# A look under the emission curve: setting up a net zero scoreboard

## Testing a progress measurement framework on a sample of indicators

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# Summary


### The need for a comprehensive progress check

Achieving a climate neutral society by 2050 is the cornerstone of the European Union's economic strategy, the European Green Deal, and a legal obligation enshrined in the EU Climate Law. The transition to climate neutrality however is an unprecedented and complex socio-economic project that implies significant and well-synched transformation across sectors.

In this decisive decade for climate action, an accurate and comprehensive understanding of progress is of the utmost importance. Article 6.1 of the EU Climate Law therefore requires the Commission to, in regular intervals, assess the collective progress of EU Member States on (a) meeting the climate neutrality target and (b) advancing adaptation, as the impacts of the climate crisis unfold.

Yet, less than six months before of the publication, great uncertainty remains about the approach and scope of the Commission's assessment of EU-wide progress towards climate neutrality. In particular, there is a risk that it will rely *solely* on climate and energy headline indicators – an approach that touches the surface but fails to consider whether the underlying transformative changes and enabling conditions for the transition are on pace in all parts of EU society. In other words, it is likely that crucial insights will be 'missed in the aggregate'.

With the current decade being decisive for putting the EU on track, a less-than-comprehensive first attempt to monitor progress risks failing to identify lack of progress or inappropriate decisions in critical areas in good time, causing hard-to-reverse challenges to the transition at large.

### Objective of this working paper

This report tests an indicator framework concept developed in a past project, which identified sectoral and cross-sectoral fields of action – termed 'net zero elements' – that are crucial to reaching climate neutrality by 2050. In doing so, it also offers a glimpse at areas where developments are currently headed in the right direction or lagging behind, but it is important to note that it does *not* yet provide a comprehensive assessment to communicate if the EU is or is not on track towards climate neutrality, nor does it analyse yet fully the underlying reasons thereof.

Instead, this report aims to complement discussions on what a meaningful indicator set might look like and how it could be utilized to check EU progress towards climate neutrality. In particular, we seek to support the thinking within the Commission and the European Scientific Advisory Board on Climate Change (ESABCC), but also aim to contribute to the discussion within the wider climate planning and monitoring expert community.

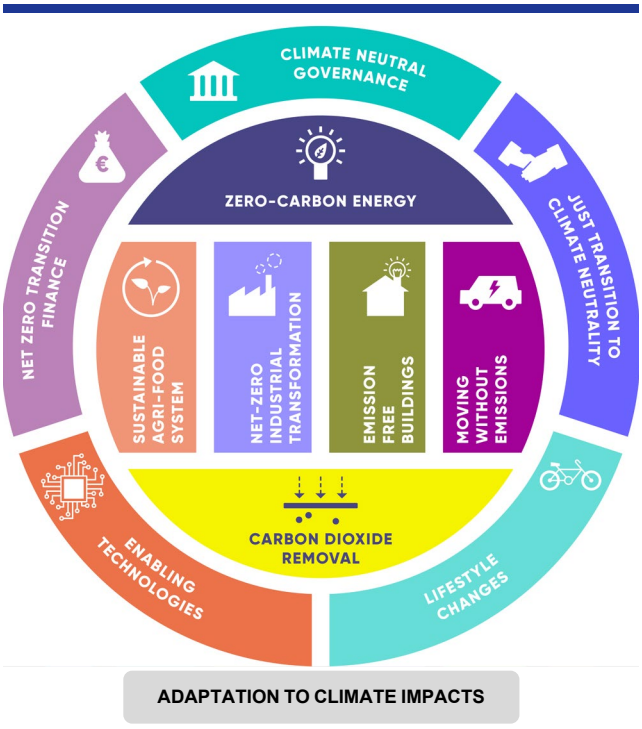
## A framework for an indicator-based progress check

Indicators to measure progress towards climate neutrality must address the often structural, sectoral, and cross-sectoral changes implied by the transition, covering both the economic and social dimensions. To unpack this complexity, in past work in cooperation with IDDRI we developed a framework based on so-called **'net zero elements'** (Velten et al., 2021).

The net zero elements constitute key fields of action categorised into two groups: (1) **sectoral elements** (inner circle in Figure 1) and (2) **horizontal elements** (outer circle in Figure 1).

For each sectoral and horizontal element, we identified headline **objectives** as well as the **enablers** that support the change towards these overarching goals. We then derived indicators for both objectives and enablers, which together can provide a comprehensive picture of the current state of the transition.

**Figure 1: Net zero elements to structure the indicator selection and analysis**




Source: own presentation adapted from Velten et al., 2021.

For the present analysis we added the element on 'Adaptation to climate impacts' to fully reflect the scope of the EU Climate Law. We then tested the proposed methodology, analysing two indicators per element. The selection of indicators to test the concept on was informed by expert opinions collected in a survey and for ease, based also on data availability.

## Checking progress towards climate neutrality

Progress on each indicator was measured by comparing the historic development over a five-year period with what would have been required in the same period to be on track towards a future benchmark where available. We chose benchmarks from current EU laws and strategies, which generally refer to 2050 when the EU must achieve climate neutrality by. Interim benchmarks were considered where deemed useful. To provide a harmonised benchmark set, most of the benchmarks were taken from the impact assessment underlying the EU LTS. However, we must emphasise that the strategy and its impact assessment are somewhat outdated and thus may not fully reflect the rate of progress that is needed.

The ratio between the historical trend and the required change was then used to classify the indicator progress into four categories. Simply put, the best category signifies that an progress on an indicator has developed in line with the required change (●●●●), and the worst category points to indicators that have developed in the wrong direction ( ●○○○ ).

## A first glimpse of EU progress towards climate neutrality

Only among five of the indicators analysed as part of this proof of concept, progress is currently in line with a transition to climate neutrality by 2050. Developments on seven

indicators have been somewhat progressive, and on six remained rather stable. On another six indicators, developments currently go in the wrong direction. Positive change was reported in areas within the *zero carbon energy*, *just transition, governance for climate neutrality*, and *moving without emissions* elements, while the chosen indicators on *zero carbon buildings*, *carbon dioxide removal*, *lifestyle changes* and *technology* showed no progress or even developments in the wrong direction (see Table 1).

However, as mentioned above, this analysis offers only a snapshot. With only two indicators under each element, the insights do not amount to a comprehensive assessment of the EU's progress on the road to net zero.

**Table 1: Indication of progress towards climate neutrality in twelve net zero elements**

| Elements | Indicators | Scoring |
|---|---|---|
| **Zero carbon energy** | Share of renewable energies [% of gross final energy consumption] |  |
| | GHG emission from energy generation [$tCO_2e$] |  |
| **Agri-food system** | GHG emissions of agriculture [$tCO_2e$] |  |
| | Share of organic farming [% of agricultural land] |  |
| **Industrial transformation** | GHG of industrial processes and product use [$tCO_2eq$] |  |
| | Final energy consumption in industry [GJ] |  |
| **Emission-free buildings** | GHG emissions of the building sector [$MtCO_2e$] |  |
| | Final energy consumption in buildings [PJ] |  |
| **Moving without emissions** | GHG emissions from transport [$MtCO_2e$] |  |
| | Share of zero-emission vehicles [% of newly registered cars] |  |
| **Carbon Dioxide Removals** | Natural $CO_2$ removal of different land types [$MtCO_2$] |  |
| | Contributions of GHG reductions and removals to an overall GHG net reduction target [$MtCO_2e$] |  |
| **Net zero transition finance** | Price on carbon (EU ETS carbon price) [$EUR/tCO_2e$] |  |
| | Fossil fuel subsidies [EUR] |  |
| **Enabling technologies** | Government budget allocation to environmental and energy-related R&D [% of total allocation to R&D] |  |
| | Fossil fuel subsidies [EUR] |  |
| **Lifestyle changes** | Average per-person consumption of meat [kcal/capita/day] |  |
| | Modal split in private transport [% of total transport] |  |
| **Just Transition** | Population unable to keep home adequately warm [% of population] |  |
| | Share of housing fuels expenditure [% of households' expenditure] |  |
| **Climate neutral governance** | Member States with climate laws [number of MS] |  |
| | Member States with a dedicated institution for independent scientific advice on climate policy [number of MS] |  |
| **Adaptation to climate impacts** | Share of protected areas [% of total area] |  |
| | Share of naturally regenerating forest [% of total forest] |  |

Source: own presentation

## Key learnings from the application of, and proposed improvements to, the framework

1. *Adjustments may help improve the progress measurement methodology*

Our analysis has touched on several areas in which the COVID-19 pandemic clearly influenced progress. While this influence has mostly been positive from a carbon neutrality perspective, provisional estimates show that these gains have partly rebounded in 2021, and are thus, if at all, only partly an indication for structural change. Our analysis draws the trendline from the first and the last data point, making these two years in history especially influential to the overall outcome. Unusalities in the first or later data point can skew the results. Alternatively, the trendline could include the values for all years. A longer period would likewise smooth outliers, but it would also shift the focus away from the short-term progress.

2. *Objective-level indicators must be complemented with indicators linked to enablers*

Observing enabling indicators ensures that progress in the objective-level indicators is assessed comprehensively. An objective might look promising, but if the transitions underlying beneath the mere emission numbers do not progress, it will stagnate at some point. Likewise, enabling conditions that are on track will drive emission reductions of tomorrow and therefore provide an early indication of future progress. This was confirmed by the expert survey that guided the selection of indicators for this proof of concept. When asked to limit their choice to two indicators, survey participants often selected one that measures an objective and one that measures an enabler. This suggests that the underlying conditions are considered relevant. An assessment of progress should therefore cover objective-level indicators but be complemented by indicators that provide insights on progress with their enablers.

3. *There is need for a review where indicators are broad or overlap*

Indicators can be quite broad, covering not only climate-related data but also non-climate related aspects. For example, the indicator *R&D expenditure* is not exclusive to climate research but can have implication for the transition. In these cases, the indicators might provide a proxy, but it would be more meaningful to extract the climate-related data where such extraction is possible.

Also, indicators can overlap or measure the same thing. While overlapping indicators can be useful to better understand an aspect from different angles, duplication may not always reveal additional insights. More importantly, the inclusion of overlapping indicators may put undue focus on the covered aspect. Thus, we note that where overlapping indicators have been selected, these should be reviewed more closely.

4. *A structured approach is required to identify relevant data collection effort*

Data availability for indicators differed significantly between elements, and we had to conduct additional research and make compromises for data continuity and frequency where reasonable. This highlights the need for a structured gap analysis for each element. Further work should take a structured approach to identify datasets that are deemed most important for tracking progress towards climate neutrality and recommend specific data collection efforts in those areas.

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## Abbreviations

| | |
|---|---|
| **BECCS** | Bioenergy with Carbon Capture and Storage |
| **CAGR** | Compound Annual Growth Rate |
| **CCUS** | Carbon Capture, Usage and Storage |
| **CDR** | Carbon Dioxide Removal |
| **$CO_2e$** | Carbon Dioxide Equivalents |
| **CRT** | Carbon Removal Technologies |
| **DACCS** | Direct Air Carbon Capture and Storage |
| **EAP** | Environment Action Programme |
| **EC** | European Commission |
| **EEA** | European Environmental Agency |
| **ESABCC** | European Scientific Advisory Board on Climate Change |
| **EU** | European Union |
| **GHG** | Greenhouse Gas |
| **LTS** | Long Term Strategy |
| **LULUCF** | Land Use, Land Use Change and Forestry |
| **MS** | Member States [of the EU] |
| **NECP** | National Energy and Climate Plan |
| **nZEB** | Nearly Zero Energy Building |
| **R&D** | Research and Development |
| **SDG** | Sustainable Development Goal |
| **TRL** | Technology Readiness Level |

# 1 Monitoring of progress towards climate neutrality

'WHAT YOU CANNOT MEASURE, YOU CANNOT MANAGE […] INDICATORS HELP US TO DO SO'

Executive Vice-President Frans Timmermans (July 2022)

### The need for a progress check

Achieving a climate neutral society by 2050 is the core long-term objective of the European Green Deal and has been enshrined in the EU Climate Law. Climate neutrality and its related pathways – as outlined in the long-term strategies and underlying decarbonisation scenarios of both the European Union (EU) and its Member States – show that we need significant transformative change to tackle the climate crisis. In this decisive decade for climate action, an accurate understanding of progress, and of whether and where the underlying structural changes for this progress are or aren't happening, is of the utmost importance.

To properly understand if and how the EU is on track to reach net zero by 2050 therefore requires comprehensive monitoring. Article 6.1 of the EU Climate Law requires the Commission to assess, in regular intervals, the collective progress of EU Member States both on (a) meeting the climate neutrality target and (b) adaptation. The assessment will be prepared together with and complement other reporting under the Governance Regulation (Article 29(5)). The Commission's first climate neutrality progress report is due by 30 September 2023 and will then only be repeated every five years thereafter together with the State of the Energy Union report.

### The role of indicators in EU policymaking

The EU Climate Law does not prescribe how the assessment should be conducted, or at which level of detail. We can assume that indicators will play a crucial role in such a progress measurement exercise. They are a common and important tool in EU policymaking as they can show past developments and assess these against a specific past or future benchmark. Indicators can also be used in modelling exercises to show expected future developments.

Examples of indicator sets currently used in official processes include the indicator scoreboard in the EU Semester's macroeconomic imbalance procedure, the monitoring of EU progress towards the United Nations Sustainable Development Goals (SDGs), the indicators requested as part of the National Energy and Climate Plans (NECPs) under EU climate-related legislation and the indicator set for assessing the 8$^{th}$ Environment Action Programme (EAP) (EC, 2022). In addition, the European Environment Agency (EEA) shows progress on a regular basis for the climate and energy headline indicators in its Trends and Projections in Europe report (EEA, 2022b).

While it is safe to assume that indicators will be a core part of the Commission's climate neutrality assessment methodology, it remains unclear which indicators the Commission will use for assessing progress towards climate neutrality. The choice of indicators however will determine the accuracy, granularity and ultimately the usefulness of the process to policymakers across Europe.

