets from the FF55 package, but RES and EE targets not strictly implemented. MSR design as proposed by the COM.

	2025	2026	2027	2028	2029	2030
EUA price [€/t]	56	73	92	113	136	160

Please provide base year and type of prices	• Base year: 2021 • Type: nominal [ ] real [X]

Note: For the workshop we will harmonize price data to EUR$_{2022}$ using Eurostat inflation rates EU 27 (avg. of monthly reported figures).

	Average of inflation rate %	2015 real
2015	0.12	1.001167
2016	0.19	1.003086
2017	1.56	1.018717
2018	1.79	1.036969
2019	1.43	1.051746
2020	0.68	1.058933
2021	2.91	1.08973
2022	8.54	1.182841

Relevant price drivers

Please select the <u>three most important drivers</u> for prices in 2025, and in 2030. For the 2030 prices, please also provide the sensitivity range for the selected most important drivers.

	2025	2030	Range [EUR/t]
Policy parameters (excluding LRF adjustment) MSR thresholds, MSR withdrawal rate, MSR cancellations, Timing of supply (auctions, allocation, supply), Type of supply - allocation vs. auction, Use of revenues	☒	☒	+60€ in 2030 with more constrained MSR design vs ref
Power sector Renewable targets, Power demand, Fuel prices, Coal/Fossil phase-out policies, Cost of new capacities, Grid costs and constraints, Expansion constraints/bottlenecks	☒	☒	-100€ in 2030 due to RES & EE targets vs ref (with integrated approach)
Industry Abatement costs (Cost of substitute fuels, Costs of CO2, Technological learning), Industrial growth/deindustrialisation, Short-term demand response, Carbon contracts for difference	☐	☐	
New sectors and international transport Costs of substitute fuels, Short-term demand response, Behavioural trends (Flight shame, regionalisation)	☐	☐	
Behaviour Power sector hedging, Industry hedging/banking, Financial market participants, Speculation (Compliance player and financial player), Investment behaviour (e.g. adoption speed)	☒	☒	Reinjection of banked EUAs +/- 50€ in 2025 +/- 40€ in 2030
External Political signalling, Monetary policy (EUA as inflation hedge), Interest rates slowing down investments, Global climate negotiations (e.g., Article 6), Cost of carbon removals or offsets, Geopolitical risks and opportunities	☐	☐	

Please proved a short explanation for your choice of the most important drivers, focussing on the changes between 2025 and 2030.

Design of the MSR is a substantial driver of the EU ETS price
With different designs, e.g. as proposed by the EU Parliament, the price could end up around 60€/t higher in 2030 than in the reference case, with the same cap.
The MSR would indeed absorb much more allowances after 2024, leading to a significantly higher price since the start of the projection period (due to anticipation of actors) and sustaining this higher price up to 2030.

Interactions of ETS reduction objective with RES and EE targets
Assuming full implementation of the RES and EE objectives (i.e. that the Member States do what it takes to achieve these) can significantly impact the price, with up to -100€/t in 2030 compared to the reference case. In such a case, the emission reductions would first be mostly driven by national measures to support RES, leading the price to drop (vs reference). This results is obtained by implementing all objectives as part of our full energy system model, accounting for interactions between all sectors (i.e. not only power and industry).

Behavioural aspects can also significantly impact the price
To illustrate this point, we performed a sensitivity analysis comparing a case where industrials would keep their stock of banked allowances up to 2030, vs. a case where they would progressively use it by then. We obtain differences of about +50€/t in 2025 and -40€/t in 2030 between the cases. This example is rather illustrative, as the dates of utilisation of banked EUAs were rather exogenous, but it still illustrates the role that behaviour could play in determining the price.

