European Climate Neutrality Observatory

Flagship Report:

State of EU progress to climate neutrality

An indicator-based assessment across 13 building blocks for a climate neutral future

26 June 2023

Authors

Eike Karola Velten, Clara Calipel, Matthias Duwe, Nick Evans, Charlotte Felthöfer, Markus Hagemann, Judit Hecke, Lukas Kahlen, Simon Lalieu, Hugh McDonald, Natalie Pelekh, Thomas Pellerin-Carlin, Julien Pestiaux, Konstanty Ramotowski, Paula Schöberlein, Hannes Schritt, Aleksander Śniegocki, Aneta Stefańczyk, John Tarpey

Contributions

Vivian Depoues, Thomas Gilon, Niklas Höhne, Louise Jeffery, Lucile Rogissart, Jenny Tröltzsch, Clothilde Tronquet, Zofia Wetmańska

With special thanks to

Erica Hope and Nimali Samarasinha,
as well as colleagues from ECF and from our institutes
for providing valuable feedback

Branding and design by 89up, infographic support by John Lang

Contents

Executive Summary

The EU wants to become a climate neutral economy by 2050. Achieving this goal requires transforming the way we produce, consume, move, and eat.

The EU wants to become a climate neutral economy by 2050. Achieving this goal requires transforming the way we produce, consume, move, and eat. EU institutions have already put in place many measures to guide and support governments, businesses, and citizens in this transition. To be effective, policy-makers must now understand how, and at what pace, these measures are translating into changes in the real world. The European Climate Neutrality Observatory (ECNO) flagship report is the first ever assessment to provide this information at an **economy-wide level**.

ECNO's assessment looks across thirteen building blocks of a climate neutral future.

Within each of these, the assessment identifies enabling conditions for the change needed, which are then measured using 104 indicators for progress achieved thus far. The approach is designed to accompany the implementation of the European Green Deal. Because of the delay in data availability, this first assessment considers mostly data from the 2015–2021 period, at a moment when the European Green Deal was in its infancy. Green Deal policies are factored in where possible, and will shape future developments in each building block.

Key Insights

The EU is moving in the right direction, but still too slowly

1 The progress assessment shows that the EU has, over the period analysed, moved in the right direction, but needs to significantly pick up the pace of change to be on an effective path towards climate neutrality by 2050. This overall promising orientation was the case for all building blocks except for finance and carbon dioxide removals. A look at the additional policies adopted under the European Green Deal in the past two years indicates that the EU is taking steps to accelerate progress in most areas. This already shows in the governance system for climate policy that is assessed as being 'on track'.

2 The assessment contains detailed results to inform decision-makers about areas in need of closer attention. Further targeted action is most needed where objectives and key underlying enablers have been progressing 'far too slowly', or – as in some instances – have moved in the wrong direction. Enabling conditions are critical areas for investigation as they unlock essential transitions. Inadequate pace on enablers carries significant risk to the EU's ability to meet its target.

Action is most needed where objectives and key underlying enablers have been progressing far too slowly or not at all

3 A specific concern is the state of finance for transition in the EU. Counter-productive economic incentives remain in place, with some of them worsening in 2021 and 2022. Furthermore, the EU economy consistently puts too little public and private capital into climate investments, while still over-investing in fossil fuels. This endangers the transition at large as today's climate investments enable tomorrow's emissions reduction.

Significant gaps in data and ambition setting remain

4 Transparency on past progress is a crucial element of climate governance and the efficient allocation of capital by public and private economic actors. This needs adequate, reliable data and official benchmarks. The assessment however reveals that significant gaps in data and ambition setting remain. Without a solid information base and framework for assessment, decisive barriers or lack of progress may go unnoticed.

5 Current EU progress tracking is not designed to reveal detailed real-world developments to inform targeted policy action. Going forward, EU institutions should set up an official, up to date, granular, open-source monitoring system that is sufficiently granular to fulfil this function. The tracking system needs to be updated regularly, based on recent modelling of reliable pathways to 2050, and integrated with existing EU planning and monitoring systems. For full effect, EU decision makers should consider integrating into the EU Climate Law a dedicated action trigger based on the results of the assessments, akin to existing processes under the European Semester.

EU institutions should set up an official, up to date, open-source monitoring system

ecno
European Climate Neutrality Observatory

Effective EU policymaking towards climate neutrality needs detailed information

The transition to climate neutrality is essential for ensuring a liveable future.

It requires the modernisation of many existing structures and practices – from the way we move, to how our food is produced, and how we warm and cool; from what our buildings are made of, to how our cities are organised. All these building blocks must transform so that we fulfil our needs while releasing net zero or net negative greenhouse gas (GHG) emissions into the atmosphere.

Achieving climate neutrality by 2050 at the latest is further the cornerstone of the European Union's (EU) strategic vision and of its commitment under the Paris Agreement.

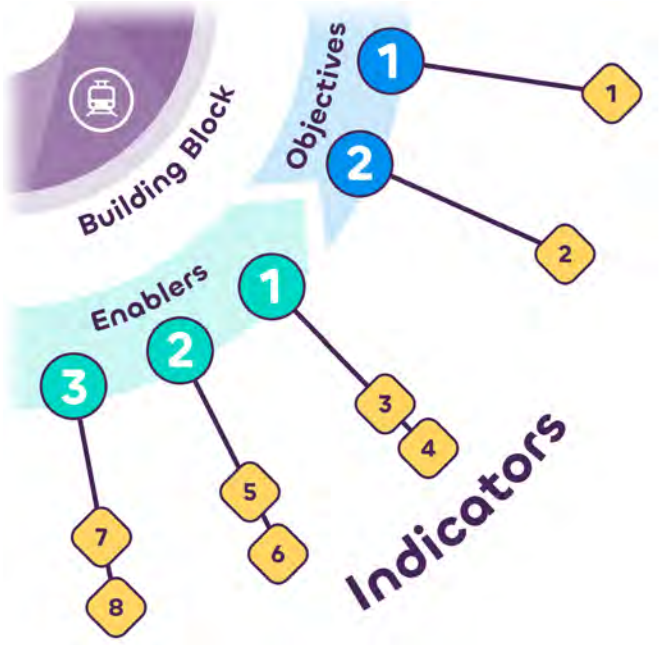
Getting there will need coordinated action based on long-term planning, effective monitoring, and targeted policy interventions. The EU Climate Law responds to this by demanding regular checks of EU Member States' collective progress towards the climate neutrality goal. The first of these progress assessments is due by 30 September 2023, and is to be repeated every five years. However, the official existing monitoring system does not contain the information needed to understand if sufficient progress is happening in the structural changes that need to occur beneath the overall emissions curve.

Obtenu pour vous par
Obtained by
agence europe

ecno
European Climate Neutrality Observatory

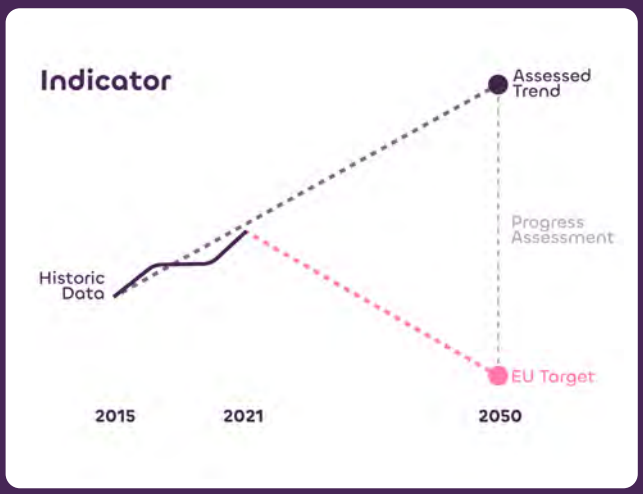
An in-depth, indicator-based understanding of real-world change

ECNO seeks to strengthen the EU's official processes and contribute to evidence-based policy-making.



ECNO's first-of-its-kind assessment of EU progress towards climate neutrality by 2050 takes an in-depth look at state of the changes that need to occur across **13 building blocks** essential to a climate neutral future. The assessment presents **objectives** for each of these blocks and identifies key **enablers** to realise them. It then measures progress for both the objectives and their enablers. This approach is different from traditional monitoring practices, which tend to focus on headline targets only and miss out on more granular developments in the enabling conditions for the transition. Observing the development of enablers provides insights on the current trend of the transition in a given sector or policy field, and an indication of how progress on the objectives may continue in the future.

A total of 104 indicators were identified to measure past progress over a set period (using data mainly from 2015–2021). Data trends are combined with an expert assessment of up-to-date developments in EU policy, to arrive at a robust progress assessment for each building block. To be consistent with EU planning and monitoring, progress is measured against the EU's own vision for a climate neutral future, formed from official EU documents and the targets and benchmarks indicated therein.



Thirteen building blocks of a climate neutral future

The 13 building blocks used for this assessment combine classic economic sectors with cross-cutting policy areas that all have a bearing on the EU's ability to achieve climate neutrality. The sectoral building blocks include mobility, industry, buildings and the agrifood system, with electricity as a key driver for the transition at large. The need for carbon dioxide removal to compensate for residual greenhouse gas (GHG) emissions is also considered.

The cross-cutting building blocks strongly influence sectoral developments and support their GHG emission reductions. Finance, clean technology, and lifestyles underpin the necessary changes in the sectors, while governance covers the overarching decision-making framework for climate policy. Just and inclusive transition measures are key to manage the impact on EU regions and citizens. The EU's responsibility to respond to climate change impacts and counteract vulnerabilities of its citizens is covered under adaptation, and the final cross-cutting building block assesses the consistency of EU external action with climate neutrality.