### The value of indicators in progress assessments

To provide the necessary information to see whether policies are working, and to inform course correction as and where needed, a comprehensive progress check should include the monitoring of progress towards the EU's milestone and legally binding climate and energy targets. However, the chosen indicator set should also help us understand the more nuanced shifts, in other words, what is happening 'under the hood' of economic sectors and within our society. The progress assessment must be capable of interpreting whether the underlying structural changes are going in the right direction and if they are happening at sufficient pace to be consistent with the EU's long-term climate objective.

A sufficiently comprehensive progress check therefore needs a well-thought-out set of indicators that are both manageable and meaningful. The indicator set then requires a robust database as well as benchmarks to measure current developments against. Data collection efforts on EU level or harmonised data from EU Member States will be needed; benchmarks should be based on policy objectives and deep decarbonisation scenarios, so they can reveal the necessary systemic changes that need to occur to achieve the high-level policy objectives. In other words, benchmarks are the target values or thresholds that allow for assessing if socio-economic change is moving in the right direction. At the same time, deep decarbonisation scenarios can help identify the underlying enablers to achieve net zero emissions by 2050 – and should in turn serve as a basis to further select and develop indicators.

### Uncertainty around the European Commission's progress check

Less than six months ahead of submission date, great uncertainty remains about the approach and scope of the Commission's new assessment of EU-wide progress towards climate neutrality under the EU Climate law. There is a risk that it will rely *solely* on climate and energy headline indicators – an approach that only touches the surface and fails to consider whether the underlying transformative changes and enabling conditions that net zero pathways will depend on further in the transition are on pace in all parts of EU society. In other words, it is likely that decisive insights will be 'missed in the aggregate'.

The current decade is decisive for reaching the EU's climate neutrality objective, and a less-than-comprehensive first attempt to monitor progress that fails to identify lack of progress in critical areas in good time, could risk to lock in hard-to-reverse challenges to the transition. In addition, a lacklustre approach risks a lack of transparency within the EU about Member States 'convergence' on net zero – a concern that is already expressed in the Fit-For-55 discussions.

# 2 Objective and approach of this report

## 2.1 Objective

This report aims to complement discussions on what a meaningful indicator set might look like and how it could be utilized to check EU progress towards climate neutrality. In this way, we seek to support the thinking within the Commission and the European Scientific Advisory Board on Climate Change (ESABCC) but also in the broader climate community. We aim to provide practical insights on how one could approach the need to accurately assess EU progress towards net zero, while simultaneously ensuring that the EU develops a meaningful understanding of progress across different socio-economic elements.

This report tests an indicator framework concept developed in a past project, which identified the sectoral and cross-sectoral fields of action – termed 'net zero elements' – that are crucial to reaching climate neutrality by 2050. As an initial test, this report does not yet provide a comprehensive assessment of whether the EU is or is not on track towards climate neutrality, nor does it analyse underlying reasons for developments in either direction. By testing a framework and methodology for tracking progress, this report offers a first glimpse of where developments are headed in the right direction, where more effort is needed, and how these diverse developments could paint a comprehensive picture of the EU's progress.

## 2.2 Approach

The analysis underlying this report is based heavily on a recently developed, indicator-based framework for measuring progress that is structured around net zero elements or fields of action (Velten et al. 2021). For this report, we further developed the framework and tested the concept by:

- checking and updating the selection of net zero elements in the context of the European Climate Law (see section 3);
- updating the base indicator list to consider relevant developments in the field of climate action (see section 4.1);
- identifying two indicators for each net zero element to test the methodology on, with indicator selection based on data availability as well as expert opinion obtained from an online survey (see section 4.2); and
- analysing progress in each net zero element using two relevant indicators (see section 5) based on a progress methodology that compares the past trend with the required change – i.e., the change that would have been in line with reaching a future benchmark that is in line with net zero emissions (see Box 1 or Velten et al. 2021).

We present our key findings to provide a window into the value of this approach overall, and conclude with suggestions for possible further research stemming from this proof of concept (see section 6).

**Box 1: Progress measurement methodology**

**Evaluating progress**: There are different approaches for measuring and determining whether progress is sufficient. In this report, we use an approach adapted from the Eurostat methodology for monitoring of SDGs in the EU (Eurostat, 2014). Progress measurement builds upon historic data comparing past developments against a trajectory that would have led to the achievement of a specified benchmark. This means that we base our assessment on the past trend in the real economy and do not rely on, e.g., modelling policy scenarios. This has its advantage in being simple and available for all indicators with some historic data. However, it is important to note that the trend does not consider present or future policy decisions, technology advances, or economic/societal trends but is based on a specific past period. Therefore, it can only provide an indication of the current direction of developments and cannot predict a final value in a specific year.

It must also be noted that the methodology presented here might not be directly applicable to the whole set of indicators – it may need adjustment for individual instances and further refinement overtime.

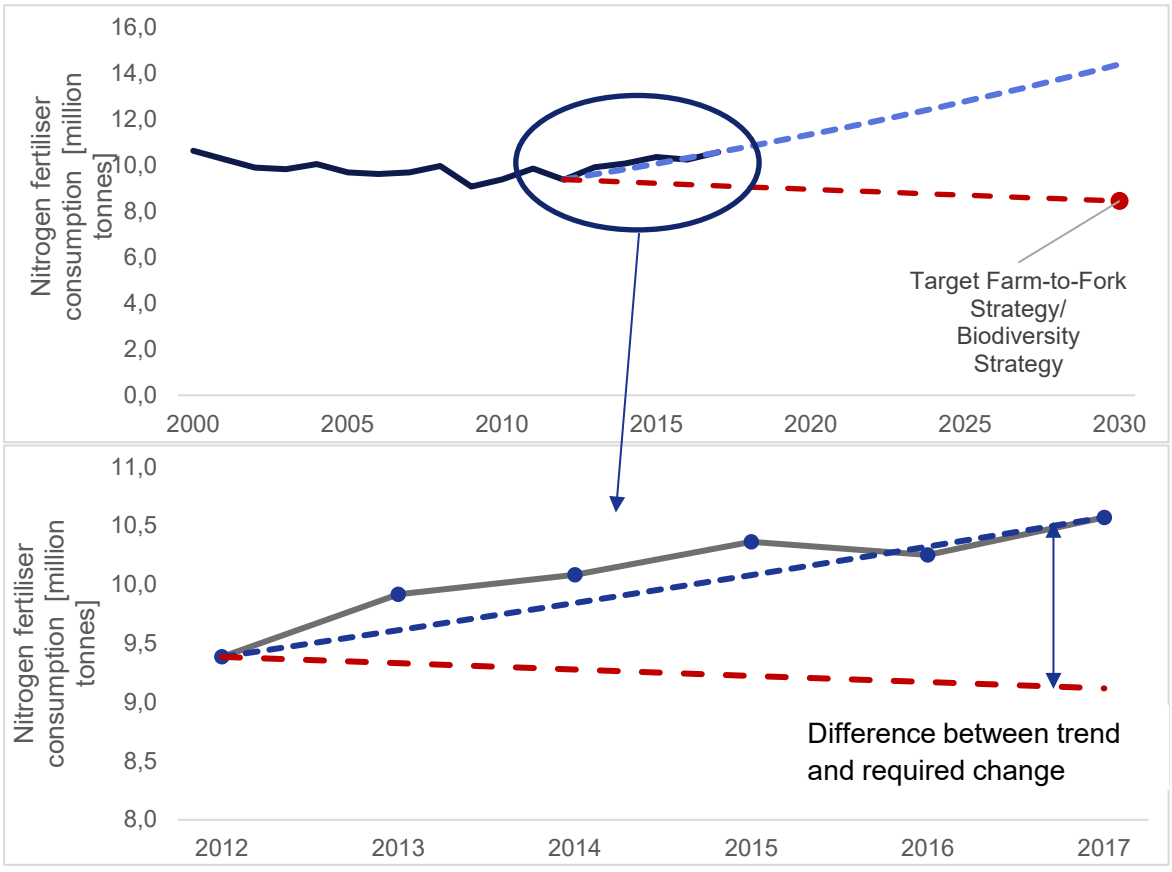
**Time period covered**: In general, the methodology suggests a focus on the short-term, and the analysis of trend of the past five years. For some indicators, however, it can be useful to base the assessment on a long-term trend of e.g., 10-15 years – for example, when unusual events cause a strong trend distortion. In this analysis, we considered post-2000 data in such cases, to be able to check the short-term trend in light of the long-term trend.

**Benchmarks**: The benchmarks used generally refer to 2050, when the EU must to achieve climate neutrality by. Exceptions include areas in which benchmarks need to be achieved earlier and then remain stable. Interim benchmarks are considered if useful, e.g., when there is a relevant EU 2030 or 2040 target. We checked for benchmarks outlined in EU documents prioritising in the following order: 1) a quantitative target set out in EU law; 2) a quantitative benchmark provided by an EU document; 3) a quantitative benchmark provided by a study; 4) a quantitative benchmark provided by experts; 5) a *qualitative* definition if the indicator should increase or decrease.

Most of the benchmarks used were taken from the impact assessment underlying the EU LTS (EC, 2018) whereby we chose the average value of the 1.5 Tech/1.5 Life scenarios. The main reason for this is that the documents offer a harmonised benchmark set for a range of indicators. However, it must be noted that the strategy and its impact assessment are somewhat outdated and might not necessarily reflect the progress needed by 2050.

**Annual change to measure progress**: The methodology uses the 'compound annual growth rate' (CAGR), which is the average annual change between two data points (e.g., 2015 and 2020). The annual change over a certain past period, i.e., the trend (= actual CAGR) is compared to the theoretically required change (= required CAGR) over the same period in the light of reaching a specific benchmark – e.g., in 2030 and/or 2050. Where the benchmark is not quantified, the trend is compared to the desirable direction of change, including the magnitude of change (see also Eurostat, 2014).

**Figure 2: Visualisation of the progress measurement method for nitrogen fertiliser use**




Source: own presentation based on Eurostat (2014), trend data from (Eurostat, 2022a) and the target for 2030 from the Farm-to-Fork Strategy and the Biodiversity Strategy. The trend is -417 % of the required change to reach the 2030 benchmark.

**Classification of progress for single indicators**: The difference between the actual trend and required change is grouped into four categories. Here we deviate from the Eurostat methodology and apply a descriptive and quantified classification to be able to better communicate different progress 'scores' (see Table 1).

**Table 1: Classification of progress towards a benchmark or direction**

| Descriptive scoring | Quantified scoring | | Range for quantified benchmarks | Range for direction |
|---|---|---|---|---|
| **In line with net zero emissions objective** | 4 |  | Trend is at least 95 % of the required change | Trend is > 1 % in the right direction |
| **Progressive but insufficient for net zero emissions objective** | 3 |  | Trend is 60 % - < 95 % of the required change | Trend is 0 % - 1 % in the right direction |
| **Not supporting the net zero emissions objective** | 2 |  | Trend is 0 % - < 60 % of the required change | Trend is 0 % - 1 % in the wrong direction |
| **Opposing the net zero emissions objective** | 1 |  | Trend is below 0 % of the required change | Trend is > 1 % in the wrong direction |

Source: own representation with own scoring; values taken from Eurostat SDG monitoring (Eurostat, 2014).

**Composite value**: The quantitative scoring also allows us deriving a composite value for an indicator where the indicator builds on several sub-indicators. We use a composite value that is based on the arithmetic mean of the scores of all sub-indicators.

This approach could also be used to calculate a composite value for an element. However, we do not present composite scores at the element level in this report due to the limited number of indicators assessed in this report. The calculation as proposed would mean that for only two indicators each has the same impact on the composite value. An alternative is the use of the arithmetic mean of the CAGRs of all indicators. This approach, however, means that a single indictor with a very high or very low CAGR would strongly affect the overall score of the element. Still, the resulting score for the composite value can be transferred back to the descriptive scoring system for descriptive representation of the progress in an element.

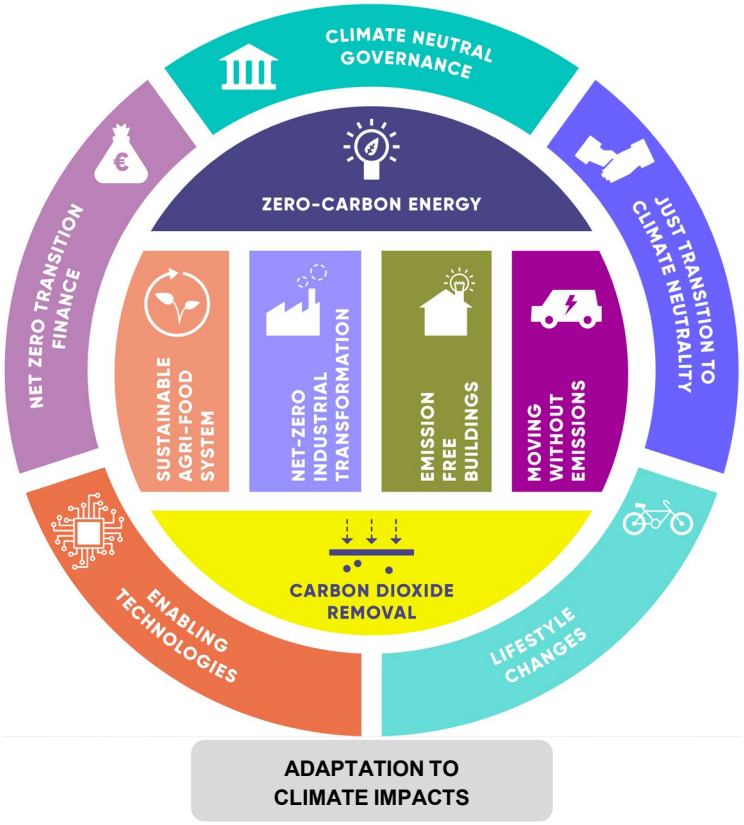
# 3 An indicator framework based on net zero elements

Selecting indicators to measure progress towards net zero emissions must address the often structural, sectoral and cross-sectoral changes of the transition, covering both the economic and social dimensions. To unpack this complexity, in past work in cooperation with IDDRI we developed a framework based on so-called **'net zero elements'** (Velten et al., 2021).