Questionnaire ETS workshop

Responding organisation	**ICIS – (Independent Commodity Intelligence Services)**

Model fact sheet

Model (suite) name	**ICIS Agent-Based Carbon Model**
Short description	The ICIS EU ETS Carbon Model is an **agent-based fundamental model** that includes a detailed representation of allowance supply and demand in the EU ETS and the EU power sector. The model iterates from quarter to quarter which allows it to reflect different behavioural strategies and the impact of the Market Stability Reserve. The model in the short-term creates a supply and demand equilibrium based on short-term emission reduction potentials (fuel switching), price dependent hedging and banking and future price expectations of market participants. In the long-term the model endogenously determines price-driven industrial abatement and power sector investments. The power sector is reflected by the fully integrated ICIS *Power Horizon Model* which is linear dispatch optimisation and iterative investment simulation. The model considers fuel costs, capacity, and interconnector constraints, investment-, financing- and operating costs, lifetime, load factor assumptions, investor hurdle rates and natural resources. ICIS power modelling can capture the relationship between policies, technology costs and demand developments, with internally consistent scenarios reflecting different pathways for the European power sector out to 2050. The model is constantly adjusted to new market realities and assumptions and scenarios are updated on a monthly basis
Representation of foresight	Limited foresight depending on agent 0-10 years.
Representation of non-compliance trading (NCT)	We can represent NCT by either modelling them as a form of static demand or as an agent with limited foresight that looks at a BAU market balance and long-term abatement costs for a given horizon to form a “fair value” for the present that impacts buying and selling patterns.

Representation of market imperfections	Limited short-term abatement in a world of static banking by industrial players, buy-and hold strategies of NCT, representation of "hedge books"
Philosophy regarding level of detail	The model is used to forecast price developments in the mid-term (10 quarters) on a quarterly basis and on a yearly basis in the long-term for a given horizon. We aim for a maximum degree of granularity on the **supply side** to be able to interpret and reflect political adjustments in the short-term (e.g. delayed free allocation, frontloading, MSR adjustments). This includes allocation by sector and country, supply by source and member state. This enables to forecast the timing of supply more accurately. For emission, the degree of detail depends on the relevance and data availability. The full integration with our power team allows for a detailed bottom-up representation of the power sector on plant level and a sophisticated modelling of dispatch and investments. For the industry sector we predict emission on a NACE code and country level. New sectors and rules can be easily added with a top-down approach (e.g. Maritime integration) Behavioural assumptions for the power sector are taken on a regional basis, for the remaining actors on a sectoral level.

EUA prices in default "Green Deal/FF55 COM" scenario

Short description of scenario	• ETS cap as proposed by FF55 EU Com, REPowerEU reflected by a frontloading of 250m allowances, Renewable buildout reflects initial FF55 targets, Maritime included

	2025	**2026**	**2027**	**2028**	**2029**	**2030**
EUA price [€/t]	77.58	81.08	84.29	85.51	82.93	83.54

Please provide base year and type of prices	• Base year: 2022 • Type: nominal [] real [x]

Note: For the workshop we will harmonize price data to EUR_{2022} using Eurostat inflation rates EU 27 (avg. of monthly reported figures).

	Average of inflation rate %	**2015 real**
2015	0.12	1.001167
2016	0.19	1.003086
2017	1.56	1.018717
2018	1.79	1.036969
2019	1.43	1.051746
2020	0.68	1.058933
2021	2.91	1.08973
2022	8.54	1.182841

Relevant price drivers

Please select the three most important drivers for prices in 2025, and in 2030. For the 2030 prices, please also provide the sensitivity range for the selected most important drivers.

	2025	**2030**	**Range [EUR/t]**
Policy parameters (excluding LRF adjustment) MSR thresholds, MSR withdrawal rate, MSR cancellations, Timing of supply (auctions, allocation, supply), Type of supply - allocation vs. auction, Use of revenues	☒	☒	+/-34€
Power sector Renewable targets, Power demand, Fuel prices, Coal/Fossil phase-out policies, Cost of new capacities, Grid costs and constraints, Expansion constraints/bottlenecks	☒	☒	+/-38€
Industry Abatement costs (Cost of substitute fuels, Costs of CO2, Technological learning), Industrial growth/deindustrialisation, Short-term demand response, Carbon contracts for difference	☐	☒	+/- 25€ LT
New sectors and international transport Costs of substitute fuels, Short-term demand response, Behavioural trends (Flight shame, regionalisation)	☐	☐	+/-10 LT

Behaviour Power sector hedging, Industry hedging/banking, Financial market participants, Speculation (Compliance player and financial player), Investment behaviour (e.g. adoption speed)	☒	☐	+/- 11 ST
External Political signalling, Monetary policy (EUA as inflation hedge), Interest rates slowing down investments, Global climate negotiations (e.g., Article 6), Cost of carbon removals or offsets, Geopolitical risks and opportunities	☐	☐	+/-

Please proved a short explanation for your choice of the most important drivers, focussing on the changes between 2025 and 2030.