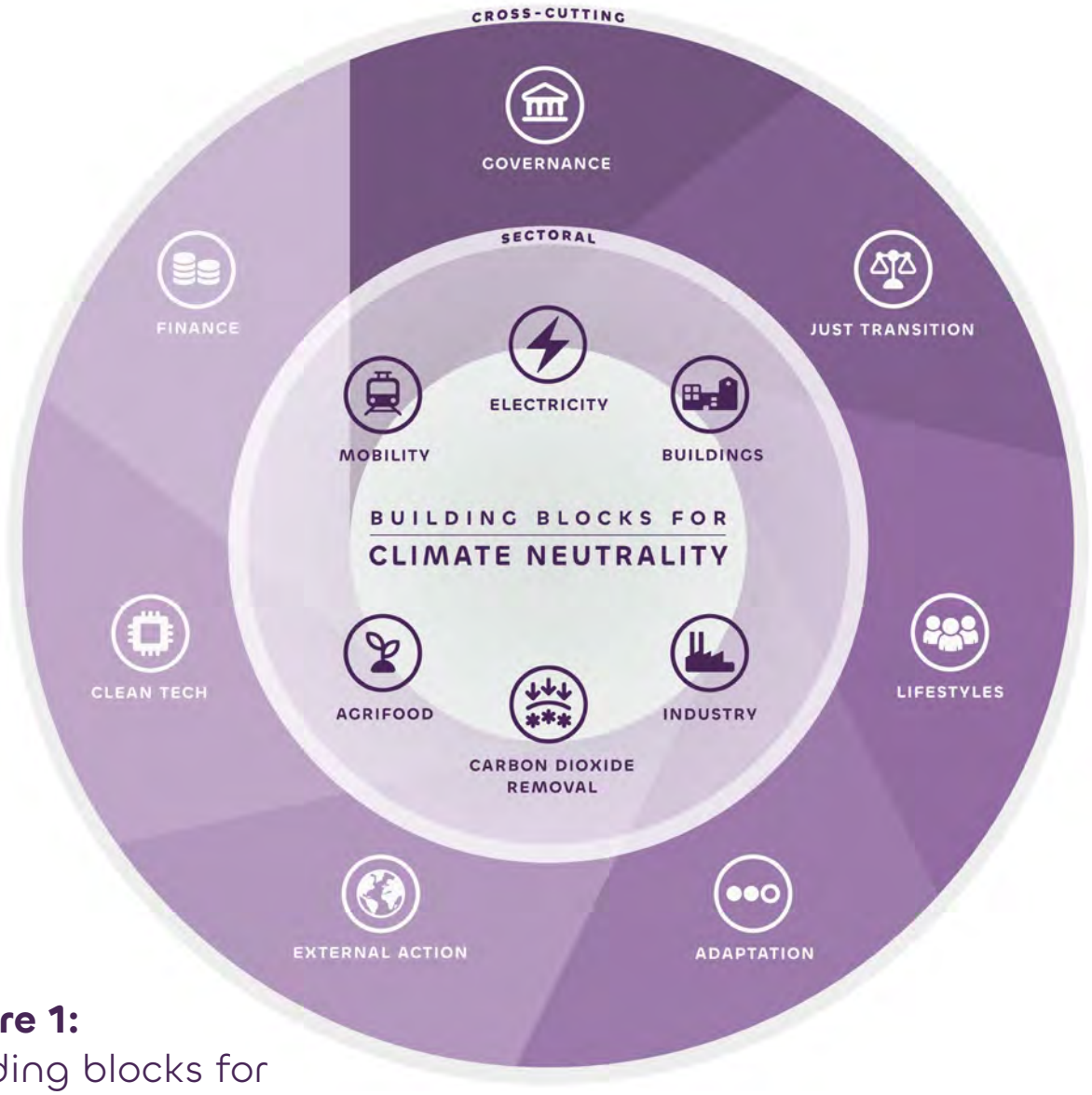


Figure 1:
Building blocks for the transition to climate neutrality

Results: Positive signals and urgent areas for policy intervention

As the EU finalises the legislation related to the European Green Deal, the analysis across 13 building blocks reveals strengths and weaknesses in the EU's progress towards climate neutrality.

Some of these insights can serve as inspiration and a source for optimism that policies are already working, while others are cause for concern and point to the need for stronger, targeted action. An overview of progress can be found in Figure 2. Detailed analysis and interpretation for each building block can be found in Chapter 4 of the full report. The top line insights are as follows:

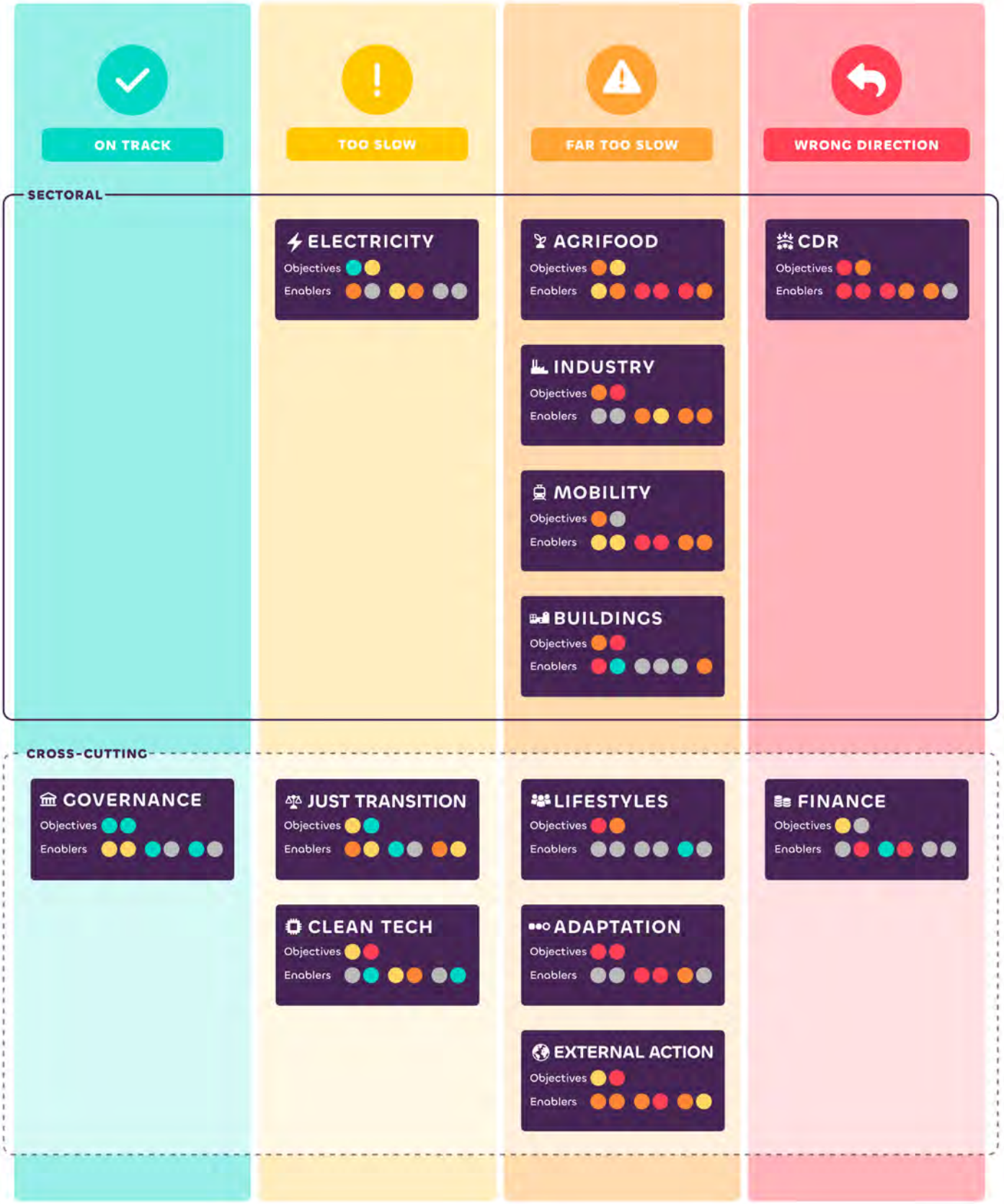
1 The assessment shows that the EU has, over the period analysed, moved in the right direction, but needs to significantly speed up its actions to be on an effective path towards climate neutrality by 2050.

2 At the outset of European Green Deal implementation, only one of the building blocks showed developments at a pace that puts it 'on track'. The observed trend for three of 13 building blocks was 'too slow' and in seven 'far too slow' when compared to what EU documents set out as is required to be on a path to climate neutrality by 2050 at the latest. In two areas, developments were moving in the 'wrong direction'.

3 Progress within the **sectors** revealed a broad spectrum. *Electricity* was almost 'on track', but the share of renewable energy and level of system integration was building up too slowly to cater for future needs in a timely manner, particularly as electrification progresses in other sectors. In *mobility*, *industry*, *buildings*, and *agrifood*, progress was found to be 'far too slow' over the assessed period, requiring a clear acceleration of change under Green Deal policies to put the EU on a path to climate neutrality. *Carbon dioxide removal* was moving in the 'wrong direction' primarily due to shrinking natural sinks.

4 The **cross-sectoral building blocks** also varied in their progress: *governance* was assessed as being 'on track', while *just and inclusive transition*, *clean technology*, *lifestyles*, and *external action* were found to be heading in the right direction but too slowly – particularly the latter two areas need to significantly speed up. Progress on *adaptation* was on the tip of going in the wrong direction and *finance* was clearly off track. Adequate financing is of particular concern considering the lack of climate investments and the increase in fossil fuel subsidies, that can negatively affect the transition in all sectors, slowing down progress if this remains unaddressed. The result for *governance* is, however, a promising signal. It indicates that an increasingly robust framework is being put in place to facilitate adequate actions in sectors and cross-cutting building blocks alike.