These elements constitute key fields of action, reflecting on sectors, but also cross-sectoral themes. The element selection was based on a literature review of long-term scenarios and underwent expert consultation. The elements can be categorised into two groups: (1) **sectoral elements** (the inner circle in **Error! Reference source not found.**), which are based on the scenarios used in the EU LTS, and (2) **horizontal elements**, which drive emission reductions across several sectors (the outer circle in **Error! Reference source not found.**).

For this report, we updated the element selection, adding 'Adaptation to climate impacts' (see Annex I) so it fully reflects Article 6 of the EU Climate Law, which asks the Commission to carry out a progress check for climate mitigation as well as adaptation. The focus of this new element is on societal adaptation measures and progress; it does not take into consideration broader indicators on climate change impacts, such as global or European average temperature, sea-level rise, or occurrence of extreme events.

**Figure 3: Net zero elements to structure the indicator selection and analysis**




Source: own presentation adapted from Velten et al., 2021.

**Table 2: A short introduction to the net zero elements**

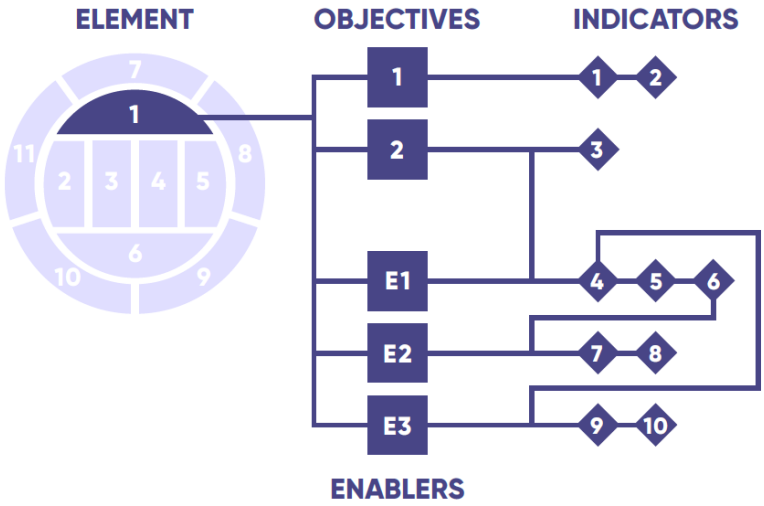
| Sectoral elements | Horizontal elements |
|---|---|
| **Zero carbon energy**: describes progress on switching to renewables and low carbon sources for electricity, heating and cooling and transport, considering sector coupling and flexibility. | **Net zero transition finance**: describes progress towards net zero compatible finance and other sustainability objectives of investments undertaken by both private and public entities. |
| **Sustainable agri-food system**: describes progress towards reducing the use of pesticides and fertilisation, restoring ecosystems, preserving biodiversity and ensuring a healthy diet for all. | **Enabling technologies**: describes progress in allocating means and resources to Research, Development and Demonstration (RD&D) and on the uptake of key technologies. |
| **Net zero industrial transformation**: describes progress towards improved energy and material efficiency and circularity as well as switching to zero carbon energy carriers for industrial processes. | **Lifestyle changes**: describes progress in the collective and individual behaviours related to the way people move, live, eat, work and consume that contribute to the transition to a net zero society. |
| **Emission-free buildings**: describes progress towards zero-emission building stocks with improved material and energy efficiency throughout their lifetime and use of zero-carbon energy carrier. | **Just transition**: describes progress towards the reduction of vulnerabilities and energy poverty in society and ensuring an inclusive transformation leaving no one behind. |
| **Moving without emissions**: describes progress towards emission-free transportation services for passengers and freight that meets mobility needs. | **Governance for climate neutrality**: describes progress towards a robust and inclusive governance system, enabling, determining and contributing to the required changes in all sectors and horizontal elements. |
| **Carbon dioxide removal**: describes progress towards the conservation and development of natural carbon sinks and the uptake of carbon removal technologies. | **Adaptation to climate impacts:** describes progress towards adapting and preparing for climate impacts, present and projected. |

For each sectoral and horizontal element, past work identified existing headline objectives as well as enablers that drive change within that element. While the objectives outline the overarching goals within an element, enablers represent the essential systemic changes needed to achieve those larger goals.

For this analysis, headline objectives are derived from EU law and strategies and include EU targets or target values from the EU LTS scenarios reaching net zero emissions in 2050. The enablers were defined based on drivers and barriers of decarbonisation in the respective fields as identified through literature review.

For each objective and each enabler, indicators were then selected to provide insights into the progress. This approach therefore does not only measure overarching goals but also their underlying drivers, providing a comprehensive picture of the transition.

**Figure 4: Progress measurement in elements uses indicators for headline objectives and enablers**




Source: Adapted from Velten et al., 2021.

# 4 Indicator selection

The present study tests the analytical framework developed in Velten et al. (2021) on a limited set of indicators, while keeping the overall structure of net zero elements and their objectives and underlying enablers intact. In this section, we describe the process for selecting sample indicators.

## 4.1 New indicators addressing new aspects

Further elaboration of the existing indicator set revealed the need to add several indicators to account for relevant developments related to or influencing climate action. Among these were the Russian war on Ukraine and its consequences for the transition to zero carbon energy, consumer readiness in the lifestyle change element, participation opportunities under governance as well as a whole new set of indicators for adaptation. Furthermore, we conducted additional research specifically for those elements where there were less than five indicators with good data availability. As part of this process, we also checked other indicator sets for monitoring and progress checking in climate policy and related fields, such as the 8th Environment Action Programme (EC, 2022), the Green Deal statistics (Eurostat, 2022b) as well as the SDG Monitoring Indicators for SDGs 7 (Energy) and 13 (Climate action) (Eurostat, 2022d) (for the comparison see Annex II). A snapshot of these new indicators includes among others: 'import dependency' (now under *zero carbon energy*), 'self-reported climate-conscious behaviour' (*lifestyle change*) and 'self-reported public support for mitigation' (*governance*).

## 4.2 Selecting sample indicators to test the concept

To keep the test progress assessment manageable, we selected two indicators per element only. While there are a variety of criteria that can be used to select indicators (EC, 2016, 2021a), we prioritised data availability to narrow down the list and then employed expert

judgement via an online survey to identify the top two most relevant indicators from this pre-selection.

### Pre-selecting indicators based on data availability

The availability and quality of data is a key consideration to ensure that indicators will actually be measurable. In this context, we considered the following:

- ease of accessibility, i.e., downloadable from a public website without costs;
- data continuity, i.e., at least five consecutive years;
- frequency, i.e., at least biennial publication of data and
- time lag, i.e., latest available data point at least for the year 2018

Our aim was to have at least five indicators per element that fulfil these prerequisites. This meant that in some cases we had to conduct additional research, specifically for buildings, agri-food, finance, technologies, industry, carbon dioxide removal, and governance. However, we also had to make compromises on data continuity and frequency where reasonable, e.g., data for land coverage is only available every three years.

### Expert survey for indicator selection

To further narrow down the indicator selection, we used an online survey to capture expert opinions on indicator importance. The survey asked participants to choose the top three most *relevant* indicators (from the pre-selected list) in the context of measuring progress towards net zero emissions and to briefly explain their choices. In addition, the survey asked for any relevant but missing indicators in the pre-selected set, again prompting an explanation. The final selection was then derived from the survey results using a quantitative approach, which allowed us to sort indicators in each element based on a combination of the ranking and respective expertise of the participant (see Annex III). A list of all pre-selected indicators per element can be found in section 5 or in Annex III.

# 5 A first glimpse of progress in the net zero elements

The following sub-chapters provide a first glimpse into current progress to EU climate neutrality across the twelve net zero elements. The chapters show the results on the 24 indicators we chose to test the methodology on.

Each chapter starts with a short introduction to each element, discusses the selection of the indicators, present the results of the indicator-based progress check and reflects on learnings.

## 5.1 Zero carbon energy

The element *zero carbon energy* captures progress on switching to an energy system that emits close to no GHG emissions. Such a change requires the full-scale substitution of fossil fuels with renewable energy sources. The energy market, energy infrastructure, and -systems need to support this transition. Enabler 1 documents regulatory frameworks that support zero-emission technologies, such as renewables; energy storage (also in the form of new fuels); and carbon capture, utilisation, and storage (CCUS). Enabler 2 comprises changes to infrastructure, such as network build-up, expansion, and conversion. Enabler 3 reflects

reduced energy consumption through improved efficiency, new practices, and lifestyle changes.

*Indicator selection*

The survey results showed a clear preference for indicators measuring headline objectives rather than their underlying enablers: The *share of renewable energies in gross final energy consumption* was considered the most meaningful for assessing progress on decarbonising the energy sector. The *GHG emissions from energy generation* ranked second and the *carbon intensity of electricity generation* third (see Table 3).

**Table 3: Ranking of indicators for 'zero carbon energy' following the online survey**

| Rank | Indicators for zero carbon energy | Position in the element |
|---|---|---|
| 1. | Share of renewable energies [% of gross final energy consumption] | Objective |
| 2. | GHG emission from energy generation [$tCO_2e$] | Objective |
| 3. | Carbon intensity of electricity generation [$gCO_2/kWh$] | Objective |
| 4. | Final energy consumption [PJ] | Enabler 3 - Reduced energy consumption |
| 5. | Fossil fuel subsidies [EUR] | Enabler 1 - Regulatory frameworks |
| 6. | Share of households' expenditure on housing fuels [% of expenditure] | Enabler 1 - Regulatory frameworks |
| 7. | Energy related investment [EUR] | Enabler 1 - Regulatory frameworks |
| 8. | Renewable energies capacity [MW] | Objective |
| 9. | Primary energy consumption [PJ] | Enabler 3 - Reduced energy consumption |
| 10. | Energy import dependency [% of energy imports] | Enabler 3 - Reduced energy consumption |

Source: own compilation based on the online survey

*Benchmarks and findings*

In current EU policies, two goals define the target trajectory for the share of renewable energies in gross final energy consumption: the current EU 2030 target of 32 % share of renewable energies, and the average value of the EU LTS scenarios 1.5 Tech/1.5 Life for 2050 of 74 % share of renewable energies (EC, 2018). The trend of the last five years for which data is available (data source is Eurostat, 2022c) shows that the past developments are in line with both objectives: the average annual increase was 4.4 % for the share of renewables while a growth rate of 4.2 % annually would have been sufficient to reach the target of 74 % share of renewable energies in 2050. The GHG emissions from energy generation must fall to 46.0 $MtCO_2e$ by 2050 according to the in-depth analysis in support of the EU LTS (EC, 2018). The trend in the last five years for which data are available (data source is EEA, 2022a) was progressive but insufficient for reaching that benchmark. Emissions only fell 6.7 % per year instead of 8.9 %.

In summary, the deployment of renewable energies showed remarkable progress and is in line with the EU's current net zero emission trajectory. Nevertheless, the emission reductions to date are too slow.

**Table 4: Progress check of the two highest ranked indicators in 'zero carbon energy'**

| Indicator | Scoring | |
|---|---|---|
| **Share of renewable energies [% of gross final energy consumption]** |  | In line with net zero emissions objective |
| **GHG emission from energy generation [$tCO_2e$]** |  | Progressive but insufficient for net zero emissions objective |

Source: own presentation

*Reflections*

While the analysed indicators show the overarching developments in their area, it remains unclear why and how these changes have happened. This highlights the importance of a more comprehensive approach that also looks at enabling conditions. Within the *zero carbon energy* element, this could include the shift to other low-emission technologies (Enabler 1) or whether energy consumption declines fast enough (Enabler 3). Further indicators related to infrastructure bottlenecks might also be relevant (Enabler 2). Due to inaccessibility of data, there was no indicator available for measuring progress on Enabler 2.

Meanwhile, we found that some indicators slightly overlapped in what they measure, for example where they measure relative and absolute values of the same theme. For example, the indicators ranked 2 and 3 in Table 4 refer to similar developments, whereby the carbon intensity of electricity is a sub-indicator of the broader energy generation. When deciding on an indicator set for future research, it might be reasonable to select only one of them to have a rather selective collection.

## 5.2 Sustainable agri-food system

This element describes progress towards a sustainable agri-food system, which ensures a healthy diet for all, while simultaneously reducing GHG emissions, the use of pesticides and fertilisers, preserving biodiversity, and contributing to ecosystem restoration. The enablers of a sustainable agri-food system are: 1) fostering new eco-agricultural practices and innovations, 2) improving land-use for enhanced carbon removal, 3) dietary changes and 4) the reduction and re-use of food waste (Velten et al., 2021).

*Indicator selection*

In the survey, participants ranked *GHG emissions from agriculture* first, followed by the *net emissions of land use, land use change, and forestry (LULUCF)* (see Table 5). The third indicator directly points towards a change in agricultural practices as it refers to the *share of agricultural land with organic farming*.

In the following, we consider the first and third ranked indicators. The *net GHG removal from LULUCF* will be covered in section 5.6 on *carbon dioxide removal*.

**Table 5: Ranking of indicators for 'agri-food system' following the online survey**

| Rank | Indicator for agri-food system | Position in the element |
|---|---|---|
| 1. | GHG emissions of agriculture [$tCO_2eq$] | Objective |
| 2. | Net GHG emissions of land use, land use change, and forestry (LULUCF) [$tCO_2eq$/year] | Enabler 2 - Improving land-use |
| 3. | Share of agricultural land with organic farming [% of agricultural land] | Enabler 1 - New agricultural practises |

| | | |
|---|---|---|
| 4. | Average per-person consumption of meat [kg/capita per year] | Enabler 3 - Dietary changes |
| 5. | Traded meat and feed [tonnes imported/ exported] | Enabler 3 - Dietary changes |
| 6. | Food utilisation (for feed; seed; food) [tonnes] | Enabler 2 - Improving land use |

Source: own compilation based on the online survey

*Benchmarks and findings*

The EU's target trajectory for agricultural emissions is defined by the in-depth analysis in support of the EU LTS (EC, 2018)[1]. Here, the current trend does not align, as emissions hardly declined at all with a 0.2 % reduction between 2015 and 2020. This is significantly less than the required average annual decline of 1.2 % (EEA, 2022a). The benchmark for the share of organic farming is set through the European Commission's Farm-to-Fork Strategy, which asks for 25 % of agricultural land to be organic by 2030 (EC, 2020). The trend here is progressive but insufficient for reaching the objective, as the share increased, on average, by 6.7 % between the years 2015 and 2020. However, an increase of 9.3 % would have been needed to be on track to reaching the benchmark.