Short-term drivers

Power sector is currently unable to deliver short-term emission reduction at economic costs due to extremely high gas prices. This leads to a fast depletion of surplus in the market and a situation where the supply is not enough to meet the markets inflexible hedging demand which could lead to rapidly rising prices. While the policy response of frontloading allowances provides the market with more flexibility to continue with business-as-usual hedging without skyrocketing prices, this could also be enabled by a change in behaviour.

The political discussion around a linearly declining MSR upper threshold increases our forecasted prices significantly by on average €34/tCO2e between 2023-2030 with an immediate effect before entry into force.

Long-term driver:

The ETS cap trajectory (FF55) will require a very fast and deep decarbonisation of the power sector. This is achieved by a significant phase-down of coal and lignite capacities in Europe as well as market driven fuel switching. If coal phase-out policies are dropped in the light of the ongoing energy crisis and further gas prices stabilize on significantly higher levels, we see the cheapest form of abatement shifting to the RHS of the merit order and predicted EUA price to be on average €38/tCO2e higher.

This upside risk should also be considered in a scenario where the expansion of renewables falls short of the initial 40% target by the European Commission which implies an extremely ambitious build-out trajectory and electrification of transport and buildings further outpaces RES capacity buildout

The inclusion of Maritime adds around €10/tCO2e to our long-term forecasts as the sector has limited economic abatement potential towards 2030. Higher abatement cost assumption for industry or the unavailability of certain technologies such as a wide application of CCS in the cement industry provide further upside risk to our forecast.

Questionnaire ETS workshop

Responding organisation	**Potsdam Institute for Climate Impact Research (PIK)**

Model fact sheet

Model (suite) name	LIMES-EU
Short description	LIMES-EU is a linear dynamic cost-optimization model with a focus on the electricity sector. It simultaneously optimizes investment and dispatch decisions for generation, storage and transmission technologies in five-year time steps from 2010 to 2070. Each year is modelled using six representative days, comprising eight blocks of three hours. The representative days are estimated using a clustering algorithm, which enables the short-term variability of supply (namely, wind and solar) and demand to be captured. The model covers 32 generation and storage technologies, including different vintages for lignite, hard coal and gas. The energy-intensive industry is also covered and represented by a step-wise linear marginal abatement cost curve for each country. The EU ETS is implemented in line with the recent 2018 reform, including the MSR and cancellation of allowances. Additional overlapping policies that influence prices by reducing the demand for allowances (coal phase-out and RE measures at the EU member state level) are also considered in the model. A comprehensive description of the LIMES-EU model, including parameters, equations and assumptions, is provided in the documentation available from the model's website: https://www.pik-potsdam.de/en/institute/departments/transformation-pathways/models/limes
Representation of foresight	Default: Perfect foresight (benchmark approach) Optional: limited foresight
Representation of non-compliance trading (NCT)	Default: Not represented Optional: Indirectly represented (additional demand/supply, simulation mode)
Representation of market imperfections	Not represented (benchmark approach)

Philosophy regarding level of detail	In general, we aim for a suitable trade-off between high detail and model complexity (run time). It should not take longer than 6 hours to solve the model (which requires multiple iteration because of the MSR). With regard to detail, we prioritize inclusion of aspects/features according to their expected impact on EUA prices. We belief there is a risk of “over-calibration” especially for long term analysis, which is the main focus.

EUA prices in default “Green Deal/FF55 COM” scenario

Short description of scenario	• Reform of ETS according to FF55 COM proposal • REPowerEU not considered

	2025	2026	2027	2028	2029	2030
EUA price [€/t]	94	99	104	109	114	120

Please provide base year and type of prices	• Base year: 2015 • Type: nominal [ ] real [x]

Note: For the workshop we will harmonize price data to EUR$_{2022}$ using Eurostat inflation rates EU 27 (avg. of monthly reported figures).