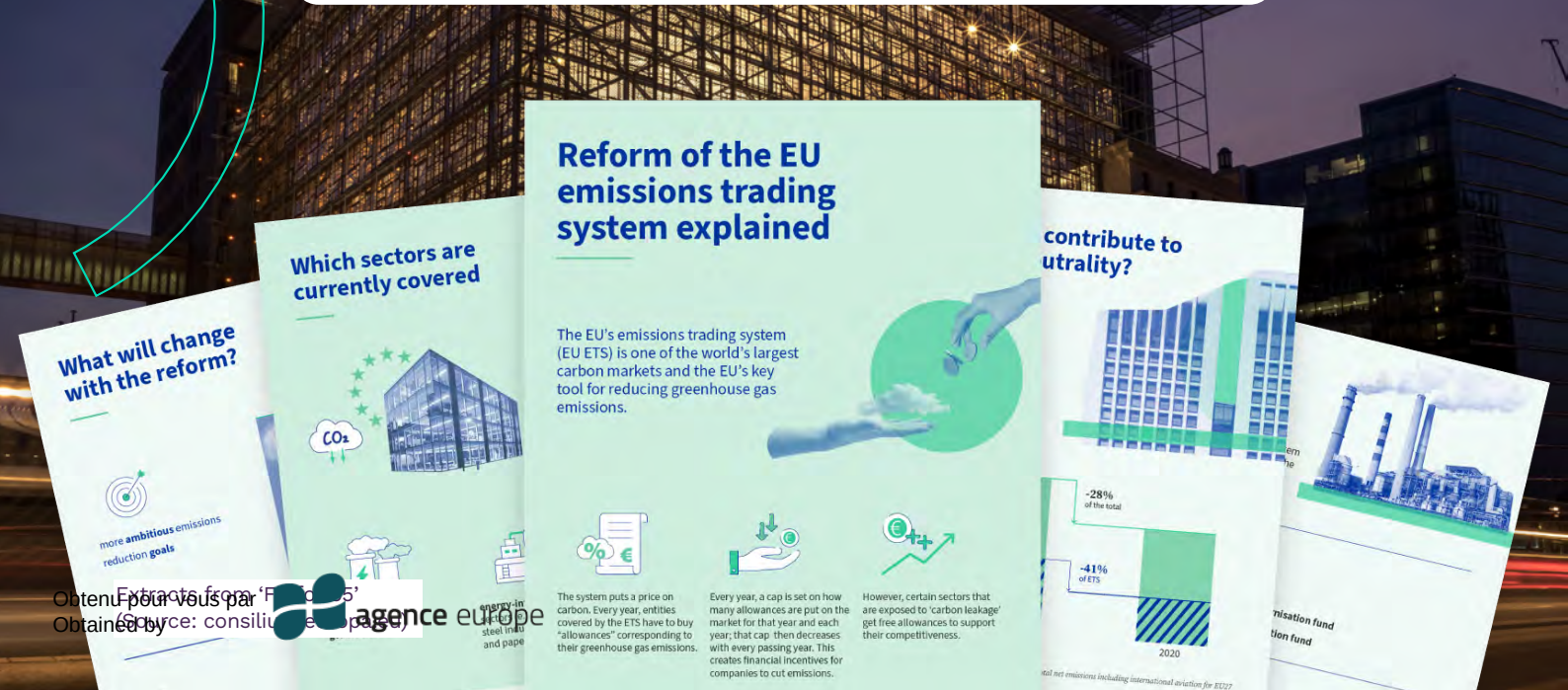
Figure 2: Progress across the building blocks for reaching climate neutrality



A likely speed boost from recent policy changes

The findings, largely derived from data for 2015–2021 and up-to-date qualitative information, need to be understood in the context of a rapidly developing landscape of EU climate policy. The European Green Deal and the subsequent 'Fit for 55' package of measures include expanded and additional policies that are and will continue to provide further guidance and levers to steer the building blocks in the right direction. This wealth of new policy initiatives at EU level for climate neutrality and for greater energy independence are signs that EU institutions are engaging with several of the necessary sectoral transitions. When deciding progress classifications for the building blocks for this report, the respective expert authors accounted for some of these recent political developments, thus supplementing the analysis of indicator values. Going forward, the indicator values themselves will show a changing reality if the policies have been designed effectively and if their implementation is sound and timely. Future reiterations of the assessment will be able to analyse such effects or the lack thereof.

The task is now for policy-makers to consider where the results of the assessment identify areas of inadequate progress that are not already addressed by recent policy changes, and therefore require additional targeted action.



Looking forward: Recommendations for policy-makers

The assessment underscores that to navigate this decisive decade for climate action, EU policy-makers urgently need a tracking system that is capable of indicating clearly and comprehensively where progress is sufficient, where it is not fast enough, or where it is even going in the wrong direction. Such insights will be key to formulating corrective policies or revising existing policies to align better with a path to climate neutrality – as well as identifying and removing of policies that set the wrong incentives.

The assessment found that, in principle, the EU already has a governance system in place that is correctly designed for the transition to climate neutrality. Yet, it needs to continue evolving and above all, needs to be implemented adequately. Article 6.1 of the EU Climate Law obliges the European Commission to assess progress towards climate neutrality, the lack of a sufficiently granular monitoring framework is an obvious blind spot. ECNO has been set up to fulfil this function in the absence of EU institutions doing it as comprehensively as needed; ultimately however, it is decision-makers who need to own this process.

The assessment has also revealed that presently, data to measure progress on important objectives and enablers is missing and that existing targets and benchmarks are often out-of-date. Such data gaps lower the accuracy of any progress assessment and leave policy-makers with blind spots that undermine their ability to make the right decisions.

These considerations lead to the following set of recommendations for EU institutions:

Take action

on the areas where the assessment shows particularly concerning developments, meaning where certain objectives and particularly crucial enablers of change were found to be going in the wrong direction. This concerns finance and carbon dioxide removals overall, but also specific enablers within other building blocks, such as shifting livestock production towards a more sustainable model, a modal shift in passenger and freight transport, or adaptation to climate impacts in agriculture and forestry.

Set up an official monitoring system

designed to inform policy-making, based on a comprehensive set of indicators, which looks at the structural changes under the emissions curve and their enabling conditions.

Integrate and align the monitoring system with other EU tracking systems

(e.g., 8th Environmental Action Programme, EU Semester, etc.) to reduce administrative effort and inform multiple processes in a coherent manner, including national-level planning and reporting.

Regularly update

both the underlying pathways and the progress assessment – at least every two years.

Close data gaps

via new reporting obligations and adjusted data collection routines.

Involve expert stakeholders

from Member States, civil society, business, and academia in the development of the system in a transparent and open fashion to enhance support and facilitate its application.

Design an action trigger mechanism

possibly akin to the Alert Mechanism Report under the European Semester, to verify the seriousness of an observed lack of progress and ensure targeted policy interventions are put forward if needed.

Obtenu pour vous par
Obtained by
agence europe

There is a **window of opportunity** to implement these recommendations for a better official EU monitoring system through the upcoming reviews of the Governance Regulation and the EU Climate Law in 2024. But there is no need to wait. Under the existing obligation for a progress assessment, the European Commission can already kickstart the process.

With this first in-depth assessment report, the ECNO wants to inform a broader dialogue on how the EU can best track progress and to highlight areas for priority action based on its findings. **ECNO welcomes feedback** and exchange with all interested parties on both the methodology and results of this exercise. ECNO intends to repeat this assessment on an annual basis and seeks to progressively expand its understanding and refine the underlying approach to further improve the insights for policymakers.

If you have any questions or comments, please contact the ECNO team:

info@climateobservatory.eu

1. Introduction

1.1 Monitoring progress is essential for effective climate policy

The global transition to climate neutrality is essential for ensuring a liveable future. This unprecedented project for humanity comes with changes to many of the essential structures and practices in our economies and societies. From the way we move to how our food is produced and how we keep warm (and cool); from what our buildings are made of, to how our cities are organised – all these building blocks must transform, so that we are fulfilling our needs with net zero or net negative greenhouse gas (GHG) emissions released to the atmosphere.

A strategic long-term vision informs EU climate policy and its targets

Achieving climate neutrality by 2050 at the latest is also the cornerstone of the European Union's (EU) economic strategy, the EU Green Deal. The EU has set itself this objective as its contribution to the landmark international agreement to stop the climate crisis, the Paris Agreement, which entered into force in 2016. Realising this whole economy transition now requires coordinated actions based on long-term planning, effective monitoring, and targeted policy adjustments.

As a first essential step, the EU published its long-term strategy (EU LTS) in late 2018, detailing how it plans to tackle this mammoth task (EC, 2023p). The analysis underpinning this goal and the EU's strategy was updated in 2020 with the EU 2030 Climate Target Plan (EC, 2020f). This plan highlighted that higher emission reductions are relevant and cost-effective already by 2030, following which the EU increased its 2030 climate target to -55% net GHG emissions compared to 1990. Since 2021, **climate neutrality is enshrined as legally binding in the EU Climate Law**. Enshrining this overarching goal in framework legislation is key to mainstreaming the goal across EU policy areas. An all-of-government approach is fundamental to making good policy decisions

and ensuring that the implications of a climate neutral society are integrated into all relevant initiatives and laws.