Thus, both indicators show that current progress in the agri-food system is not sufficient.

**Table 6: Progress check of the two highest ranked indicators in 'sustainable agri-food system'**

| Indicator | Scoring | |
|---|---|---|
| **GHG emissions of agriculture [$Tco_2e$]** | ● ● ○ ○ | Not supporting the net zero emission objective |
| **Share of agricultural land with organic farming [% of agricultural land]** | ● ● ● ○ | Progressive but insufficient for net zero emissions objective |

Source: own presentation

*Reflections*

The indicator ranked highest in the expert survey was *GHG emissions of agriculture*, which reflects how the EU approaches its objective for sustainable agriculture. While at objective level, the indicator does not show positive development, the enabler indicator is much more progressive. This suggests that underlying structural change is occurring, albeit at a rate that has not (yet) translated significantly into a reduction of GHG emissions.

We further note that central aspects of the element were not covered due to the lack of available data, most importantly: the nuances of agricultural practices, such as tillage referred to in Enabler 1. Similarly, indicators measuring current food waste in the EU are absent.

Overlap occurs mainly with other elements. For instance, while a central concept in a *sustainable agri-food system*, land use is additionally represented in the elements *CDR* and *adaptation*.

[1] We used 'non-$CO_2$-emissions of agriculture' for this calculation, as total agricultural emissions were not disclosed separately in the in-depth assessment in support of the EU LTS. However, as $CO_2$-emissions for the 'tertiary' sector (which includes agriculture) are marginal in the net zero scenarios for 2050, this serves as an approximation (EC, 2018).

## 5.3 Net zero industrial transformation

The element *net zero industrial transformation* describes advancement towards climate neutral industry in the EU. This transformation implies the implementation of several process and product changes, and given the long investment cycles of the sector, the integration of long-term implications in today's investment decisions is crucial. Key enablers in this area include the creation of lead markets for innovative technologies (Enabler 1) as well as the unlocking of value chains for material efficiency and circularity (Enabler 2). A third enabler is the integration of industrial, climate, energy, and trade policy to drive industry engagement in the zero-carbon transformation and prevent the relocation of production to regions with less stringent climate policies in place. Finally, the shift to zero carbon industry requires the development of adequate supporting infrastructure, such as the development of hydrogen infrastructure or the possibilities for electrification (Enabler 4) (Velten et al., 2021).

*Indicator selection*

According to the expert survey, looking at the *GHG emissions of industrial processes and product use* and the *final energy consumption in industry* are the two most relevant indicators for assessing progress to net zero (see Table 7). Embodied GHG emissions, i.e., how much $CO_2$ was emitted in the production of a product consumed in the EU (Eurostat, 2022e), was ranked as a third priority.

**Table 7: Ranking of indicators for 'net zero industrial transformation' following the online survey**

| Rank | Indicator for net zero industrial transformation | Position in the element |
|---|---|---|
| 1. | GHG of industrial processes and product use [$Tco_2e$] | Objective |
| 2. | Final energy consumption in industry [GJ] | Objective |
| 3. | Embodied GHG emissions [$Tco_2e$] | Objective |
| 4. | Circular material use rate [%] | Enabler 2 – Unlocking of value chains |
| 5. | Raw material consumption [tonnes] | Enabler 2 – Unlocking of value chains |
| 6. | Recycling of wastes [% of total waste] | Enabler 2 – Unlocking of value chains |
| 7. | GHG of waste management [$Tco_2e$] | Enabler 1 – Creation of lead markets |
| 8. | Exports of environmental goods and service sector [% of total exports] | Enabler 3 – Help industries engage |
| 9. | Small and medium sizes enterprises producing products that are easier to maintain, repair or reuse [% of all SME] | Enabler 2 – Unlocking of value chains |
| 10. | Number of certificates for an environmental management system (EMAS) [new certified organisations per year] | Enabler 1 – Creation of lead markets |

Source: own compilation based on the online survey

*Benchmarks and findings*

The in-depth analysis of the LTS foresees that GHG emissions from industrial processes and product use fall to 95 Mt $CO_2$ in 2050 and industrial $CO_2$ emissions from energy consumption reach 25 Mt $CO_2$ (EC, 2018). The former declined by 2 % per year between 2015 to 2020 (EEA, 2022a). Although this does imply a reduction in emissions, it is not enough to reach the benchmark for net zero. Emissions would have to drop by at least 3.4 % per year. The trend in industrial emission reductions is therefore progressive but insufficient.

The final energy consumption in industry fell by only 0.2 % between 2015 and 2020, which is not even a quarter of the necessary reductions. This means that both indicators show a decline but are far from a pathway that is in line with the net zero emission objective.

**Table 8: Progress check of the two highest ranked indicators in 'net zero industrial transformation'**

| Indicator | Scoring | |
|---|---|---|
| **GHG of industrial processes and product use [$tCO_2e$]** |  | Progressive but insufficient for the net zero emission objective |
| **Final energy consumption in industry [GJ]** |  | Not supporting the net zero emission objective |

Source: own presentation

*Reflections*

First, the analysed indicators again merely looked at objectives of the industrial transition. A broader perspective that accounts for underlying processes in production would in principle be essential for assessing progress to net zero more adequately. However, there was no indicator with good data availability for the fourth enabler on the development of infrastructure.

Second, trendlines on both indicators were clearly impacted by the COVID-19 pandemic: GHG emissions from industry remained rather constant before falling significantly in 2020 due to the pandemic, where production rates decreased by roughly 27 % between February and April alone (Eurostat, 2022h). Industrial energy consumption in fact *increased* between 2015 and 2019, before significantly dropping in 2020. Given the (at least partial) bounce-back to pre-pandemic levels, progress in these areas will thus likely be less advanced than what the current % change may suggest.

In way of additional indicators to consider, the experts mentioned the technology readiness level (TRL) of technologies deployed as a possible indicator to for innovation, which is also relevant to the enabling technologies element (see section 5.8). Additional indicators could measure energy sources used within industrial processes, such as the share of renewables or the GHG emissions of industrial energy use, specifically.

## 5.4 Emission-free buildings

The element *emission-free buildings* describes the transformation towards an emission-free building stock. This implies improved material and energy efficiency throughout a building's lifecycle, the use of mainly renewables to cover remaining energy needs, and that all new construction projects are 'nearly zero energy buildings' (nZEBs). The enablers of the element are 1) the facilitation of emission-free buildings through the distribution of information to professionals, capacity building, and upskilling in regard to clean technologies, 2) raising demand for emission-free buildings by enhancing economic viability and public information, and 3) digitalisation, e.g., through the installation of smart meters (see Velten et al., 2021).

*Indicator selection*

The first two indicators on the survey's ranking measure the development towards the headline objectives of the buildings sector rather than their underlying enablers: The most relevant indicators for the transition to net zero in buildings were seen to be the *GHG emissions of the building sector* and its *final energy consumption*. The share of renewables in heating and cooling ranked third (see Table 9).

**Table 9: Ranking of indicators for 'emission-free buildings' following the online survey**

| Rank | Indicator for emission-free buildings | Relation to element |
|---|---|---|
| 1. | GHG emissions of the building sector [$MtCO_2e$] | Objective |
| 2. | Final energy consumption in buildings [% change to 2005 and/or PJ] | Objective |
| 3. | Share of renewables in heating and cooling [% in heating and cooling] | Objective |
| 4. | Share of households' expenditure on housing fuels [% of expenditure] | Enabler 2 - Enhancing economic viability |
| 5. | Recovery rate of construction and demolition waste [% of treated construction and demolition mineral waste] | Enabler 1 - Capacity building |
| 6. | Gross fixed capital formation for dwellings [% of GDP] | Enabler 2 - Enhancing economic viability |

Source: own compilation based on the online survey

*Benchmarks and findings*

To be line with the net zero emission target, *GHG emissions of buildings* should not exceed 130 $MtCO_2e$ per year in 2050 (EC, 2018). Accordingly, the emissions would have needed to decrease by 2.6 % per year between 2015 and 2020, but the actual decrease was only 0.9 % (EEA, 2022a). Hence, the current trend does not support the objective. For the *final energy consumption in buildings*, past development even opposes the benchmark: final energy consumption increased between 2015 and 2020 and is nowhere near the necessary reduction of 46 % by 2050 (Eurostat, 2022f). This might mean that the uptake of renewables has compensated somewhat for increased energy consumption, keeping emissions more or less stable.

**Table 10: Progress check of the two highest ranked indicators in 'emission-free buildings'**

| Indicator | Scoring | |
|---|---|---|
| **GHG emissions of the building sector [$MtCO_2e$]** | ●●○○ | Not supporting the net zero emission objective |
| **Final energy consumption in buildings [% change to 2005 and/or PJ]** | ●○○○ | Opposing the net zero emissions objective |

Source: own presentation

*Reflections*

A closer look at indicators like the *share of households' expenditure on housing fuels* (ranked fourth in the expert survey) would have been helpful to see if the transition exacerbates or eases energy poverty. However, this indicator can also be covered within the just transition element. The average size (in square meters) of dwellings and commercial space per person could give additional insights on energy sufficiency, but there is no data available that covers at least five consecutive years. The indicator set further excludes the third enabler on digitalisation. This is likewise due to a lack of good data availability for the respective indicators.

## 5.5 Moving without emissions

The element *moving without emissions* describes progress towards an emission-free transport system for passengers and freight that meets future mobility needs. Crucial change within this element includes 1) the shift towards zero carbon transportation solutions based on

electricity, synthetic fuels, and hydrogen; 2) the change in modes of transport to more public and collective transportation as well as active mobility (walking and cycling); 3) planning and the implementation of urban and territorial urban planning; and 4) the use of digitalisation to reduce the mobility needs (EC, 2018).

*Indicator selection*

The survey outcome shows that *GHG emissions from transport*, an indicator which relates to the headline objective of the element, is deemed to be of highest relevance. The second indicator on the ranking points to an enabler of the transition: the *share of zero-emission vehicles in newly registered cars*. The experts thus assess the shift of fuels to be more meaningful than the reduction of overall mobility or modal shift. The overall energy consumption of transport, irrespective of whether fossil fuel based or renewable, ranked third in the expert survey (see Table 11).

**Table 11: Ranking of indicators for 'moving without emissions' following the online survey**

| Rank | Indicator for moving without emissions | Relation to element |
|---|---|---|
| 1. | GHG emissions from transport [$MtCO_2e$; % change to 1990] | Objective |
| 2. | Share of zero-emission vehicles [% of newly registered cars] | Enabler 1 - Zero carbon transportation solutions |
| 3. | Energy consumption of transport [PJ] | Objective |
| 4. | Share of low-emission fuels [% of fuels used in transport] | Enabler 1 - Zero carbon transportation solutions |
| 5. | Average GHG emissions of new vehicles [$gCO_2e/km$] | Enabler 1 - Zero carbon transportation solutions |
| 6. | Passenger transport volume [passenger-km] | Enabler 2 - Change modes of transportation |
| 7. | Freight transport volume [tonne-km] | Enabler 2 - Change modes of transportation |
| 8. | Vehicle stock [number of vehicles] | Enabler 1 - Zero carbon transportation solutions |
| 9. | Expenditure per capita on transport [EUR; % of overall household expenditure] | Enabler 2 - Change modes of transportation |

Source: own compilation based on the online survey

*Benchmarks and findings*

The GHG emissions of transport need to fall by 90% by 2050 (EC, 2018, 2020b). Between 2015 and 2020, the GHG emissions of transport declined by 1.9 % per year, which was not enough to reach the required change of 6 %. Thus, the trend does not support the net zero objective (see Table 12).

It is further important to note that, in 2020, the transport sector was strongly influenced by the COVID-19 pandemic: the pandemic significantly reduced overall mobility following remote working and travel restrictions. In previous years, emissions had been in a steady rise meaning that, with the (partial) return to pre-COVID times, one should expect the future trend to be even less positive.

For the registration of zero-emission vehicles, the progress was in line with the objective. The growth rate lies at 67.7 % per year, which even exceeds the necessary growth rate to reach the goal of only registering zero-emission vehicles by 2035 (Eurostat, 2022g). Thus, it can be expected that the automobile market is prepared for the implementation of the ban of conventional vehicles (EP, 2022).

**Table 12: Progress check of the two highest ranked indicators in 'moving without emissions'**

| Indicator | Scoring | |
|---|---|---|
| **GHG emissions from transport [Mt $CO_2e$; % change to 1990]** |  | Not supporting the net zero emission objective |
| **Share of zero-emission vehicles [% of newly registered cars]** |  | In line with the net zero emission objective |

Source: own presentation

*Reflections*

Notes on the selected indicator set include that there is some overlap: the indicators *share of zero-emission vehicles on newly registered cars* and the *average GHG emissions of new vehicles* basically measure the same issue (besides a focus on cars and a focus on vehicles more broadly). In contrast, there is no indicator yet included in the set under Enablers 3 and 4 on better urban planning and digitalisation.

## 5.6 Carbon Dioxide Removal

This element describes progress with the development of carbon dioxide removal (CDR), acting as a complement, never as a replacement, for GHG emission reductions. They are needed to compensate for hard-to-decarbonise sectors (IPCC, 2021). CDR can be divided into natural sinks and carbon removal technologies (CRT). Natural sinks store $CO_2$ in the form of biomass on land and oceans and can be enhanced through ecosystem restoration, reforestation, and improved forest management practices that also tackle the biodiversity crisis. CRTs include the use of biomass for energy generation coupled with carbon capture and storage (BECCS), direct air $CO_2$ capture and storage (DACCS), biochar, enhanced weathering, ocean alkalinisation, and ocean fertilisation. CDR enablers are: 1) enhancing natural carbon sequestration, 2) investment in research, development, and demonstration, and 3) public acceptance of carbon dioxide removal (Velten et al., 2021).