	Average of inflation rate %	2015 real
2015	0.12	1.001167
2016	0.19	1.003086
2017	1.56	1.018717
2018	1.79	1.036969
2019	1.43	1.051746
2020	0.68	1.058933
2021	2.91	1.08973
2022	8.54	1.182841

Relevant price drivers

Please select the <u>three most important drivers</u> for prices in 2025, and in 2030. For the 2030 prices, please also provide the sensitivity range for the selected most important drivers.

	2025	2030	Range [EUR/t]
Policy parameters (excluding LRF adjustment) MSR thresholds, MSR withdrawal rate, MSR cancellations, Timing of supply (auctions, allocation, supply), Type of supply - allocation vs. auction, Use of revenues	☒	☒	Rebase timing +/- 0 More auctions +1
Power sector Renewable targets, Power demand, Fuel prices, Coal/Fossil phase-out policies, Cost of new capacities, Grid costs and constraints, Expansion constraints/bottlenecks	☒	☒	Fuel prices +9/-5 No CCS +25 CoC RES +4/-4 No transmission expansion -2
Industry Abatement costs (Cost of substitute fuels, Costs of CO2, Technological learning), Industrial growth/deindustrialisation, Short-term demand response, Carbon contracts for difference	☐	☐	
New sectors and international transport Costs of substitute fuels, Short-term demand response, Behavioural trends (Flight shame, regionalisation)	☐	☐	
Behaviour Power sector hedging, Industry hedging/banking, Financial market participants, Speculation (Compliance player and financial player), Investment behaviour (e.g. adoption speed)	☐	☐	
External Political signalling, Monetary policy (EUA as inflation hedge), Interest rates slowing down investments, Global climate negotiations (e.g., Article 6), Cost of carbon removals or offsets, Geopolitical risks and opportunities	☒	☒	Discount rate +10/-30

Please proved a short explanation for your choice of the most important drivers, focussing on the changes between 2025 and 2030.

The most important driver remains the discount rate. Since allowance banking is a provision to reduce costs in the future, firms bank less if they discount at a higher rate. Put differently, if firms have a higher discount rate they put a lower weight on the future and thus bank less. A lower bank in turn implies that fewer allowances go into the MSR and therefore also cancellations are lower. Another important driver is the fuel price. We only evaluated variations in gas prices and focused on higher gas prices. In the most extreme case we assume a gas price (wo transport costs) 5 times as high as in the reference scenario (e.g., 132 eur/MWh vs. 30 eur/MWh). This impacts severely gas generation, reinforcing the need for coal. As a result, there are more emissions in the shorter term and thus fewer transfers to the MSR. This leads to an overall higher emissions budget, which leads to lower carbon prices.

Finally, the largest effect occurs when there is no CCS. This is relevant due to the unavailability of BECCS rather than fossil-based CCS. Anticipating the lack of negative emissions in the future that help to offset some remaining emissions, decarbonization increases substantially in the short term. This in turn leads to higher banking and thus to higher cancellations (8.3 $GtCO_2$ compared to 7.7 $GtCO_2$ in the reference scenario) that tighten further the ETS.