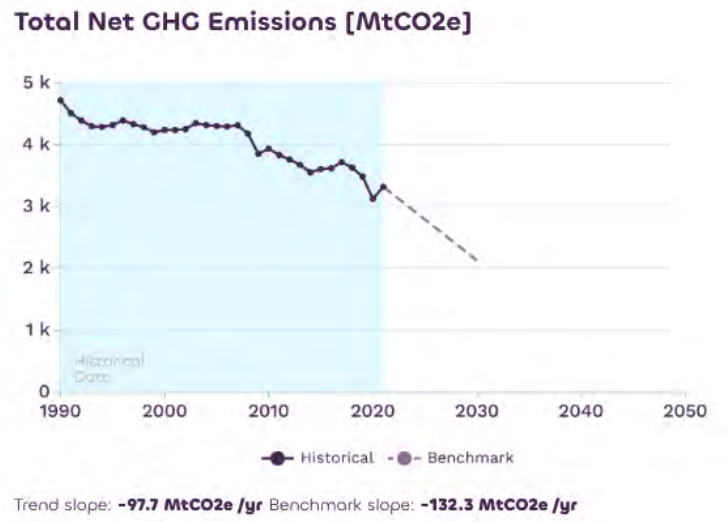
These essential foundations for EU Green Deal implementation come just at the right time. The latest reports by the Intergovernmental Panel on Climate Change (IPCC, 2023) indicate clearly that to keep the Paris Agreement goal of limiting global temperature change to 1.5° degrees within reach, the 2020s are the crucial decade to trigger the global transition to climate neutrality.

The EU Green Deal must bend the emissions curve

A bird's eye view of the **observed change in overall net GHG emissions** over the past five years of data offers a clear message: While emissions in Europe have continued to go down, a faster rate of reduction is required to meet both the 2030 target and climate neutrality by 2050.

Between 2016 and 2021, the EU achieved an annual net emission reduction of 98 Mt of carbon dioxide equivalents (CO_2e) or -30% in 2021 compared to 1990 (EEA, 2023b). To be on a linear path to the 2030 target, net annual emission reductions must increase by roughly a third to 132 Mt CO_2e starting from the last datapoint in 2021. There will also be a likely need to compensate for a slight emission increase in 2022 (EEA, 2022f; Eurostat, 2022i) as a result of the energy crisis spurred by Russia's war against Ukraine. EU Green Deal policies have been designed to bend the emissions curve and must now be closely monitored for their impact.

Figure 1: Annual change in net GHG emission reductions must increase to reach 2030 target



Source: own presentation based on EEA (2023b)

Policy makers need to look 'beneath the emissions curve' for targeted changes

Overarching trends for GHG emissions only provide a superficial sense of progress. Knowing whether the EU is on the right course requires substantially more information than is currently available from existing monitoring tools. A comprehensive picture needs to consider how all the building blocks of society fit together and whether the critical underlying structural changes are underway that will form a climate neutral economy in the future.

Only through comprehensive monitoring with a structured, sufficiently detailed, and manageable set of indicators can policy-makers begin to understand what is happening 'under the hood' of the EU economy and be sure that the EU gets – and remains – on a pathway towards climate neutrality by 2050. Such an indicator set needs both historical data as well as clear benchmarks to measure developments against.

The EU does not yet have an adequate climate neutrality monitoring system in place

In acknowledgment of these challenges, the EU Climate Law has thrown legal force behind the EU climate neutrality goal and requires regular checks of EU Member States' collective progress. The European Commission's (EC) first climate neutrality progress assessment is due by 30 September 2023 and must be repeated every five years. The law does not prescribe any specific procedural steps or a clear methodology, other than the use of a linear trajectory towards 2050 as a yardstick. And the existing climate policy monitoring system focuses on the headline targets, not the changes underpinning them.

While the EU Climate Law is a sign that the EU is serious about climate neutrality, the strength of the new progress assessment, not to mention its ability to align policies with a climate neutral future, remain to be seen. And regardless of its quality, having results from the next assessment available only in five years is evidently too late to contribute to policy-making under the next EC and European Parliament (EP). It is too late in this crucial decade for action as choices made today will put us on – or take us off – the path to climate neutrality.

1.2 ECNO's Mission

This is where the European Climate Neutrality Observatory (ECNO) comes in. ECNO is a new initiative spearheaded by a consortium of research organisations, and in its inception funded by the European Climate Foundation (ECF). It aims to help ensure the EU achieves its climate goals,

and most importantly the long-term climate neutrality target, by providing scientifically rigorous analysis of economy-wide on-the-ground progress and an independent check of the EU climate policy processes that drive it.

As an independent observatory, ECNO seeks to inspire the uptake of better monitoring practices and policy-making as the EU moves into the critical era of implementation and create greater transparency on the EU's path to climate neutrality.

1.3 Objective of this report

This report aims to tell **a comprehensive story of EU progress towards climate neutrality**. It is based on a set of indicators that span thirteen building blocks of a climate neutral future, presenting a unique and up-to-date picture of current progress.

As the EU Green Deal moves into implementation, this report seeks to highlight where the EU is on a pathway towards climate neutrality and where accelerated action is most urgently needed to get on track. To be consistent with EU planning and monitoring, **progress is measured against the EU's own vision for a climate neutral future: one that is formed from EU targets and benchmarks taken from official EU documents**. The analysis does not define its own objectives or benchmarks to measure progress – nor does it assess whether the existing EU targets and pathways are compatible with the Paris Agreement and the target to limit temperature increase to 1.5°C over pre-industrial levels.

The ECNO approach focuses on the **underlying enablers of change**, not only specific objectives or 'headline' indicators used traditionally to measure progress on climate action. By investigating enablers, the report can show if the necessary structural changes are occurring at a sufficient speed, which in turn provides an early indication of the adequacy of ongoing developments that will drive future emission reductions. This analytical framework offers an unparalleled perspective on the EU's current standing and prospects.

As European institutions embark on their own progress assessments, **the report highlights where critical data gaps exist** – in terms of historical data but also in terms of the long-term vision, which provides insights into the magnitude of required changes.

This report is the first assessment of its kind, and as such provides a foundation for further work. In addition to providing insights on state of progress, it identifies issues to be addressed to deliver more refined and granular assessments in the future, in support of more effective and efficient policy-making.

1.4 Research approach

ECNO uses an **indicator-based framework** that tracks progress in economic sectors and cross-cutting policy areas, i.e., the '**building blocks**' of a climate neutral future. The selection builds on the typical sectoral split, which is also used in GHG inventories, and adds cross-cutting themes that have an impact on the emitting sectors, like finance, governance, and lifestyles. These building blocks or some constellation thereof are commonly found in EU Member States' long-term strategies and are often referred to in the climate policy literature (EC, 2018c, 2020f; IPCC, 2018a; Pestiaux et al., 2018; Velten et al., 2022; Tsiropoulos et al., 2020). Monitoring activities at global as well as national level also use similar approaches (e.g., Schumer et al., 2022; UKCCC, 2022).

Figure 2: Building blocks for the transition to climate neutrality

Source: ©ECNO based on previous work by Velten et al. (2021)

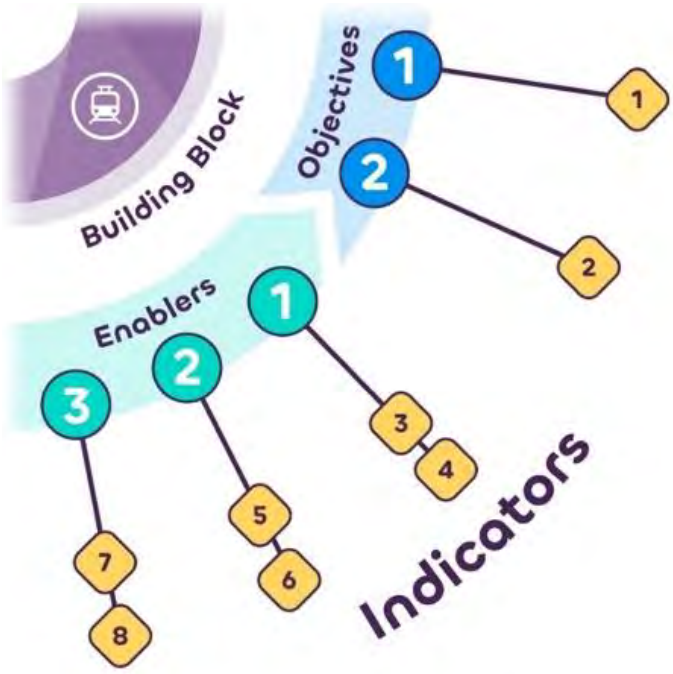
Within each building block the authors have defined objectives and enablers. **Objectives** outline what the building block must achieve to support the overall climate neutrality goal, while **enablers** are the supporting conditions needed to meet the objectives in each building block. Enablers thus reflect on the *drivers* of and *barriers* to decarbonisation and, as such, can provide an early sense of progress – or lack thereof.

The assessment of progress for each building block towards its objectives and enablers is based on dedicated **indicators**. The selected indicators describe specific aspects of the objectives and enablers and provide a view on past changes in the context of the required future changes.

Box 1: What is an enabler?

The ECNO analytical framework defines enablers as the underlying real-world or structural preconditions that support each building block in realising its objectives *en route* to climate neutrality. Enablers tend to function in one of three ways: **(1) removing** climate-damaging activities such as excessive fertiliser use (agrifood); **(2) shifting** attitudes, consumption patterns, or business practices like the uptake of zero emission and low carbon transport (mobility); or **(3) improving** existing systems, such as adopting robust institutional arrangements to ensure coherent policy-making (governance).