*Indicator selection*

Expert survey participants ranked *natural $CO_2$ removal of different land types* as most important, followed by the *contribution of GHG reductions and removals to an overall net reduction target* and the *carbon stock in living biomass* (see Table 13). All three indicators relate directly to the headline objective of the element and overlap significantly. In fact, the $CO_2$ removal by different land types can be viewed as sub-indicators of overall GHG removals because currently only natural removals contribute meaningfully to the net zero target. Technical removals are, at the time of writing, still in the development phase, and do not remove emissions in measurable quantities (see e.g., category 1.C in the GHG inventories (EEA, 2021)).

**Table 13: Ranking of indicators for 'carbon dioxide removal' following the online survey**

| Rank | Indicator for carbon dioxide removal | Relation to element |
|---|---|---|
| 1. | (Net) natural $CO_2$ removal of different land types [$MtCO_2$] | Objective |
| 2. | Contributions of GHG reductions and removals to an overall GHG net reduction target [$tCO_2e$] | Objective |
| 3. | Carbon stock in living biomass [tonnes of carbon] | Objective |
| 4. | Land conversion to urban or other artificial land (land take) [km²/ year] | Enabler 1 – Enhancing natural carbon sequestration |
| 5. | Change in land coverage [%-share; ha] | Enabler 1 – Enhancing natural carbon sequestration |

Source: own compilation based on the online survey

*Benchmarks and findings*

Natural removals decreased by 2% on average annually between the years 2005 and 2020.[2] This trend opposes the objective to reach the LULUCF target of 310 $MtCO_2e$ emission removals by 2030 proposed by the Commission (EC, 2021b). With a view towards 2050, EC (2018) sets benchmarks for $CO_2$ removal of individual land types. In the net zero scenarios 1.5 Tech/1.5 Life, forest land, cropland, as well as harvested wood products count as net $CO_2$ sinks. The analysis of these land types paints a mixed picture. Over the last 15 years for which data is available, the sink function of forests has decreased, with net removals declining by 1.6 % on average annually. This does not meet the required annual increase of 0.4 %. Grassland should be turned from an emission source to a sink. This however would have required a reduction of 196.6 %, which is far away from the real decline of 2.6 %. Therefore, like forests, the trend for grasslands is not aligned with a net zero future. In contrast, GHG removal through harvested wood products (2.7 % average annual growth) surpassed the trajectory compatible with net zero (0.9 %).

Besides the positive developments for harvested wood products and grassland, forests are by far the largest sink and their reduced removal directly drives overall removals in the LULUCF sector. Thus, the contribution of removals to the overall net GHG reduction target is, in fact, declining and not in line with the objective.

**Table 14: Progress check of the two highest ranked indicators in 'carbon dioxide removal'**

| Indicator | Scoring | |
|---|---|---|
| **(Net) natural $CO_2$ removal of different land types [$MtCO_2$]** |  | Not in line with net zero emissions objective |
| **Contributions of GHG reductions and removals to an overall GHG net reduction target [$tCO_2e$]** |  | Opposing the net zero emissions objective |

Source: own presentation

*Reflections*

The indicator set did not touch on technical sinks due to missing data. However, for a complete picture it is necessary to also understand progress in this field. This was also

[2] Due to the slow changes in the LULUCF sector, we decided to look at the trend of the last 15 instead of 5 years.

highlighted by the survey participants. Options may include to monitor current costs for storing a tonne of $CO_2$ or to track available technical absorption capacity. Further potentially helpful indicators mentioned in the expert survey were the carbon stock in the atmosphere and the quantity of GHG removed through nature-based solutions.

## 5.7 Net zero transition finance

This element describes the transition towards net zero compatible, sustainable finance and investments. Transitioning to a net zero economy requires significant investments in low or zero carbon technologies, such as renewable energies, services, and products and a phase out of investments contributing to GHG emissions. The enablers of this transformation are: 1) public funds oriented towards the transition, 2) an enabling regulatory framework, and 3) a financial system that supports private finance aligned with the net zero objective (see Table 15).

*Indicator selection*

Interestingly, in the expert survey, the two indicators rated as most relevant. Both look at enabling conditions: the *price on carbon* and *fossil fuel subsidies*. Both indicators measure how policy shapes finance streams and (dis-)incentivise new investment. Ranked third was energy-related investment, an indicator measuring an objective of the element.

**Table 15: Ranking of indicators for 'net zero transition finance' following the online survey**

| Rank | Indicators for net zero transition finance | Relation to element |
|---|---|---|
| 1. | Price on carbon (EU ETS carbon price) [EUR/$tCO_2e$] | Enabler 2 – Enabling regulatory framework |
| 2. | Fossil fuel subsidies [EUR] | Enabler 2 – Enabling regulatory framework |
| 3. | Energy related investment [EUR] | Objective |
| 4. | Expenditure on environmental protection [% of GDP] | Enabler 2 – Enabling regulatory framework |
| 5. | Climate related economic losses [EUR] | Enabler 3 – Financial system aligned with net zero |
| 6. | Environmental tax revenue as a share of GDP [% of GDP] | Enabler 2 – Enabling regulatory framework |
| 7. | Contribution to the international USD 100bn climate finance [EUR] | Enabler 1 – Public funds oriented towards the transition |
| 8. | Environmental tax revenue as a share of public revenue [% of public revenue] | Enabler 2 – Enabling regulatory framework |
| 9. | Principles for Responsible Investment Signatories [number of signatories] | Enabler 3 – Financial system aligned with net zero |

Source: own compilation based on the online survey

*Benchmarks and findings*

The EU has no target for the price on carbon, but since a higher carbon price is a stronger incentive for low carbon investment, the trend here has been deemed in line with the net zero emission objective: The mean yearly EU ETS price increased substantially over the last five years for which data is available—by 58.5 % per year on average.

There is also currently no quantified target for fossil fuel subsidies. However, the EU Commission's communication for the Green Deal states that 'removing subsidies for fossil

fuels' is part of a green national budget (EC, 2019). As the subsidies have increased by, on average, 1.8 % yearly between 2015 and 2020, this indicator is out of line.

The two highest ranked indicators point in opposite directions, indicating that these developments may be counteracting each other. While the price on carbon indicates a shift in investment incentives, the continued increase of fossil fuel subsidies calls into question if governments are creating adequate conditions for net zero financing. Hence, additional indicators could help to better understand if the element moves in the right direction overall. Other indicators measuring the objectives of net zero finance, such as energy-related investment, would further shed light on the larger picture.

**Table 16: Progress check of the two highest ranked indicators in 'net zero transition finance'**

| Indicator | Scoring | |
|---|---|---|
| **Price on carbon (EU ETS carbon price) [EUR/$tCO_2e$]** |  | In line with net zero emissions objective |
| **Fossil fuel subsidies [EUR]** |  | Opposing the net zero emissions objective |

Source: own presentation

*Reflections*

Most indicators listed here focus on public incentives, but substantial private investment is needed to accomplish the net zero transition. Data on green bonds and other green finance mechanism exist but are, at the time of writing of this report, hidden behind a paywall. Overlap exists mainly around the two indicators on environmental tax revenue: one in relation to GDP and another in relation to public revenue. Experts deemed the former as more relevant. Additional indicators were recommended under Enabler 1 on public funds oriented towards the transition.

## 5.8 Enabling technologies

The element enabling technologies describes the uptake of key technologies necessary for reaching a net zero economy. A portfolio of technologies must support and enable the transition in all sectors of the economy and areas of society, such as technologies that electrify end-use sectors; carbon capture, utilisation, and storage (CCUS); green hydrogen, as well as decarbonisation technologies for production processes in high-emitting industries. The enablers of such innovations are: 1) support for climate related research and innovation and 2) public policy promoting mass deployment of low and zero carbon technologies.

*Indicator selection*

In the survey, experts rated indicators measuring enabling conditions the highest. Participants suggested the most relevant indicator to be *government budget allocation to environmental and energy-related R&D*, followed by *fossil fuel subsidies* and the *electrification of the economy.*

**Table 17: Ranking of indicators for 'enabling technologies' following the online survey**

| Rank | Indicators for enabling technologies | Relation to element |
|---|---|---|
| 1. | Government budget allocation to environmental and energy-related R&D [EUR; % of total allocation to R&D] | Enabler 1 – Support for research and innovation |
| 2. | Fossil fuel subsidies [EUR] | Enabler 2 – Public policy supporting technology deployment |
| 3. | Electrification of the economy [% of electricity in final energy consumption] | Enabler 2 – Public policy supporting technology deployment |
| 4. | R&D expenditure in the EU [EUR; % of total expenditure] | Enabler 1 – Support for research and innovation |
| 5. | Total value of green early-stage investment [EUR/population] | Enabler 1 – Support for research and innovation |
| 6. | Eco-innovation related patents (in environment-related technologies, climate change adaptation technologies, sustainable ocean economy inventions) [number] | Enabler 1 – Support for research and innovation |
| 7. | Overall R&D personnel [% of active population] | Enabler 1 – Support for research and innovation |

Source: own compilation based on the online survey

*Benchmarks and findings*

There is no quantitative target for either of the two highest ranked indicators, but it is evident that the share of government budget allocated to environmental and energy-related R&D in total budget *should increase* to advance existing and develop new key technologies (as well as to advance on products and processes and the broader understanding of the transition and its implications through research in other scientific fields). However, since the share decreased gradually by 0.2% annually for the last five years for which data is available, the indicator's trend opposes the objectives. The trend for fossil fuel subsidies too went into the wrong direction, as fossil fuel subsidies grew, on average, by 1.8 % yearly further locking-in traditional fossil fuel use. This means that both indicators are not in line with the zero emissions objective. Not enough is being done to advance the deployment of zero carbon technologies, including a lack of coherent financial support.

**Table 18: Progress check of the two highest ranked indicators in 'enabling technologies'**

| Indicator | Scoring | |
|---|---|---|
| **Government budget allocation to environmental and energy-related R&D [% share allocated to R&D]** |  | Opposing the net zero emissions objective |
| **Fossil fuel subsidies [EUR]** |  | Opposing the net zero emissions objective |

Source: own presentation

*Reflections*

The two indicators chosen for this element both cover enablers and hence different aspects of clean technology diffusion. The wider indicator set however has a strong focus on R&D and less so on the wider market penetration of clean technologies. Indicators analysing manufacturing capacities for instance could complement the picture, but data availability is poor.

Experts further proposed in the survey to include overall subsidies for clean technologies or to track the technology readiness level. This would require additional effort in collecting and dis/aggregating relevant data. The indicators *R&D expenditure in the EU* and *overall R&D*

*personnel* are not directly attributable to climate-related technologies and instead refer to the overall emphasis on research. Open questions remain regarding the definition of some indicators, such as green investment or eco-innovation. Knowing what counts in both cases is crucial for assessing progress.

## 5.9 Lifestyle changes

This element describes the shifts in collective and individual behaviour necessary to reach a climate neutral society. Adopting climate-friendly lifestyles involves choosing low-carbon products and services, dietary changes (Poux and Aubert, 2018), changes in mobility habits and housing. The enablers of lifestyle change are: 1) raising collective knowledge on lifestyle impacts on the environment, 2) promoting low carbon alternative solutions, and 3) enhancing environmental regulation and economic incentives.

*Indicator selection*

In the survey, the highest ranked indicators related to specific changes in behaviour: dietary shift measured by the *average consumption of meat* (ranked first), changes in mobility habits as indicated by the *modal split in private transport* (ranked second), and an overall shift in behaviour through *self-reported climate-conscious behaviour* (ranked third, see Table 19).

**Table 19: Ranking of indicators for 'lifestyle changes' following the online survey**

| Rank | Indicators for lifestyle changes | Relation to element |
|---|---|---|
| 1. | Average per-person consumption of meat [kcal/capita/day] | Enabler 1 – Raising collective knowledge |
| 2. | Modal split in private transport [% of total transport] | Enabler 2 – Promoting low carbon solutions |
| 3. | Self-reported climate-conscious behaviour [% of surveyed population] | Enabler 1 – Raising collective knowledge |
| 4. | Household waste [kg per capita] | Enabler 1 – Raising collective knowledge |
| 5. | Rooms per person [rooms] | Enabler 2 – Promoting low carbon solutions |
| 6. | Total calories consumption per capita per year [kcal per capita] | Enabler 1 – Raising collective knowledge |

Source: own compilation based on the online survey

*Benchmarks and findings*

The benchmark for meat consumption derived from the in-depth assessment underlying the EU LTS (EC, 2018) still allows for an increase of 0.01 % yearly on average. However, the trend between 2014 and 2019 exceeded this with a yearly average increase of 0.4 % annually, which means that past developments are not aligned with the net zero target**.** The in-depth assessment further assumes in both the 1.5 Life and the 1.5 Tech scenarios that meat consumption stays the same until 2050 when compared to 2013 and does not require substantial reductions.

The changes in mobility habits as outlined by the modal split of passenger transport can be divided into sub-indicators for road, rail, aviation, and inland shipping. For road traffic, aviation, and inland shipping, the passenger kilometres decreased over the years 2015 to 2020 (3.3 %, 17.0 % and 11.8 % respectively) surpassing the required annual decline (0.05 %,1.4 % and 1.0 %) following the EU LTS scenarios 1.5 Tech/1.5 Life. This means that

the trend for these sub-indicators is in line with the objective. However, the development for rail traffic opposes the objective. It decreased by 9.4 % annually on average, while the required *growth* is 0.01 % yearly. Across all sub-indicators, the trend for modal split was progressive but insufficient for net zero. The development of the modal split indicator must be interpreted with caution, as the measures taken to address the COVID-19 pandemic had significant impacts on mobility habits in 2020. For example, early data shows that transport emissions have partly bounced back in 2021 (Förster et al., 2022), indicating that the decline in transport activity due to the pandemic was only temporary.