Questionnaire ETS workshop

Responding organisation	**Refinitiv**

Model fact sheet

Model (suite) name	Refinitiv EUA price forecasting model
Short description	The EUA price forecasting model is a linear optimization model projecting yearly EU ETS prices to 2030 (2035). It consists of three modules. Module 1 is an econometric model projects future carbon price based on ETS balances forecast. The balances forecasts are based on emissions separately for power and industry (incl. Aviation) sectors and supply forecast for EU ETS including auctioning and free allocation. Market Stability Reserve is modelled in this module too. The second module simulates the interaction between the future EUA price expected by the market and the amount of abatement in the EU ETS. It uses a feedback loop to estimate the impact of abatement on the carbon price and to forecast the future carbon prices and abatement levels, based on in-house marginal abatement cost curves for the power and industry sectors. The third module provides a constraint, which specifies that market participants cannot be short of EUAs for their annual compliance needs. The module simulates the market's reaction to a potential future shortage by calculating companies' abatement assuming they aim to minimise costs. Market participants are assumed to begin to cover shortages by beginning to abate emissions five years in advance. Power sector emissions forecast is based on a least cost dispatch optimization model, which is then used to calculated power sector's EUA demand profile with assumed three-year ahead forward hedging rates. Industry emissions forecast is based on econometric model and in-house analysis of production and CO2 intensity and assumed four-year ahead forward-looking horizon. The model documentation is available in Refinitiv Eikon.
Representation of foresight	Default: limited foresight for 3 to 5 years depending on the sector
Representation of non-compliance trading (NCT)	Default: Not represented

Representation of market imperfections	This is captured via the econometric model based on historic balances, most importantly 'perceived balances' considering market participants' behaviour changes and probabilistic approach of uncertainties regarding ETS policies.
Philosophy regarding level of detail	We aim to use the model to represent actual market conditions and project accurately EUA prices. Hence we maintain relatively frequent updates of the model, on a quarterly basis, to make the assumptions up to date and reflecting realities. A complete update of the forecast including emissions and supply will be conducted in stages and take around 5 hours to run. Our model is also built as scenario simulation tool for some of the inputs. It takes half an hour to run scenarios with various MSR parameters.

EUA prices in default "Green Deal/FF55 COM" scenario

Short description of scenario	• Reform of ETS according to FF55 COM proposal • REPowerEU sales of EUAs considered in base case as of October 2022

	2025	2026	2027	2028	2029	2030
EUA price [€/t]	76	84	96	106	116	127

Please provide base year and type of prices	• Base year: 2021 (actual emissions and prices) • Type: nominal [x] real []

Note: For the workshop we will harmonize price data to EUR_{2022} using Eurostat inflation rates EU 27 (avg. of monthly reported figures).

	Average of inflation rate %	2015 real
2015	0.12	1.001167
2016	0.19	1.003086
2017	1.56	1.018717
2018	1.79	1.036969
2019	1.43	1.051746

2020	0.68	1.058933
2021	2.91	1.08973
2022	8.54	1.182841

Relevant price drivers

Please select the three most important drivers for prices in 2025, and in 2030. For the 2030 prices, please also provide the sensitivity range for the selected most important drivers.

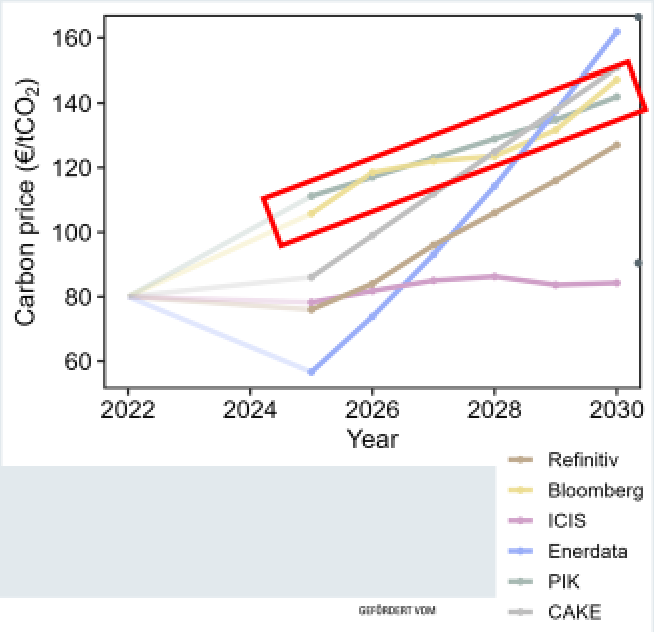
	2025	2030	Range [EUR/t]
Policy parameters (excluding LRF adjustment) MSR thresholds, MSR withdrawal rate, MSR cancellations, Timing of supply (auctions, allocation, supply), Type of supply - allocation vs. auction, Use of revenues	☐	☒	+/-20
Power sector Renewable targets, Power demand, Fuel prices, Coal/Fossil phase-out policies, Cost of new capacities, Grid costs and constraints, Expansion constraints/bottlenecks	☒	☐	+/-15
Industry Abatement costs (Cost of substitute fuels, Costs of CO2, Technological learning), Industrial growth/deindustrialisation, Short-term demand response, Carbon contracts for difference	☐	☒	+/-30
New sectors and international transport Costs of substitute fuels, Short-term demand response, Behavioural trends (Flight shame, regionalisation)	☐	☐	
Behaviour Power sector hedging, Industry hedging/banking, Financial market participants, Speculation (Compliance player and financial player), Investment behaviour (e.g. adoption speed)	☒	☒	+/-20
External Political signalling, Monetary policy (EUA as inflation hedge), Interest rates slowing down investments, Global climate negotiations (e.g., Article 6), Cost of carbon removals or offsets, Geopolitical risks and opportunities	☒	☐	+/-15