Figure 3: Selecting indicators based on building block objectives and enablers



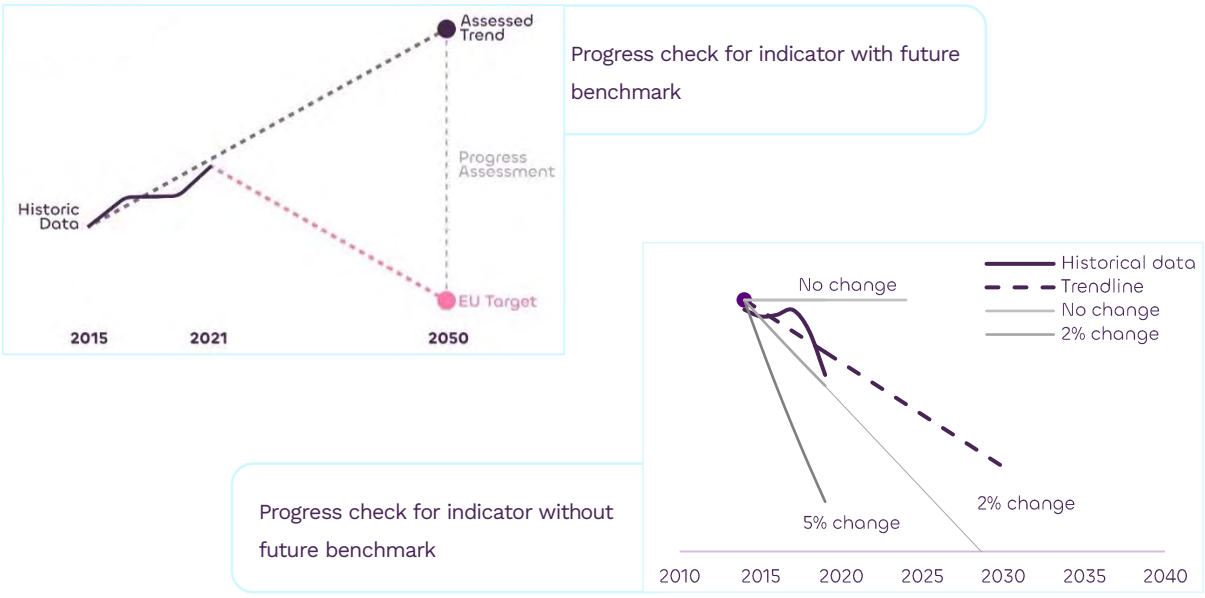
Source: ©ECNO based on previous work by Velten et al. (2021)

While data on headline indicators, such as GHG emissions or renewable energy shares, are readily accessible, limited and less regular or continuous information is collected for the structural changes that enable the transition. **A significant challenge to an assessment of detailed progress is therefore the availability of data**. In order *not* to restrict the selection of relevant indicators due to data limitations, the assessment also incorporates indicators that lack a comprehensive dataset. Where this limits the interpretation of results, the report highlights critical information gaps. The report further reflects on these constraints in its conclusions (see Chapter 3).

Importantly, ECNO checks past progress against **the EU's own vision of climate neutrality** formed from official EU targets and benchmarks derived from EU strategic planning documents. This includes the underlying impact assessments of the EU 2030 Climate Target Plan and the EU LTS as well as EU Directives and Regulations.

The **progress check compares the absolute annual change of the past development with the required annual change** to meet the future benchmark starting with the last data point of the trendline and drawing a straight line to the benchmark. The ratio between these two values indicates the required change in the pace of development (a similar method is used by Schumer et al., 2022). If no quantified future benchmark can be derived from EU sources, the analysis relies on qualitative insights from official EU documents as well as on external scientific literature outlining the desired direction and speed of change (see Figure 4). For more detail, please see a description of methodology on the ECNO website.

Figure 4: Progress check for indicators with and without a benchmark



Source: ©ECNO based on e.g., Schumer et al. (2022) and Eurostat (2014). Please note that classification for indicators without a benchmark can deviate from the given ranges to reflect on the characteristics of an indicator.

To ease the communication of results, **progress for each indicator is classified** along a four-degree scale: 'on track', too slow', 'far too slow', and 'wrong direction'; 'insufficient data' indicates data availability limitations (see Table 1). For indicators with a defined benchmark the classification is based on the ratio of the required change to the past observed change. A different approach based on the desired direction and speed of change using pre-defined ranges is used for indicators without a benchmark (similar to the approach taken by Eurostat, 2014). However, this approach for indicators without a benchmark has its limitations due to the characteristics of different indicators. Therefore, the analysis also considers non-official EU benchmarks and expert judgement to put past development into perspective.

The same classification is used to describe the **overall progress for each climate neutrality building block**. Largely, their classification is based on the progress of the underlying indicators, but it does not follow a mathematical formula. It is an expert judgement informed by a nuanced reflection on the indicator values, their respective importance, and recent developments in the policy area in the context of past trends (a similar approach is taken e.g. by the IEA, 2023c).

Table 1: Progress classifications for indicators with and without benchmark

Description			Indicators with benchmark	Indicators without benchmark
	On track	Change is occurring at or above the required pace	Ratio of required change to past change is ≤ 1	Average annual percentage change is ≥ 5%
	Too slow	Change is heading in the right direction at a promising but insufficient pace	Ratio of required change to past change is > 1 to 2	Average annual percentage change is ≥ 2% to < 5%
	Far too slow	Change is heading in the right direction, but well below the required pace	Ratio of required change to past change is > 2	Average annual percentage change is ≥ 0% to < 2%
	Wrong direction	Change is heading in the wrong direction, and a U-turn is needed	Ratio of required change to past change is < 0	Average annual percentage change is < 0%
	Insufficient data	Data is insufficient to assess the progress	/	/

Source: ©ECNO based on e.g., Schumer et al. (2022) and Eurostat (2014). Please note that classification for indicators without a benchmark can deviate from the given ranges to reflect on the characteristics of an indicator.

2. Results: EU progress towards climate neutrality

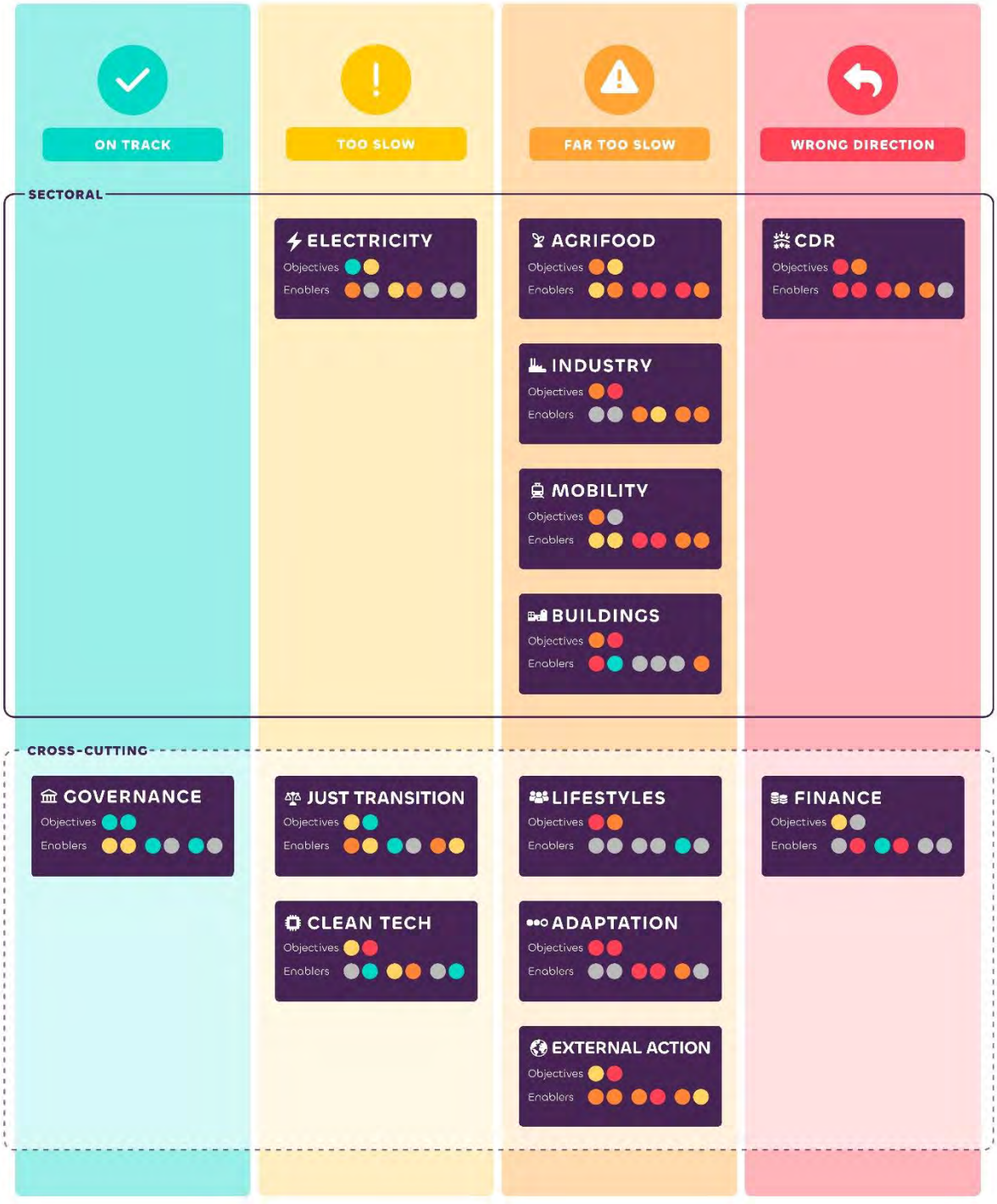
This assessment analyses the EU's progress towards climate neutrality using 104 indicators which collectively reflect important objectives and enablers of change for 13 building blocks of a climate neutral society (see section 1.4). The progress check is based on the rate of past change, compared with the rate of change needed to meet climate neutrality – as measured against official EU modelling and targets. Due to data availability, the results of this assessment largely reflect the rate of change over the period 2015 to 2021, thus providing an unprecedentedly detailed window of where it is most urgent and important that implementation of the EU Green Deal and further policies has impact.