**Table 20: Progress check of the two highest ranked indicators in 'lifestyle changes'**

| Indicator | Scoring | |
|---|---|---|
| **Average per-person consumption of meat [kcal/capita/day]** |  | Opposing the net zero emissions objective |
| **Modal split in private transport [% of total transport]** |  | Progressive but insufficient for net-zero emissions objective |

Source: own presentation

*Reflections*

The two selected indicators illustrate the broad scope of this element. The varying trends lead to the tentative conclusion that while developments in one area head in the right direction, signalling a change in behaviour, this does not necessarily apply to other areas as well. Both indicators have their methodological caveats: the benchmark for meat consumption was based on lenient assumptions in the scenarios underlying the EU LTS; for modal split, the changes in 2020 due to the pandemic skewed the results. According to the expert survey, flying, eating meat, and car ownership are deemed to have the highest impact on individual carbon footprint. Thus, indicators covering more of those aspects could be added, such as the rate of car ownership and flights per year.

## 5.10 Just Transition

This element describes progress towards a just and inclusive transition to a climate neutral society. Policy levers for a just transition include actions to support citizens, companies, and regions through training, education, creating new economic and social opportunities, or distributional policies (Atterdige & Strambo, 2020). The enablers for this element are: 1) meaningful participation of citizens and stakeholders in policy processes considering existing economic environmental or social inequalities, 2) a proactive structural public policy, 3) ensuring a just environmental pricing, and 4) the availability of low-carbon solutions.

*Indicator selection*

The element just transition measures progress on distributional impacts in societies, which makes data availability more challenging than the sectoral ones. Among survey participants, the greatest concern was people's ability to pay their energy bills, which is a problem particularly for vulnerable groups: When *households' share of expenditure on housing fuels* increases larger parts of the population are *unable to keep their home adequately warm*. These two indicators were ranked second and first, respectively, in the expert survey. A just transition further entails that people derive value from an intact ecosystem. This should be ensured through *environmental protection measures and resource management activities* (ranked third, see Table 21).

**Table 21: Ranking of indicators for a 'just transition' following the online survey**

| Rank | Indicator for a just transition | Relation to element |
|---|---|---|
| 1. | Population unable to keep home adequately warm [% of population] | Enabler 3 – Ensuring a just environmental pricing |
| 2. | Share of households' expenditure on housing fuels [% of expenditure] | Enabler 3 – Ensuring a just environmental pricing |
| 3. | Value added in environmental protection and resource management activities [EUR; % of GDP] | Enabler 4 – Availability of low-carbon solutions |
| 4. | Years same hereof life lost due to PM2.5 exposure [years lost per 100.000 inhabitants] | Enabler 2 – Proactive structural public policy |
| 5. | Employment rate in the environmental sector [% of population aged 10-64] | Enabler 2 – Proactive structural public policy |
| 6. | High speed internet by type of area [% of households] | Enabler 4 – Availability of low-carbon solutions |

Source: own compilation based on the online survey

*Benchmarks and findings*

There are currently no quantifiable targets for the two highest ranked indicators. However, it is clear that while higher prices can incentivise energy saving, they should not worsen the situation of vulnerable groups. Hence, ideally, both indicators should see a decline. In 2021, 6.9 % of the EU population was unable to keep their homes adequately warm (Eurostat, 2022b). Compared to 2016, the number declined by 5.2 %, which suggests the indicator trend is in line with the desired development. The share of households' expenditure on housing fuels declined by 0.5 %. Under the assumption that the share should generally decrease with increased energy efficiency, the indicator's development is progressive but considered insufficient due to the rate of decline.

**Table 22: Progress check of the two highest ranked indicators in 'just transition'**

| Indicator | Scoring | |
|---|---|---|
| **Population unable to keep home adequately warm [% of population]** | ●●●● | In line with the net zero emission objective |
| **Share of households' expenditure on housing fuels [% of expenditure]** | ●●●○ | Progressive but insufficient for the net zero emission objective |

Source: own presentation

*Reflections*

The two selected indicators are both related to household expenditure on fuels, which suggests that survey participants are concerned about energy prices. At the same time, indeed, one could discuss how far (and if at all) the share of expenditure on housing fuels should decrease. For now, cross-sectoral indicators and indicators to measure progress on 'just environmental pricing' (Enabler 3) are missing from the indicator set and there is hardly any indicator measuring distributional effects on different parts of the society.

## 5.11 Governance for climate neutrality

This element pertains to institutions and processes meant to help achieve net zero GHG emissions. Climate neutral governance must provide clear long-term policy guidance and measure progress on an ongoing basis. The enablers of this element are: 1) regular policy

planning cycles to improve and toughen up measures – based on regular monitoring, 2) dedicated institutional arrangements, i.e., a clear assignment of responsibilities, and 3) ongoing political support and buy-in, not only from decision-makers but also from stakeholders and the public – to increase both transparency and (perceived) legitimacy. Due to varying national circumstances among Member States, climate governance must also aim to coordinate both national and EU-level actions (Velten et al., 2021).

*Indicator selection*

Survey participants rated governance mechanisms in the Member States as the most relevant for assessing the progress of this element. The number of *Member States with climate laws* was ranked first, and the number of *Member States with dedicated institutions for independent scientific advice on climate policy* was ranked second. The *public support for mitigation action*, which was ranked third in the expert survey, is another crucial enabling factor for the successful implementation of climate policies (see Table 23).

**Table 23: Ranking of indicators for 'climate neutral governance' following the online survey**

| Rank | Indicator for climate neutral governance | Relation to element |
|---|---|---|
| 1. | Member States with climate laws [number of MS] | Enabler 2 – Institutional arrangements |
| 2. | Member States with a dedicated institution for independent scientific advice on climate policy [number of MS] | Enabler 2 – Institutional arrangements |
| 3. | Public support for mitigation action [% of surveyed population] | Enabler 3 – Political and societal support |
| 4. | Member States with a dedicated institution for climate policy related stakeholder engagement [number of MS] | Enabler 2 – Institutional arrangements |
| 5. | Population covered by the Covenant of Mayors for Climate and Energy signatories [number of inhabitants] | Enabler 3 – Political and societal support |

Source: own compilation based on the online survey

*Benchmarks and findings*

There are no legal requirements for the implementation of a climate law or a scientific advisory body. The European Climate Law indicates a direction by inviting all Member States to establish a scientific advisory body (Art. 3.4). Hence, we determined though expert judgement that all Member States should have a climate law and a scientific advisory body by 2025 at the latest. The data for the historical development can be found in the literature (e.g., Evans and Duwe, 2021) and governance research by the Grantham Research Institute and Ecologic Institute, among others.[3] Analysis showed that the development for both indicators is progressive but still insufficient: The trend was 90 % (climate laws) and 85 % (scientific advisory bodies) of the required change.

**Table 24: Progress check of the two highest ranked indicators in 'climate neutral governance'**

| Indicator | Scoring | |
|---|---|---|
| **Member States with climate laws [number of MS]** | ○ ○ ○ ○ | Progressive but insufficient for the net zero emission objective |

[3] The Grantham Research Institute Climate Change Laws of the World resource is available at https://climate-laws.org/ - last accessed 19 February 2023.

| | | |
|---|---|---|
| **Member States with a dedicated institution for independent scientific advice on climate policy [number of MS]** | ○○○○ | Progressive but insufficient for the net zero emission objective |

Source: own presentation

*Reflections*

Overall, data availability is poor for this element, as the quantification of political processes and policies comes with many challenges. The two indicators chosen for this analysis measure the existence of mechanisms for climate neutral governance, but they do not provide information on institutional design, which is crucial for the effectiveness of governance structures. They also do not provide a sense of the *quality* of governance mechanisms.

Furthermore, there are no indicators to cover the objectives or Enabler 1 of this element. Measuring the policy learning cycle (Enabler 1) for instance would require a multifaceted assessment to obtain the necessary data. Thus, additional analysis should consider the comprehensiveness and quality of existing governance structures and policies, which will require nuanced rating systems. Furthermore, experts proposed to include climate neutrality targets and other commitments, such as fossil-fuel subsidies phase out dates, in this indicator set.

## 5.12 Adaptation to climate impacts

This element describes progress on adapting to climate change, which means taking action to prepare for and respond to both current climate impacts as well as those impacts expected in the future. The EU Adaptation Strategy 2021 outlines four principal objectives: to make adaptation smarter, faster, and more systemic, and to improve international action for climate resilience. The enablers of this element are: 1) sufficient budget/funding dedicated to adaptation, 2) a governance framework for adaptation in place, 3) attitudes to adapting to the adverse impacts of climate change and 4) on the ground actions and measures.

*Indicator selection*

The survey participants ranked highest the share of protected areas and the share of naturally regenerating forest on forest land (for a definition, see FAO, 2020a).

**Table 25: Ranking of indicators for 'adaptation to climate impacts' following the online survey**

| Rank | Indicators for adaptation to climate impacts | Relation to element |
|---|---|---|
| 1. | Share of protected areas [% of total area] | Enabler 4 – On the ground actions and measures |
| 2. | Share of naturally regenerating forest on forest land [% of total forest] | Enabler 4 – On the ground actions and measures |
| 3. | Share of wetlands [% of total area] | Enabler 4 – On the ground actions and measures |
| 4. | Share of agricultural land under organic farming [% of agricultural land] | Enabler 4 – On the ground actions and measures |
| 5. | Population covered by the Covenant of Mayors for Climate and Energy signatories [% of population] | Enabler 1 – Budget and funding for adaptation |

Source: own compilation based on the online survey

*Benchmarks and findings*

The target trajectory for the share of protected forest is set through the EU Biodiversity Strategy, which stipulates that 30 % of terrestrial land should be protected areas by 2030 (EC, 2020a). The trend required to reach this target would be 3 % annually on average, which the trend of 6 % between 2016 and 2021 surpassed. Thus, the development is in line with the objective. There is no quantitative target value for the share of naturally regenerating forest on forest land. Since naturally regenerating forest helps to increase resilience and 'contribute more to biodiversity conservation and provide a wider range of benefits' (FAO, 2020b, p. 27), the share should be increasing. However, the trend over the last five years for which data is available shows a decline of 0.1 % annually on average, meaning the indicator is headed in the wrong direction.

**Table 26: Progress check of the two highest ranked indicators in 'adaptation to climate impacts'**

| Indicator | Scoring | |
|---|---|---|
| **Share of protected areas [% of total area]** | ● ● ● ● | In line with net zero emissions objective |
| **Share of naturally regenerating forest on forest land [% of total forest]** | ● ○ ○ ○ | Opposing the net zero emission objective |

Source: own calculations

*Reflections*

Adapting to the impacts of climate change consists of as many components as climate mitigation. This means one could compile a similarly comprehensive picture as we have done here for mitigation *just for climate adaptation*. Survey participants suggested to include the number of nature-based solutions as an indicator. However, data is only available in patches, which makes gaining a comprehensive picture of the developments in the element even more difficult.

# 6 Conclusions and recommendations

Pilot testing the indicator framework with two indicators for each net zero element has enabled us build effectively onto preceding work and gain valuable insights on the methodological front which can now inform the design and implementation of future, more comprehensive analysis. Key learnings touch on the selection of indicators, the identification of data gaps, and the role of data interpretation when analysing progress.

The preliminary results of the assessment of EU progress carried out in this report however provide just a first glimpse into the change over the past five years. As we suggest in our wider framework, a much more comprehensive assessment, with more indicators to cover each objective and enabler, would be required to establish a progress report that can inform decision-making in a robust manner, and adequately focus minds on trendlines around which additional effort is needed most.

### A first glimpse on EU progress towards climate neutrality

As an overarching message, only five indicators (out of 24 total selected indicators across all elements) are presently in line with a transition to net zero emissions by 2050. Seven indicators are currently progressive, but developments are not sufficient to reach the specified benchmarks. An additional six indicators remained rather stable and did not support or oppose the transition. The last six indicators showed development in the wrong direction.

Most promising seem the elements *zero carbon energy*, *just transition* and *climate neutral governance*. The related two indicators in each element showed at least some progress in the last five years with data, although it was not sufficient in all instances. In *moving without emissions* one indicator was currently in line and one not supportive, which paints a mixed picture. The two indicators in the elements *zero carbon buildings*, *carbon dioxide removal*, *lifestyle changes* and *technology* show no progress or even developments in the wrong direction (see Table 27).

**Table 27: Indication of progress towards climate neutrality in twelve net zero elements**

| | Indicator | Scoring |
|---|---|---|
| Zero carbon energy | Share of renewable energies [% of gross final energy consumption] | In line with net zero emissions objective |
| | GHG emission from energy generation [$tCO_2e$] | Progressive but insufficient for net zero emissions objective |
| Agri-food system | GHG emissions of agriculture [$tCO_2e$] | Not supporting the net zero emission objective |
| | Share of organic farming [% of agricultural land] | Progressive but insufficient for net zero emissions objective |
| Industrial trans-formation | GHG of industrial processes and product use [$tCO_2eq$] | Progressive but insufficient for the net zero emission objective |
| | Final energy consumption in industry [GJ] | Not supporting the net zero emission objective |
| Emission-free buildings | GHG emissions of the building sector [$MtCO_2e$] | Not supporting the net zero emission objective |
| | Final energy consumption in buildings [PJ] | Opposing the net zero emissions objective |

| | | | |
|---|---|---|---|
| **Moving without emissions** | GHG emissions from transport [$MtCO_2e$] | Not supporting the net zero emission objective | |
| | Share of zero-emission vehicles [% of newly registered cars] | In line with the net zero emission objective | |
| **Carbon Dioxide Removals** | Natural $CO_2$ removal of different land types [$MtCO_2$] | Not in line with net zero emissions objective | |
| | Contributions of GHG reductions and removals to an overall GHG net reduction target [$MtCO_2e$] | Opposing the net zero emissions objective | |
| **Net zero transition finance** | Price on carbon (EU ETS carbon price) [$EUR/tCO_2e$] | In line with net zero emissions objective | |
| | Fossil fuel subsidies [EUR] | Opposing the net zero emissions objective | |
| **Enabling tech-nologies** | Government budget allocation to environmental and energy-related R&D [% of total allocation to R&D] | Opposing the net zero emission objective | |
| | Fossil fuel subsidies [EUR] | Opposing the net zero emissions objective | |
| **Lifestyle changes** | Average per-person consumption of meat [kcal/capita/day] | Opposing the net zero emissions objective | |
| | Modal split in private transport [% of total transport] | Progressive but insufficient for net-zero emissions objective | |
| **Just Transition** | Population unable to keep home adequately warm [% of population] | In line with the net zero emission objective | |
| | Share of housing fuels expenditure [% of households' expenditure] | Progressive but insufficient for the net zero emission objective | |
| **Climate neutral governance** | Member States with climate laws [number of MS] | Progressive but insufficient for the net zero emission objective | |
| | Member States with a dedicated institution for independent scientific advice on climate policy [number of MS] | Progressive but insufficient for the net zero emission objective | |
| **Adaptation to climate impacts** | Share of protected areas [% of total area] | In line with net zero emissions objective | |
| | Share of naturally regenerating forest [% of total forest] | Opposing the net zero emission objective | |

Source: own presentation; for explanation of scoring see Box 1.