Please proved a short explanation for your choice of the most important drivers, focussing on the changes between 2025 and 2030.

Power sector will remain the most active market participant type in next years and their hedging will still play important rule in EUA market prices. In addition, volatilities in financial markets via inflation hedging or geopolitical risks will also affect carbon market prices to some extent. The market stability reserve will function to help to absorb demand-side shocks, such as the demand destruction or faster decline in power sector emissions. After 2025, the declining cap will lead to rather tight balances and industry abatements costs will be price setter. Hence the abatement measures’ adoption speed will be important. Against this backdrop of tight balances, supply-side factors such as MSR parameters and auctioning timing etc. will also be more important price drivers.

Appendix II: Summary slides (for webinar)

WEBINAR „TEAM-SLIDE“: BLOOMBERGNEF



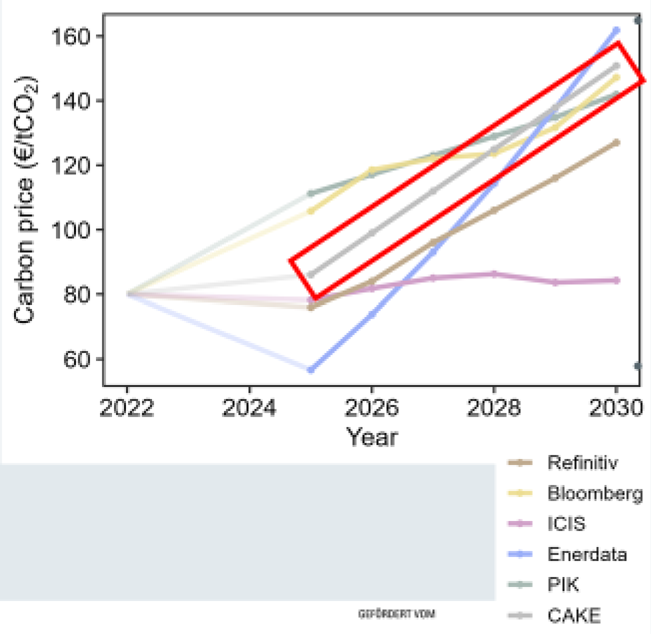
What **drives the price** (in your model) in a nutshell?

- Power and industrial (operational and permanent) abatement costs
- Policy signals of commitment to EU climate ambitions

What are the **main workshop takeaways**?

- It is time to start considering the post-2030 evolution of the EU ETS.
- There is a wide range of disparate behaviors responding to the market, both on the analysis/modelling side but also on the participant hedging, banking, trading and strategy side.

WEBINAR „TEAM-SLIDE“: CAKE/KOBIZE



What **drives the price** (in your model) in a nutshell?

- Climate policy: GHG target, MSR. Extension of the current MSR 24% intake rate until 2030 would result in a much faster tightening of supply.
- Long-term speculators (e.g. pension funds that invest for a very long period of 10-15 years)

What are the **main workshop takeaways**?