This chapter presents the top line insights of the analysis, providing an overview of the key outcomes for the EU as a whole and then more specifically for sectoral and cross-cutting building blocks. Full details on the building blocks and their evaluation can be found in section 4.

2.1 Big picture: Moving in the right direction, but progress is too slow

The overarching finding of the assessment is that the EU is generally moving in the right direction but needs significantly pick up the pace. Only one of the building blocks showed development that was *on track*. The observed trend for three of thirteen building blocks was *too slow* and in seven *far too slow* when compared to what is required to reach the EU's legally binding commitment of climate neutrality by 2050 the latest. Worryingly, developments are moving in the *wrong direction* when it comes to finance and carbon dioxide removals (see Figure 5 for full details and Table 2 for all related indicators). A promising signal is that EU climate governance is assessed as *on track*, meaning that the creation of high-level management structures for the transition is occurring. This has the potential to help address the shortcomings in other areas as governments progress in their implementation.

Figure 5: Progress across the building blocks for reaching climate neutrality



Source: ©ECNO

This overall picture, based largely on data for 2015 to 2021 and up-to-date qualitative information, needs to be put into the context of the COVID-19 pandemic and the energy crisis resulting from the Russian war against Ukraine, both of which have had significant impacts on the backdrop for EU climate policy in recent years. The EU Green Deal (EC, 2019b) and the subsequent 'Fit for 55' package of measures, negotiated through to 2023, include expanded and additional policies that provide further guidance and levers to steer the building blocks in a better direction (see, e.g., CAT, 2023; EC, 2020f). Examples of this include the introduction of the EU Climate Law with its oversight, policy consistency, and progress monitoring functions; a second emissions trading system (ETS2) for the transport and buildings sectors that will start later in the decade, combined with the establishment of the Social Climate Fund; or the phase-out of sales of new cars that emit tail-pipe CO_2 emissions by 2035. This wealth of new policy initiatives at EU level for climate neutrality and for greater energy independence are signs that the EU institutions are engaging with some of the necessary sectoral transitions and working to create an adequate governance framework.

2.2 Headline results across the thirteen building blocks

To show the specific strengths and weaknesses in progress, this section unpacks the headline results for each building block. It presents a compact summary of progress of each building block and its respective objectives and enablers, first for the sectoral building blocks, and then for the cross-cutting ones. Interlinkages between classic economic sectors will be increasingly important in a climate neutral future, and the cross-cutting building blocks provide essential supporting functions for the sectoral transitions. Full details for each building block are available in Chapter 4.

2.2.1 Sectoral perspective: Concerns over pace of change in most sectors; additional boost needed for clean electricity

Progress in the main economic sectors is variable – from *electricity supply* being almost on track, to changes in *carbon dioxide removals* going in the wrong direction due to the continued loss in sinks. In *mobility*, *industry*, *buildings,* and *agrifood*, the analysis shows that progress was far too slow over the assessed period, requiring a clear acceleration of change to put the EU on a path to climate neutrality.

Too slow

The greenhouse gas (GHG) emissions from **electricity** have been decreasing at sufficient speed to reach the EU's own 2040 benchmark from the EU long-term strategy (EU LTS). However, crucial enablers for the faster uptake of renewable electricity generation and its integration into the power system are currently developing too slowly, putting change required further on in the transition at risk. This is why overall, the building block's progress is rated as *too slow*. Further progress is required especially in overcoming barriers for renewable investment as well as the coordinated scale-up of grid and clean flexibility options to ensure a secure shift to renewables. The EU Emissions Trading System (ETS) already provides an important incentive to accelerate the coal phase-out while the electricity market reform is ongoing, and RePowerEU aims to increase the speed of the energy transition. However, short-term measures incentivising a shift from gas to coal in the RePowerEU plan would undermine the EU's own emission reduction efforts. Slow(ing) progress in this building block will also have knock-on effects on other sectors that rely on electrification as a driver (see section 4.1).

Far too slow

In **mobility**, progress was *far too slow* but has recently started moving in the right direction. This is the case for emission reductions as well as in terms of slowing growth in transport volumes. In passenger transport, the observed decline is arguably mainly a result of the COVID-19 pandemic and may thus be (partly) reversed, and with it the recent reduction in emissions. The modal split for passenger and freight transport is going in the wrong direction with increasing shares of road traffic. The turn to electric and zero-emission vehicles was far too slow, although EVs are being taken up. The new ETS for transport (to start in the second half of the 2020s) and the phase-out of fossil-fuel vehicles sales by 2035 are set to help address this issue and may lead to an increase in the pace of change before 2030 (see section 4.2).

Far too slow

With the transformation towards climate neutral industrial production not yet sufficiently evident in the available data, overall progress for **industry** was assessed as *far too slow*. The reduction of GHG emissions from industry needs to happen 2.7 times faster than it did in the period observed to achieve the benchmark outlined in the 2030 Climate Target Plan. Moreover, the use of clean energy carriers stagnated, even pointing slightly in the wrong direction. There is insufficient data to identify the state of on-the-ground progress towards Carbon Capture and Storage (CCS) and related CO_2 injection capacity or the annual production of renewable hydrogen. Circularity remains low. However, this too is a sector where EU policies proposed in the last two years, for example under the Circular Economy Action Plan, could lead to improvements in the future. The

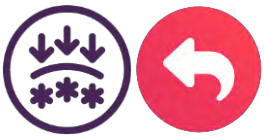
Net Zero Industry Act, currently under negotiation and following on to the EC's Green Deal Industrial Plan, aims at increasing the industrial base for clean technologies (see also section 4.8) and for CO_2 storage. These and other policy initiatives have the potential to help speed up necessary change (see section 4.3).

Far too slow

Progress in **buildings** was *far too slow*. The annual reduction of GHG emissions in buildings was not happening at sufficient speed and must be 7.5 times faster up to 2030 to meet the target from the EU's Renovation Wave Communication. This follows in part from a far too slow switch from fossil-fuels to renewable or electric heating. Available data on renovation suggest that the pace of deep renovation was also too slow. The living area per capita further increased, partly offsetting the gains in reduced heating need per living space. The recent policy context suggests that developments could increase in speed: the goals of the Renovation Wave are to be implemented by amendments to the Energy Performance for Buildings Directive and the Renewable Energy Directive; and the new ETS for buildings and the Social Climate Fund will start in the second half of the 2020s. In response to the energy crisis resulting from the Russian war against Ukraine, the RePowerEU plan outlines a significant increase in use of heat pumps, and an end to the sale of fossil fuel boilers by 2029 via the Ecodesign Directive. The Renewable Energy Directive implements a binding increase of renewable deployment on national level (see section 4.4).

Far too slow

Similarly *far too slow*, but with less policy action in recent years, is the overall progress in the **agrifood** sector. Agricultural emission reductions must occur 2.4 times faster to achieve the 2050 emissions level presented in the EU LTS, but projected future emission reductions will fall far short of this based on the current state of enabling conditions. All enablers show no or limited improvements: progress on improved nutrient management was limited with reductions in nitrogen fertiliser use only slightly declining. This needs to accelerate by almost 2 times to meet the target from the Farm to Fork Strategy. Organic farming uptake would have to accelerate by 3 times to meet the Farm to Fork target, manure management emissions intensity and livestock numbers continued to increase rather than fall, and end-of-supply-chain measures also showed progress that was far too slow. The 2023-2027 Common Agricultural Policy (CAP) is not likely to change this picture, considering Member State-level CAP strategic plans are expected to continue business as usual. On a more positive note, trends in bovine meat consumption show that reductions only need to be 1.3 times faster to achieve the dietary guidelines presented in the EU LTS. Fundamental shifts in the way the EU produces and consumes food will be needed for the agrifood sector to be on track to minimise its emissions (see section 4.5).



Wrong direction

Carbon dioxide removals are an essential counterweight to residual emissions that cannot be avoided, but were heading in the *wrong direction*, with removals from land use, land use change and forestry (LULUCF) seeing an average annual decreases of almost 14 Mt CO_2e. This must be changed to an increase of over 6 Mt CO_2e per year to achieve the 2030 target. The decline can be traced back to slower forest growth in terms of area and stock as well as limited carbon stores in soils. The EU has revised the LULUCF Regulation, the Common Agricultural Policy (CAP), and the Renewable Energy Directive, but the impact of these legislative changes remains to be seen. The upcoming Soil Carbon Law may have the potential to improve carbon stores in soils while the new EU Forest Strategy outlines options for improving the quantity and quality of forests and strengthening their protection, restoration, and resilience. Technical removal, meanwhile, is still in its infancy. There is no demonstration project in the EU so far, but some are planned. However, with deployment depending on the availability of sustainable inputs and safe storage options, its potential is limited. Application of technical but also natural removals must be well regulated and considered carefully in the light of associated risks. The EC proposal on the Carbon Removal Certification Scheme addresses some of these issues but also opens important questions with respect to long-term storage and permanence as well as in terms of the eligible uses of the removal units (see section 4.6).

2.2.2 Cross-cutting building blocks: enablers to sectoral transitions need to pick up pace

Several cross-cutting building blocks strongly influence sectoral developments and support their GHG emission reductions. *Lifestyles*, *clean technology*, and *finance* underpin for the necessary changes in the sectoral building blocks, while *governance* sets the overarching framework for climate policy-making and thus for all sectoral and cross-cutting policies. *Just and inclusive transition* measures are key to manage the impact on EU regions and citizens. *Adaptation* is another essential horizontal dimension to all other policy and pertains to government's responsibility to respond to climate impacts and counteract the vulnerabilities of its citizens. The last cross-cutting building block assesses the consistency of EU *external action* with climate neutrality.