## Key learnings and methodological reflections on the application of the framework

### 1. Progress in two elements is the result of exceptional drops in energy consumption in 2020, suggesting that a trendline adjustment can be meaningful

The analysis confirmed that the COVID-19 pandemic positively influenced trendlines among several indicators related to energy consumption, as the measures taken to containing the pandemic led to significant reductions in mobility and industrial production. While these developments are mostly positive from a climate neutrality perspective, they distort the overall picture: provisional data suggest that the trend has partly bounced back, and changes are, if at all, a weak indication for structural change.

The positive progress classification is influenced by the definition of the past trend and the chosen period. The past trend is calculated by taking the first and the last datapoint from a five-year period (see also Box 1). For most of the indicators, the last datapoint was 2020. Applying this methodology, interim values do not play a role in the progress calculation. This means that the methodology is sensitive to outliers if they constitute the first or the last year of the given period. The year 2020 is heavily carries weight as the often-last data point of the trendline. An alternative might be to use a trendline which includes the values for all years. A longer period would smooth outliers, but it would also shift the focus away from short-term progress.

### 2. Headline objective indicators are deemed most relevant but must be complemented with indicators linked to enablers

The survey showed that in almost all cases, the indicators referring to headline objectives were deemed as most significant to assess the state of progress towards climate neutrality.[4] This outcome is not surprising as the indicators linked to enablers measure more specific underlying conditions in the overall transition to net zero, whereas the objectives show the overall progress of the element.

However, when pressed, survey participants often selected an indicator that measures an objective and one that measures an enabler showing that underlying conditions are also increasingly considered relevant. In some instances, the focus on enablers was more obvious than in others. In the element ‘net zero transition finance’, enabler indicators ranked first and second while an indicator related to the objective only reached the third rank; in the element ‘moving without emissions’, the first and third ranks went to indicators measuring the objective while one indicator measuring an enabling condition reached the second rank.

Some indicators received no votes at all showing that survey participants found these irrelevant. This includes indicators that measure formalised commitments to certain sustainability actions and goals on a company level, such as the *number of EMAS certifications*, *Responsible Investment Signatories,* and *sustainable tourism licenses*.

These results indicate than an observation of enabling indicators ensure that progress in the objective-level indicators is assessed in a comprehensive manner. An objective might look promising, but if the transitions underlying beneath the mere emission numbers do not progress, it will stagnate at some point. Likewise, even though an objective shows a discouraging trend, positive developments at indicator-level announce future progress to

[4] In some elements, the survey did not include any objective indicators due to missing data. This is the case for enabling technologies, lifestyle changes, just transition, and governance.

come. This means that an assessment of progress, when covering objective indicators, should be complemented by indicators providing information on the enablers. However, besides being comprehensive, there are indeed indicators (with good data availability) that measure progress on aspects which are deemed rather irrelevant in our context and should be excluded from the indicator framework.

### 3. Broad indicators can provide a proxy but extracting climate-related data would be more meaningful

Several indicators are quite broad covering not only climate-related data. For example, the element *enabling technologies* contains the indicators *R&D expenditure* and *research personnel*, which are both not necessarily climate-specific. Similarly, the element *net zero transition finance* includes the indicator *energy related investments*, which also covers investments in fossil fuels. For the element *just transition*, this difficulty in attribution is inherent. Several, if not most, indicators do measure inequality overall, not specifically inequality in relation to the climate transition. In these and similar cases, the indicators might provide a proxy, but it would be more meaningful to extract the climate-related data where such extraction is possible.

### 4. Overlapping indicators should be reviewed to streamline the indicator set

In some cases, indicators overlap in what they measure. For example, the indicators *GHG emissions of energy supply* and *emission intensity of energy generation* in the element *zero carbon energy* both show GHG developments in the energy sector even if the first indicator measures total GHG emissions, while the second is a relative indicator in which GHG emissions are compared to energy consumption. In other cases, indicators are in fact sub-indicators of others. The indicator *natural removals of different land types*, for example, is essentially a sub-indicators of overall emission removals, as technical removals are not yet available at similar scale.

While in general, overlapping indicators can be useful to better understand an aspect of the net zero transformation , the inclusion of overlapping indicators can also unintentionally increase the focus on a particular aspect of an element, especially if not all aspects in an element are covered by the same number of overlapping indicators.

This shows, that the selection of overlapping indicators should be reviewed more closely, and the intercorrelation between indicators should be tested to exclude those which show the exact same progress over time.

### 5. A more structured approach is needed to identify where data collection efforts are necessary

Data availability for indicators differs significantly between elements. The key reasons for missing data are: 1) data is locked behind a paywall or require some form of special access, which is the case for finance-related indicators and emission removal technologies; 2) data is not collected systematically and on an ongoing basis but only available from individual studies, and 3) no database can be found.

For this proof of concept, our aim was to have at least five indicators per element before narrowing down to two with help of the expert survey. While we started with the selection outlined in Velten et al. (2021), we soon found that we had to conduct additional research to achieve our objective. We thus carried out research especially for buildings, agri-food, finance, technologies, industry, carbon dioxide removal, and governance. We also had to make compromises for data continuity and frequency where reasonable—e.g., data for land coverage is only available every three years.

As our research focussed on finding available datasets that could be relevant in light of the net zero elements; it was not a structured gap analysis for each element and the related objectives and enablers. Further work should therefore take a more structured approach to the identification of relevant datasets that are deemed most important for tracking progress towards climate neutrality. Such work could form the basis to recommend data collection efforts by public authorities or also via recurring studies.

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EU Governance Regulation: Regulation (EU) 2018/1999

# Annex I. A new net zero element: adaptation to climate change

This element describes the progress towards adapting to climate change which means taking action to prepare for and respond to both current climate impacts, as well as those impacts predicted for the future. Despite ongoing mitigation efforts global GHG emissions continue to increase, and the rising concentration of GHGs in the atmosphere will continue to push global temperatures upwards. This, in turn, will increase risks and vulnerabilities to a range of impacts including heatwaves, droughts, and floods, as well as rising sea levels and decreased biodiversity, amongst others. As such, adapting to climate impacts will require a wide range of responses across sectors, both at the European level, but also from individual Member States (see e.g. EEA, 2019).

## Objectives and targets

The EU Adaptation Strategy 2021 has four main objectives: to make adaptation smarter, faster, and more systemic, and to improve international action on for climate resilience. Smarter adaptation means improving knowledge and managing uncertainty, for example, by improving adaptation knowledge, expanding climate loss data, and enhancing the Climate-ADAPT platform. Faster adaptation refers to speeding up adaptation implementation. More systemic adaptation supports policy development across levels (EU, national, local) and fields, with a focus on integrating adaptation in macro-fiscal policy, nature-based solutions, and local adaptation. In addition to the goals of the Adaptation Strategy, the EU has set a target for climate spending to represent 30% of the EU budget in the period 2021-2027 (EC, n.d.). Although there is no mention of how this is broken down between mitigation and adaptation spending, ensuring sufficient funding will be key to successful achievement of adaptation goals. Finally, the river restoration target of the Biodiversity Strategy 2030 (at least 25,000 km of rivers to be restored to free-flowing rivers by 2030) is another target related to adaptation. Restoring free-flowing rivers supports adaptation to climate change, for example, by increasing water retention and reducing flood risk, as well as improving water availability in a river basin.

**Box 2: Adaptation to climate impacts – indicators for 'objectives and targets'**

- River restoration [km]
- Share of EU budget dedicated to climate [%]

## Enablers

### Sufficient budget/funding dedicated to adaptation

To achieve the objectives and targets outlined above, a significant portion of European, national, and local budgets will need to be earmarked for adaptation initiatives. Ensuring sufficient financing for adaptation will enable adaptation research, innovation, and the implementation of actions towards achieving relevant goals (UNEP, 2021). Unfortunately, tracking adaptation funding at the European level is not yet straightforward as initiatives are funded through a range of instruments, including, but not limited to: the Recovery and Resilience Facility, LIFE and Horizon Europe programmes, the EU Cohesion Policy, and the European Regional Development Fund. Tracking national level funding is also challenging, as there are significant differences between Member States (MS) in their reporting. Improving the monitoring and reporting of budgets and funding will be key to achieving the objectives of the EU Adaptation Strategy and reaching the 30% target for climate spending in the EU budget (Leitner, Mäkinen, et al., 2020). Finally, in 2020 the concept of 'Key Type Measures' (KTMs) was introduced as a means of both grouping and reporting on measures and actions for adaptation (Leitner, Dworak, et al., 2020). These are currently a voluntary element of national adaptation reporting, with eight MS providing data in 2021. Though they are not currently used to track *implementation* of measures, these should be considered a useful tool for monitoring and reporting moving forward.

**Box 3: Adaptation – Indicators for 'Sufficient budget/funding dedicated to adaptation'**

- Share of climate/adaptation budget of total EU budget [percentage]
- EU Budget on Adaptation [Euro]
- National Adaptation Budget [Euro]
- Investment into costal protection
- Measures meeting KTM B1 'Financing and incentive instruments' [number]
- Measures meeting KTM B2 'Insurance and risk sharing instruments' [number]

### E2: Governance framework for adaptation in place

Effective implementation of adaptation initiatives requires well-developed legal and policy frameworks. This is reflected by the preparation, development, and implementation of National Adaptation Strategies (NAS) as well as National Adaptation Plans (NAP). Whereas the NAP was established as a global tool through the UNFCCC, the NAS is an EU instrument which MS apply following a set of guidelines developed by the EC. Furthermore, the selection of adaptation actions and measures can be tracked both through Action Plans or Programmes of Measures as well as sectoral and sub-national policies (e.g. national disaster risk reduction strategies in line with the Sendai Framework). An effective governance framework should also include regular monitoring and evaluation of the policies to enable their update in an appropriate manner, and stakeholders should be involved in the assessment and review process. Finally, the mainstreaming of adaptation in different policy fields can also be a major building block – this can mean, for example, climate-checked policies or budget for adaptation-relevant actions appearing in sectoral policies (EU Council, 2022) .

**Box 4: Adaptation – Indicators for 'Governance framework for adaptation in place'**

- Member States with an approved National Adaptation Strategy
- Adaptation policies and measures implemented, e.g. as defined in action plans or sectoral policy documents
- A periodic review of the national adaptation strategy and action plans is planned
- NAS/NAP implementation is monitored and results are disseminated
- Population covered by the Covenant of Mayors for Climate and Energy signatories (with adaptation commitment)

### E3: Attitudes to adapting to the adverse impacts of climate change

Raising awareness of current and future climate impacts, as well as the importance of adapting to these impacts, is key to creating a paradigm shift in attitudes towards climate action. Encouraging knowledge and information exchange on adaptation topics leads to more-informed citizens, who can make their voices heard on relevant topics, and in turn push for the achievement of various climate objectives. Informed citizens are also enabled to implement adaptation measures themselves – for example in the building sector, where developers may choose to install passive cooling systems or to add shading elements to resist future temperature projections (Hegger et al., 2017).

**Box 5: Indicators for 'Attitudes to adapting to the adverse impacts of climate change '**

- Share of population that agree 'Adapting to the adverse impacts of climate change can have positive outcomes for citizens in the EU' [%]
- Measures meeting KTM E1 'Information and awareness raising' [number]
- Measures meeting KTM E2 'Capacity building, empowering and lifestyle practices' [number]

### E4: On the ground, actions, measures, etc.

In addition to awareness raising, developing suitable governance frameworks, and ensuring sufficient financing for adaptation, a key element in progressing adaptation is acting on the ground through the implementation of adaptation measures and actions. A wide range of actions can be taken with the intention of adapting to climate change, including 'green' and 'blue' measures or nature-based solutions, as well as 'grey' infrastructural or technological measures. The aforementioned 'Key Type Measures' approach exists as one potential categorisation of adaptation measures. Various indicators can be considered to track different aspects of adaptation action implementation. For example, identifying the share of agricultural land with organic farming represents an effort to implement practices that are adaptive and more robust in the face of climate risks (e.g., drought, erosion, flooding). Similarly, the share of wetlands on the total land area can be used to assess a nature-based approach to improving flood protection, managing water balance, promoting biodiversity, as well as other adaptation benefits.

**Box 6: Indicators for 'On the ground actions, measures, etc.'**

- Share of wetlands on total land area [%]
- Share of agricultural land with organic farming [%]
- Share of gentle tillage practices (i.e. conservation tillage and zero tillage) within overall tillage practices [%]
- Share of drip irrigation within overall irrigation [%]
- Share of mixed forest area in total forest area [%]
- Area of green roofs [m²]

# Annex II. Comparison to other indicator sets

There are a range of other indicator sets for monitoring and progress checking in climate policy and related fields, such as energy and environment. Relevant EU examples include the newly published indicator set under the 8th Environment Action Programme (EAP) (EC, 2022), the Green Deal statistics (Eurostat, 2022b) as well as the SDG Monitoring Indicators for SDGs 7 (Energy) and 13 (Climate action) (Eurostat, 2022d). To ensure our indicator set is comprehensive and relevant for current political discussions, we juxtaposed it with indicators from these three relevant EU indicator sets (see Table 28).