- Comparing of different approach to modelling
- Importance of assumptions (policy overlaping; capital cost; market players behavior)

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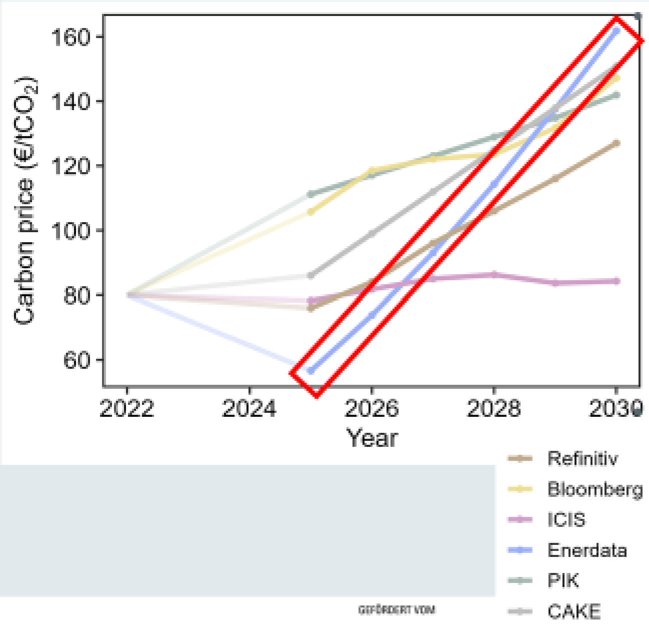
WEBINAR „TEAM-SLIDE“: ENERDATA



What **drives the price** (in your model) in a nutshell?

- Market fundamentals, with power sector playing a main role in the 2025 to 2030 horizon
- Policy parameters, including design of the market (MSR, etc.) and interactions with other policies (e.g. RES, EE targets) & Behaviour of actors, incl. hedging and banking of EUAs

What are the **main workshop takeaways**?

- A lot of approaches not having an integrated view on the energy systems; yet somewhat comparable results.
- Post-2030 issues taking a large place in the discussions, showing a shared need to deal with these in the near future.

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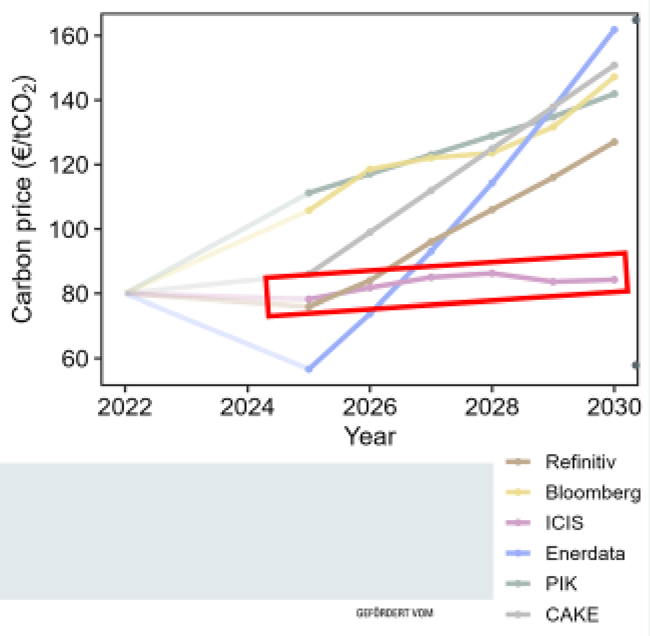
WEBINAR „TEAM-SLIDE“: ICIS



What **drives the price** (in your model) in a nutshell?

- Strong decarbonization of the power sector driven by overlapping policies and CO2 price eases long term balance
- Energy efficiency and long-term abatement in industry is profitable at moderately higher prices

What are the **main workshop takeaways**?