The assessment shows that the cross-sectoral building blocks also span the full range of the progress classification scale. *Governance* was on track; *just and inclusive transition*, *clean technology, lifestyles* and *external action* were heading in the right direction although particularly progress in *lifestyles* and *external action* need to significantly speed up. A*daptation* is on the tip of going in the wrong direction and *finance* is clearly off track.

Table 2: Progress assessment across all building block indicators, enablers, and objectives

GHG emissions of electricity generation	✓	GHG emissions from transport	⚠	GHG emissions from industry	⚠
Share of fossil fuel-fired power generation	!	Carbon intensity of passenger transport	?	Share of clean energy carrier in energy and feedstock use	↩
Share of variable renewable energies in electricity generation	⚠	Total passenger transport volume	!	Annual production of renewable hydrogen for industrial use	?
Electricity interconnector capacity availability for cross-zonal trading	?	Total freight transport volume	!	CO_2 injection capacity	?
Investment into transmission and distribution grid	!	Share of passenger transport volume by mode	↩	Circular material use rate	⚠
Share of electric smart meters	⚠	Share of freight transport volume by mode	↩	Resource productivity	!
Battery storage and dispatchable renewable energy additions	?	Share of EVs in passenger car stock	⚠	Final energy consumption in industry	⚠
Flexible power demand	?	Share of zero-emission vehicles (ZEV) in heavy-goods vehicle stock	⚠	Energy intensity of output	⚠
Buildings direct GHG emissions	⚠	Agricultural emissions	⚠	Net removals from LULUCF (land-use, land-use change and forestry)	↩
Demand for building blocks and bricks of cement or concrete	↩	Bovine meat consumption per capita	!	Net removals from technical solutions	⚠
Average space per capita	↩	Nitrogen fertiliser consumption	!	Growth in forest area	↩
Energy consumed for heating and cooling related to living space	✓	Organic farming as a share of total utilised agricultural area	⚠	Growing tree stock	↩
Investments for energy renovation	?	Manure management emissions intensity of cattle	↩	Concentration of organic carbon in arable land	↩
Average renovation rate	?	Livestock	↩	Net CO_2 emissions from croplands, grasslands and wetlands	⚠
Deep renovation rate	?	Volume of waste containing food waste	↩	DACCS and BECCS capacities	⚠
Share of renewable energy in heating and cooling	⚠	Emissions from food processing, transport, and packaging	⚠	Costs of BECCS and DACCS	?
Per-person material footprint	↩	Value added in management of energy resources and protection of ambient air and climate	!	Climate investment gap	!
Per-person carbon footprint from household expenditure	⚠	Index of eco-innovation related patents	↩	Climate hostile financial flows	?

Investment in public transport	R&D researcher and personnel working in environmental sciences	Public climate subsidies
Share of EU population living in EU Member States, regions or local communities that promote sustainable food in canteens	Index of eco-innovation related publications	Fossil fuel subsidies
Price on carbon	Funds allocated to environmental and energy R&D by governmental sector	Share of GHG emissions covered by a carbon market price or tax
Affordability of vegetarian options compared to meat options	Private energy R&I spending, relative to GDP	EU and Member States revenues from environmental taxation
Self-reported climate-conscious behaviour	Green public procurement as a share of total public procurement	Share of banks that have a sound transition plan
Climate-damaging advertisement	Private investment in clean technologies	Percentage of new banking loans that are aligned with the Paris Climate Agreement

Regional poverty rate	Comprehensive climate framework laws at national level	ND-GAIN country index
Material deprivation rate	Citizen support for and confidence in the climate neutrality transition	Economic losses from climate-related extremes
Employment in renewable energy supply-chains	Up-do-date and compliant long-term strategies (LTS)	Green urban areas
Employment in environmental goods and services	Progress monitoring with action trigger at national level	Area of green roofs
Share of accepted Territorial Just Transition Plans	Independent scientific climate advisory bodies	Share of gentle tillage practices
JTF implementation progress	Coherent all-of-government approach	Share of mixed forest area
Share of support for households	Citizens' climate assemblies	Share of wetlands
Share of support for energy efficiency purposes	Public consultations on EU climate policy impact assessments	River restoration

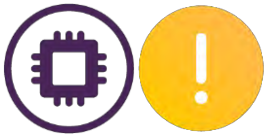
International climate finance	Imported CO_2 emissions
Public finance for international fossil fuel projects (by EIB)	Public finance for international clean energy projects (by EIB)
Paris Agreement references in trade agreements	ODA related to climate action
Climate-relevant capacities	Prioritisation of climate diplomacy

Objective indicators

Enabler indicators

Far too slow

In **lifestyles**, the facilitation and adoption of consumption habits in line with climate neutrality is progressing *far too slowly*. The per person material footprint saw some decline following the COVID-19 pandemic after years of increases. The per person carbon footprint has been declining but far too slowly. Insufficient or even no data make it challenging to assess progress of the enablers that will determine progress of these footprints in the future – particularly those related to the decisive infrastructures that promote and enable climate-neutral behaviour, such as availability of high-quality public transport. Economic incentives developed somewhat in the right direction with a higher carbon price that can influence energy consumption, but no information was found to compare, for example, the actual affordability of vegetarian compared to meat dietary options. Similarly, the diffusion of climate-neutral habits could only be assessed through self-reported climate-conscious behaviour, which is on track. EU policies are likely to address some of the enablers, notably the Ecodesign Directive, the eco-labelling scheme, the Circular Economy Action Plan, as well as the upcoming sustainable food system legislative framework and the revision of the Waste Framework Directive. However, there is no overarching sufficiency strategy yet that focusses on the impact that lifestyle has for a path to climate neutrality (see section 4.7).



Too slow

Progress on **clean technologies** was going in the right direction but was *too slow*. The increase of clean manufacturing capacity was too slow while the pace of development of new solutions was actually slowing down. While private investment is on track, annually increasing by a factor of two over the past five years, further investment in energy and environment R&D and in manufacturing is needed to ensure that additional clean technologies become available in time and keep improving to deliver more outputs with fewer inputs. The progress on green public procurement remains rather unclear due to lack of monitoring. Policies relevant for clean tech development have been announced in the EU Green Deal Industrial Plan and the subsequent proposal for a Net Zero Industry Act, which aim particularly at improving the environment for the scaling up of the EU's manufacturing capacity for clean technologies and products. These new initiatives must now need be adopted quickly and implemented to speed up progress on clean tech (see section 4.8).

Wrong direction

The most worrying result among the cross-cutting building blocks is in **finance**, which was moving in the *wrong direction* overall. This development could put the whole transition to climate neutrality at risk, as sufficient climate investment is essential for the future emission reduction potential of the economy, while a continuation of fossil fuel investments and subsidies locks the EU economy into a longer-lasting dependence on

fossil fuels. Overall, public authorities set the wrong incentives with decreased environmental taxation, and increased funding for fossil fuels of around EUR 1.5 billion per year between 2015 and 2020. This tendency was aggravated in 2021 and 2022 as most Member States increased fossil fuel subsidies and decreased the rate of taxation on fossil fuels – including VAT in some countries – in the context of the still ongoing energy price crisis and its impact on costs of living. There are, however, some positive signs from recent policy decisions: More emissions than ever were covered by a pricing scheme and this indicator will further increase with the new ETS expanding to transport and buildings. Cost increases arising from this are intended to be offset for key actors by efficiency and decarbonisation investments funded from revenues of the new ETS, via the Social Climate Fund. Moreover, Member States will have to channel 100% of their ETS revenues to climate-related uses. Checking progress on climate alignment of the financial system, however, requires more and better data. The implementation of the Corporate Sustainability Reporting Directive and the Corporate Sustainability Due Diligence Directive should make transition plans mandatory for banking institutions from 2025 onwards, but uncertainties remain on the content of these plans (see section 4.9).

Too slow

In **just and inclusive transition**, all indicators show change in the right direction, but the assessment highlights that progress was *too slow* overall. Available data indicate that progress in reducing the regional poverty rate and the support for households to tackle energy poverty was far too slow. The creation of jobs in renewable energies was far too slow, and the broader environmental goods and service sector, while a little higher, was also still too slow. Bright spots are the reduction in material deprivation rate, which is on track, as well as the adoption of Territorial Just Transition Plans by carbon-intensive regions. The upcoming implementation of the Just Transition Fund and of the Social Climate Fund will be important to improve progress in this building block (see section 4.10).

On track

Among the cross-cutting building blocks, the best news is that **governance** framework for climate policy-making is developing at a *sufficient speed* thus far. The adoption of the EU Climate Law in 2021 and the Governance Regulation in 2018 have contributed to this result. Progress stemming from these, however, is not achieved at EU level alone, but supported by positive developments in Member States. Many Member States have now put in place comprehensive climate framework laws to manage their climate policy-making. They appear to have started to generate societal buy-in – here measured as citizens' support and confidence in the transition (to the extent that there is data). In some countries, citizens are already increasingly engaged through country-wide citizens' climate assemblies. Furthermore, robust institutional

arrangements are being put in place, to strengthen the scientific underpinning in policy- and decision-making, including in the form of scientific advisory bodies. However, insufficient data does not presently allow a judgement as to whether a coherent all-of-government approach is being taken. More action is required on integrated learning cycles as progress was too slow in particular on long-term planning and monitoring systems overall. In addition, several Member States have gaps in their governance systems. These shortcomings could be addressed in the upcoming revision of the Governance Regulation which already provides common 'minimum governance standards' for Member States (see section 4.11).