**Table 28: Comparison of our net-zero indicator set (NZI) and other EU indicator sets**

| | 8th EAP | Green Deal Statistics | SDG Monitoring | NZI |
|---|---|---|---|---|
| **Total and sectoral GHG emissions (incl. LULUCF)** | ● | ● | ● | ● |
| **Primary energy consumption** | ● | ● | ● | ● |
| **Final energy consumption** | ● | | ● | ● |
| **Share of renewables in final energy consumption** | ● | ● | ● | ● |
| **Energy productivity** | | | ● | |
| **Final energy consumption in households per capita** | | ● | ● | (1) |
| **Energy import dependency** | | | ● | ● |
| **Fossil fuel subsidies** | ● | | | ● |
| **Population unable to keep home adequately warm** | | ● | ● | ● |
| **Raw material consumption** | ● | ● | ● (SDG 12) | ● |
| **Waste generation** | ● | ● | | ● |
| **Circular material use rate** | ● | ● | ● (SDG 12) | ● |
| **Consumption footprint** | ● | | ● (SDG 12) | (2) |
| **Average $CO_2$ emissions from new passenger cars** | | | ● | ● |
| **Modal split passenger transport** | ● (3) | ● (4) | ● (SDG 9)(4) | ● |
| **Modal split freight transport** | | ● (4) | ● (SDG 9)(4) | ● |
| **Zero-emission vehicles** | | ● | | ● |
| **Premature deaths due to exposure to fine particulate matter (PM2.5)** | ● | ● | ● (SDG 11) | ● |
| **High-speed internet** | | ● | ● (SDG 17) | ● |
| **Pesticide consumption** | | ● | | ● |
| **Nitrates in groundwater** | ● | ● | ● (SDG 2;6) | (5) |
| **Environmental protection expenditure** | ● | ● | | |
| **R&D expenditure** | | ● | ● | ● |
| **Share of environmental taxes in total tax revenues** | ● | | ● (SDG 17) | ● |
| **Share of green bonds on total bonds** | ● | | | ● |
| **Climate-related economic losses** | ● | ● | ● | ● |

| | 8th EAP | Green Deal Statistics | SDG Monitoring | NZI |
|---|---|---|---|---|
| **Contribution to the international 100bn USD commitment on climate related expenditure** | | | ● | ● |
| **Employment and gross added value of environmental goods and services sector** | ● | | | ● |
| **Eco-Innovation Index** | ● | | | ● |
| **Forest and other wooded land** | | ● | | ([6]) |
| **GHG emission intensity of employment** | | ● | | |
| **Population covered by the Covenant of Mayors for Climate and Energy signatories** | | | ● | ● |
| **Share of protected areas on total area** | ● | ● | ● (SDG 15) | ● |
| **Land take** | ● | | | ● |
| **Area under organic farming** | ● | ● | ● (SDG 2) | ● |
| **Drought impact on ecosystem** | ● | | | |
| **Water Exploitation Index plus** | ● | | | |
| **Forest connectivity** | ● | | | |
| **Common bird index** | ● | ● | ● (SDG 15) | |
| **Consumption of hazardous chemicals** | | ● | | |

Source: own compilation.
([1]) = included as final energy consumption from residential buildings; ([2]) = partly covered by embodied GHG emissions; ([3]) = share of busses and trains; ([4]) = share of rail; ([5]) partly considered as fertiliser consumption; ([6]) = covered under land coverage

The indicator set used in this report covers most of the indicators in the EU indicator sets. Some, however, were intentionally excluded, for the following reasons.

We did not include indicators measuring the impact of climate change, such as drought impacts or the water exploitation index plus (from the 8th EAP), which measures the ratio of water use vs. available freshwater. These indicators do not necessarily measure the (institutional) progress that is happening in the EU. As mentioned, adaptation, in our framework, refers to those measures taken to make our environment more adaptive to a changing climate and reduce the consequences of the impacts of climate change, not the impact itself.

We did not include the eco-innovation index (used in the 8th EAP), as it only allows for comparison between Member States and does not offer an EU-wide aggregate. However, we included several sub-indicators, such as eco-innovation-related patents and eco-innovation-related publications.

Some indicators were excluded because they aim at the relationship between two related, but separate, datasets, such as GHG emissions by employment (Green Deal Statistics) and energy productivity, which shows how much economic output is produced per energy input (SDG 7). Such indicators give information about the relationship between related issues, which makes their interpretation difficult.

Some we deemed to be not directly relevant for to the transition to climate neutrality, further namely indicators, such as the consumption of hazardous chemicals are not included in this methodology.

# Annex III. Online survey

## Ranking of indicators following the survey outcome

The selection of the indicators was based on the outcome of the survey using a semi-quantitative approach, which allowed us to sort indicators in each element based on a combination of the ranking and respective expertise of the participant.

For this, we allocated points to indicators in each element based on:

- expertise of the expert: scale of four (no, low, medium, high expertise) with 'no expertise' = 0 points to 'high expertise' = 4 points; and
- rank of the indicator: scale of three (1st rank, 2nd rank, 3rd rank) with '1st rank' = 3 points to '3rd rank' = 1 point.

The points for each indicator were calculated as:

$$I_P = \sum_{i=1}^{i=n} P_{rank;expert\ i} \times P_{expertise;expert\ i}$$

with:

| | |
|---|---|
| $I_P$ | = Indicator points |
| i | = number of expert |
| n | = total number of experts |
| $P_{rank;expert\ i}$ | = Points according to rank as choose by expert i |
| $P_{expertise;expert\ i}$ | = Points according to the expertise of expert i |

Subsequently, we ranked the indicators in each element based on the allocated points to select the top two indicators.

## Outline of the online consultation

### Landing page text

This section will include text on context (report and its purpose), objective of this survey and that there is no mandatory questions but that participants are free to choose what to fill-in. We will also add information on data security.

### Questions

*[there is no mandatory question in this questionnaire]*

1. **Please state your name and institution so we can set your reply into context.**

| | |
|---|---|
| *Name* | *Free entry* |
| *Institution* | *Free entry* |

### 1. Please state your email address if you would like to keep posted on our work.

| |
|---|
| *Free entry* |

### 2. Your expertise

Please indicate your expertise for the following themes or elements in the **context of reaching climate neutrality** by 2050 the latest:

| | High expertise | Medium expertise | Low expertise | No expertise |
|---|---|---|---|---|
| Use and applicability of indicators and progress measurement | [tick option] | [tick option] | [tick option] | [tick option] |
| Energy supply | [tick option] | [tick option] | [tick option] | [tick option] |
| Buildings | [tick option] | [tick option] | [tick option] | [tick option] |
| Mobility | [tick option] | [tick option] | [tick option] | [tick option] |
| Industry | [tick option] | [tick option] | [tick option] | [tick option] |
| Food system / agriculture | [tick option] | [tick option] | [tick option] | [tick option] |
| GHG removal (natural and/or technical) | [tick option] | [tick option] | [tick option] | [tick option] |
| Technologies | [tick option] | [tick option] | [tick option] | [tick option] |
| Lifestyle change | [tick option] | [tick option] | [tick option] | [tick option] |
| Finance | [tick option] | [tick option] | [tick option] | [tick option] |
| Just transition | [tick option] | [tick option] | [tick option] | [tick option] |
| Adaptation to climate change | [tick option] | [tick option] | [tick option] | [tick option] |
| Climate governance | [tick option] | [tick option] | [tick option] | [tick option] |

| | |
|---|---|
| Any comments? | *Free entry* |

### 3. Ranking of indicators in each element

In the following, we provide a list of indicators in each of the different elements. We pre-selected indicators with easily accessible database.

Please indicate for each of the elements your top three indicators which are most relevant in the context of the element and in achieving climate neutrality. Feel free to skip elements.

#### Element: Energy supply [with SKIP OPTION]

| | Rank |
|---|---|
| GHG emission from energy generation [$tCO_2e$] | [drop-down option] |
| Share of renewable energies [% of gross final energy consumption] | |
| Renewable energies capacity [MW] | |
| Carbon intensity of electricity generation [$gCO_2e/kWh$] | |
| Energy related investment [EUR] | |
| Fossil fuel subsidies [EUR] | |

| | |
|---|---|
| Share of households' expenditure on housing fuels [% of expenditure] | |
| Primary energy consumption [PJ] | |
| Final energy consumption [PJ] | |
| Energy import dependency [% of energy imports] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Net-zero industrial transformation [with SKIP OPTION]

| | Rank |
|---|---|
| GHG of industrial processes and product use [$tCO_2eq$] | |
| Final energy consumption in industry [GJ] | |
| Embodied' GHG emissions [$tCO_2eq$] | |
| GHG of waste management [$tCO_2eq$] | |
| Number of certificates for an environmental management system (EMAS) [new certified organisations per year] | |
| Recycling of wastes [% of total waste] | |
| Circular material use rate [%] | |
| Small and medium sizes enterprises producing products that are easier to maintain, repair or reuse [% of all SME] | |
| Raw material consumption [tonnes] | |
| Exports of environmental goods and service sector [% of total exports] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Emission-free buildings [with SKIP OPTION]

| | Rank |
|---|---|
| GHG emissions of the building sector [$MtCO_2e$] | |
| Share of renewables in heating and cooling [% in heating and cooling] | |
| Final energy consumption in buildings [% change to 2005 and/or PJ] | |
| Share of households' expenditure on housing fuels [% of expenditure] | |
| Recovery rate of construction and demolition waste [% of treated construction and demolition mineral waste] | |
| Gross fixed capital formation for dwellings [% of GDP] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Moving without emissions [with SKIP OPTION]

| | Rank |
|---|---|
| GHG emissions from transport [$MtCO_2e$; % change to 1990] | |
| Energy consumption of transport [PJ] | |
| Share of low-emission fuels [% of fuels used in transport] | |
| Average GHG emissions of new vehicles [$gCO_2e/km$] | |
| Share of zero-emission vehicles in newly registered cars [% of newly registered cars] | |
| Vehicle stock [number of vehicles] | |
| Expenditure per capita on transport [EUR; % of overall household expenditure] | |
| Passenger transport volume and modal split [passenger-km; % of all passenger kilometre] | |
| Freight transport volume and modal split [tonne-km; % of all tonne kilometre] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Sustainable Agri-food system [with SKIP OPTION]

| | Rank |
|---|---|
| GHG emissions of agriculture [$tCO_2eq$] | |
| Share of agricultural land with organic farming [% of agricultural land] | |
| Traded meat and feed [tonnes imported/ exported] | |
| Net GHG emissions of land use, land use change and forestry (LULUCF) [$tCO_2eq/year$] | |
| Food utilisation (for feed, seed, food) [tonnes] | |
| Average per-person consumption of meat [kg/capita per year] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Carbon dioxide removal [with SKIP OPTION]

| | Rank |
|---|---|
| Natural $CO_2$ removal of different land types [$MtCO_2$] | |
| Land conversion to urban or other artificial land (land take) [km²/ year] | |
| Carbon stock in living biomass [tonnes of carbon] | |
| Change in land coverage [%-share; ha] | |
| Contributions of GHG reductions and removals to an overall GHG net reduction target [$tCO_2e$] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Climate-neutral governance [with SKIP OPTION]

| | Rank |
|---|---|
| Member States with climate laws [number of MS] | |
| Member States with a dedicated institution for independent scientific advice on climate policy [number of MS] | |
| Member States with a dedicated institution for climate policy related stakeholder engagement [number of MS] | |
| Public support for mitigation action [% of surveyed population] | |
| Population covered by the Covenant of Mayors for Climate and Energy signatories [number of inhabitants] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Just transition to climate neutrality [with SKIP OPTION]

| | Rank |
|---|---|
| Employment rate in the environmental sector [% of population aged 10-64] | |
| Value added in environmental protection and resource management activities [EUR; % of GDP] | |
| Population unable to keep home adequately warm [% of population] | |
| Share of households' expenditure on housing fuels [% of expenditure] | |
| High speed internet by type of area [% of households] | |
| Years of life lost due to PM2.5 exposure [years lost per 100.000 inhabitants] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Enabling technologies [with SKIP OPTION]

| | Rank |
|---|---|
| R&D expenditure in the EU [EUR; % of total expenditure] | |
| Overall R&D personnel [% of active population] | |
| Government budget allocation to environmental and energy-related R&D [EUR; % of total budget allocation to R&D] | |
| Total value of green early-stage investments [EUR/population] | |
| Eco-innovation related patents (in environment-related technologies, climate change adaptation technologies, sustainable ocean economy inventions) [number] | |
| Fossil fuel subsidies [EUR] | |
| Electrification of the economy [% of electricity in final energy consumption] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Lifestyle changes [with SKIP OPTION]

| | Rank |
|---|---|
| Average per-person consumption of meat [kg/capita per year] | |
| Total calories consumption per capita per year [kcal per capita] | |
| Rooms per person [rooms] | |
| Modal split in private transport [% of total transport] | |
| Household waste [kg per capita] | |
| Self-reported climate-conscious behaviour [% of surveyed population] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Net-zero finance [with SKIP OPTION]

| | Rank |
|---|---|

| | |
|---|---|
| Energy related investment [EUR] | |
| Price on carbon (EU ETS carbon price) [EUR/$tCO_2eq$] | |
| Contribution to the international USD 100bn climate finance [EUR] | |
| Environmental tax revenue as a share of GDP [% of GDP] | |
| Environmental tax revenue as a share of public revenue [% of public revenue] | |
| Fossil fuel subsidies [EUR] | |
| Expenditure on environmental protection [% of GDP] | |
| Principles for Responsible Investment Signatories [number of signatories] | |
| Climate related economic losses [EUR] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Element: Adaptation to climate impacts [with SKIP OPTION]

| | Rank |
|---|---|
| Population covered by the Covenant of Mayors for Climate and Energy signatories [% of population] | |
| Share of protected areas [% of total area] | |
| Share of wetlands [% of total area] | |
| Share of agricultural land under organic farming [% of agricultural land] | |
| Yearly licenses on sustainable tourism accommodations [number of licenses] | |
| Share of naturally regenerating forest on forest land [% of total forest] | |

Any relevant indicator/s not on the list? If so, please add it here and if possible, please add a data source and a short explanation of why the indicator is particularly relevant from your point of view.

| |
|---|
| [free entry] |

### Remarks and thank you

Thank you very much for filling in this survey on the relevance of indicators. Your input is much appreciated! If you have any other remark or comment, please feel free to provide it here or contact us directly (eike.velten@ecologic.eu).

| |
|---|
| [free entry] |

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