- Model approaches have similarities and differences – assumptions matter
- Market participant behavior and its imperfections needs to be considered

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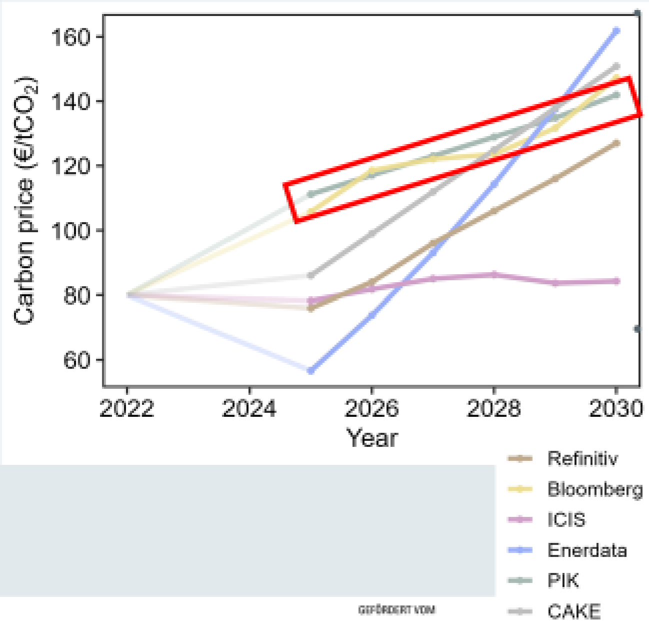
WEBINAR „TEAM-SLIDE“: PIK



What **drives the price** (in your model) in a nutshell?

- Targets (medium and long-term) -> perfect foresight assumption (and full confidence that policy will remain in place)
- Discount rates: strong impact on banking decisions (and thus on MSR operation)

What are the **main workshop takeaways**?

- Perfect foresight is a too strong assumption, but what is the most appropriate time horizon?
- Overlapping policies seem to play a key role in price formation
- Seem clear the ‘required’ price in 2030 but not how to get there (lack of convergence in 2025 prices) -> points to implicit trust in policy

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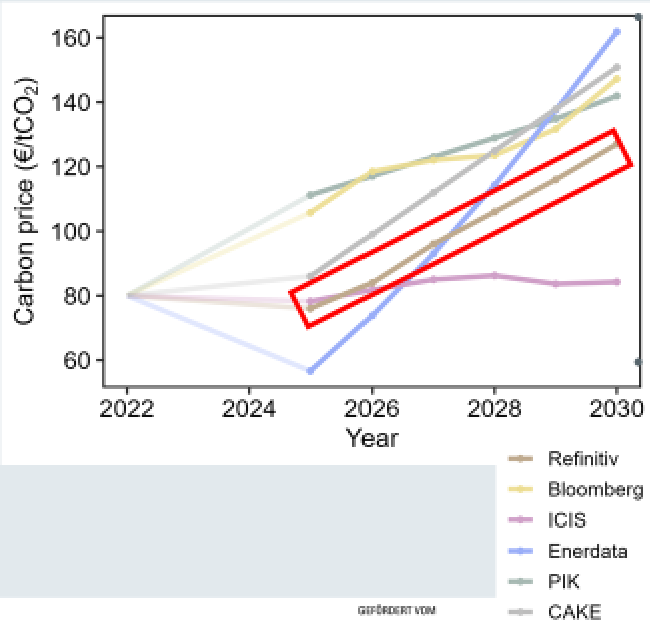
WEBINAR „TEAM-SLIDE“: REFINITIV



What **drives the price** (in your model) in a nutshell?

- EU’s long-term climate goals support ETS prices and confidence among market participants of the scheme
- Industry abatement costs will be the important ETS price-setter going forward with abatement potential declining in the Power sector

What are the **main workshop takeaways**?

- Foresight horizon is a crucial assumption behind the models and need to be taken into consideration when interpreting the various carbon price projections
- How to model the reality that investments might not be made in time (market imperfection)?

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Ariadne's thread through the energy transition: The Kopernikus project Ariadne leads the way in a joint learning process with representatives from politics, business and society, exploring options for shaping the energy transition and providing scientific guidance to policy makers along the pathway towards a climate-neutral Germany.

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More about the Kopernikus projects at kopernikus-projekte.de/en/

Who is Ariadne? In Greek mythology, Ariadne's thread enabled the legendary hero Theseus to safely navigate the labyrinth of the Minotaur. This is the guiding principle of the Ariadne energy transition project, in which a consortium of over 25 partners is providing guidance and orientation for shaping the energy transition through excellent research as a joint learning process between science, politics, business and society.
We are Ariadne:

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