Far too slow

The assessment shows that progress on **adaptation** was *far too slow*. Under the objective of becoming a climate resilient society, a country index shows that vulnerability and resilience stagnated while economic losses from climate-related extremes increased, albeit with considerable year-to-year variability. Adaptation in agriculture and forestry also went in the wrong direction with a decline of the share of mixed forest area and of gentle tillage practices on arable land. Development of blue measures showed some progress in increasing the share of wetlands, but no data exists yet to assess the river restoration target. Similarly, missing data restricted the evaluation of progress towards greening cities. The overall EU policy context has developed favourably, which could lead to further progress in the future: The EU Adaptation Strategy calls for increased investment in resilient infrastructure, improved disaster risk reduction, and coordination and coherence. The Forestry Strategy promotes forest management practices that would lead to more resilient forests and the EU's Urban Agenda includes a partnership on adaptation. Finance is available through, e.g., the European Structural and Investment Funds (see section 4.12).

Far too slow

EU progress on **external action** on climate change has been *far too slow*. While international climate finance shows some positive progress, it remains insufficient, and does not yet match the ambition of the EU as a champion in the global response to climate change. It is also worrying that the EU's ecological footprint abroad, measured by imported CO_2 emissions, has been increasing, thus moving in the wrong direction. The analysis further reveals that enhancing coordination in climate diplomacy between the EU and its Member States has seen promising but insufficient progress. The alignment of international public funds (here assessed on the basis of European Investment Bank (EIB) funding, as a proxy) and trade agreements with the Paris Agreement goals has progressed far too slowly. There is concerning movement in terms of the climate-related allocation of official development assistance (ODA), which decreased between 2016 and 2020. The EU Green Deal provides a promising narrative by emphasising the integration of climate

considerations into all aspects of EU foreign policy, but it currently lacks comprehensive measures to make good on this promise. In terms of developments in the policy context, there are only some indications for possible future progress. The Corporate Sustainability Due Diligence Directive aims to ensure that EU businesses address their environmental impact both within and outside of Europe. Additionally, the forthcoming Carbon Border Adjustment Mechanism seeks to impose a carbon price on imported carbon intensive product, discouraging carbon leakage and promoting low-carbon imports (see section 4.13).

3. Key insights and policy implications

3.1 Policy context: Bold action is being taken in Europe

Measured by targets set and legislation adopted, bold and transformational action is being taken in Europe, despite adversarial circumstances. The vision of the EU Green Deal has shone through the COVID-19 pandemic and its economic consequences. Even under the shadow of armed conflict in Europe and the resulting energy price and cost of living crisis, the overall commitment to the agenda of pursuing a green future has not faltered – because the key solutions to the climate crisis also create more independence and energy security, resilience, and lower prices in the long-term. The temporary increase in coal power production and new investments in infrastructure for imported liquified natural gas is evidence of the complexity of the current context; the general direction towards more climate action however remains clear.

Member States are now shifting to implementation mode as the climate and energy package for 2030 is being finalised at the EU level. However, countries' own projections show that current policies are insufficient and that additional instruments are needed to kickstart the required transition in key sectors. Making the required political decisions is evidently not easy, and the degree of change involved understandably triggers resistance and intense public debate. More and better public exchange and communication on effective solutions is thus essential to allow the achievement of climate neutrality. Businesses and citizens alike need to know that and what change is coming, what it means for them, and how they will be supported. Successful implementation of transformative policies requires broad acceptance.

The first-of-its kind assessment of progress presented in this report offers a spotlight on where additional action is required, helping to show where efforts should be prioritised, as well as confirming the granularity with which progress on structural changes needs to be monitored. In 2024, two of the three main EU institutions will see change, with elections for the European Parliament (EP) and a new term for the European Commission (EC). Together, they need a clear

agenda to improve the existing policies further to guarantee that the long-term goal will be met. The findings in this report – and a possible update next year – should inform these decisions on future EU policy action.

3.2 Positive signals and cause for concern from the assessment

The analysis of progress has revealed both strengths and weaknesses in the transition of the EU to climate neutrality. Some of the insights can serve as inspiration and a source for optimism that policies are working, while others are cause for concern and require targeted action. This segment focuses on the higher-level observations. More granular and policy area specific take-aways are in the deep dive sections for the individual building blocks (see section 4).

First, the positive messages:

- Most of the building blocks moved in the right direction, with the exception of finance and carbon dioxide removals. While progress over the period analysed was too slow, and in some cases far too slow, this still suggests that overall, Europe is orienting itself towards, and has a basis to build on, for faster action.
- The assessment shows that the EU is developing the right *governance framework* to achieve the goal of climate neutrality by 2050 at the latest. EU law has established some initial minimum standards for climate policy planning and monitoring at national level, and many Member States are already going a step further. The EU is thus starting to be well-positioned to accelerate progress – even as substantial room for improvement remains to further strengthen processes and institutions to manage the transition. This framework has also only been introduced very recently, with key management processes under the EU Climate Law still to be tested for the first time, which means the real impact will show only in their implementation.
- Electrification is a core overall driver for the move to climate neutrality with direct implications for other sectors. The decarbonisation of *electricity* overall was on track, though the detailed results show that more action and focus is needed on the enablers to ensure that progress continues at the necessary rate for this key building block.
- In *just and inclusive transition*, all indicators were going in the right direction, with many of the necessary changes beginning to take effect, even if progress observed so far was still too slow.

- There was significant, but uneven progress in *clean technologies*, a cross-cutting driver of the modernisation of the European economy.

To speed up change in those promising sectors, the EU should focus particularly on those objectives and enablers where changes were going in the wrong direction and where changes have stagnated. Creating the necessary enabling environments is a must-have condition for the longer-term changes needed for a climate neutral future. **Targeted policy interventions with new policies or upgrades to existing instruments, as well as the cancellation of wrong incentives are needed to bring the enablers on track** – so that the building blocks of climate neutrality can take shape.

The three building blocks that raise particular concerns are:

- *Finance* and investments, a key driver of the transition to climate neutrality at large, was found to be far off track. This impacts progress in all other building blocks as all depend on the right financial flows. Lack of progress on finance is thus a bottleneck that carries risk for the transition overall.
- *Carbon dioxide removals* (CDR) were heading in the wrong direction, in particular as natural carbon stores declined. At the same time, technical means of carbon dioxide removal are not deployed yet despite a 2030 target for focused application outlined in the EC proposal for a certification framework. This puts into question the anticipated role of CDR in balancing emission releases to achieve net zero and even net negative emissions.
- In *adaptation*, limited to no progress across both objectives and enablers as well as a significant lack of data highlights the need for action and greater transparency. In combination with the increasing occurrence and magnitude of climate-related extremes, the currently far too slow progress risks the well-being of all Europeans as well as increasing damages to the EU economy's structures and natural systems that are a foundation to all building blocks.

Particularly in these three building blocks, the EU will have to swiftly modify the current course if it wants to get on track to reach its own climate objectives.

3.3 Lessons learned from the limitations of measuring progress towards climate neutrality: the power of transparency

ECNO has designed and implemented its own monitoring methodology, in the absence of an official framework that provides the required level of depth and detail on changes happening under the emissions curve. The approach uses indicators to measure past progress in objectives and enablers across the key building blocks of a climate neutral future. This provides an unprecedented understanding about past progress overall as well as on the state of the enabling conditions that are a prerequisite for future changes. The resulting nuanced picture of progress also helps to identify where most urgent action is required, and to formulate key take-aways for targeted policy interventions.

At the same time, it is important to reflect on the drawbacks of this first ever in-depth analysis of progress towards climate neutrality in the EU.

Lesson 1: Essential data are missing to paint a complete picture

Ideally, this assessment would have drawn on official EU data only. However, these were not sufficient for a detailed and varied picture based on specific indicators for each building block. Accordingly, the data used originates from a range of sources and even partly from the research partners' own collection and compilation efforts (e.g., under governance). Still, there are 32 indicators for which no data source could be found or where there is insufficient information. In other cases, the assessment partly falls back on proxy indicators that do not exactly provide the information desired but allow for an estimated assessment. This lack of data availability means that the overall picture stays incomplete – and essential insights for policy-makers may be missing. Lack of progress, or the failure to lay the foundations for decisive change further along in the transition, may thus go unnoticed.

Lesson 2: Accurate identification of gaps needs an up-to-date vision of the future

This assessment measures progress against official EU-level targets and benchmarks for the future, where available. To this end, the ECNO analysis had to draw on a range of different official sources, including EU Directives and Regulations, the EU 2030 Climate Target Plan, the (already outdated) EU LTS in-depth impact assessment, as well as a range of other documents

including, e.g., the 8th Environmental Action Plan (EAP). Of the latter, some official targets need updating since the target year has already passed. In addition, some official EU targets are available only for 2030 and may not be fully in line with the path to climate neutrality. In some instances, no benchmarks could be found at all – which was compensated for with an indication of the overall direction needed (this was the case for 70 indicators). However, such alternative choices should not hide the fact that agreed yardsticks, stemming from official, up-to-date pathways to climate neutrality, are needed for an accurate indication of progress and related insights for necessary course corrections.

Lesson 3: *Panta rhei* – a dynamic reality needs regular tracking for robust policy-making

Lastly, there is a structural issue that no real-world data driven assessment of progress can fully compensate for: the time lag between policies adopted and observed change in the economy. As outlined above, the EU climate policy landscape has changed significantly, especially with 'Fit for 55' – and many Member States have also introduced new policies, including in the context of the energy (price) crisis. Information used for such assessments can thus only provide a snapshot of the past and can quickly become outdated, which makes it difficult to assess truly current trends. To address this challenge, this assessment included the latest insights into policy changes to provide a comprehensive picture of current progress at least at the level of the building blocks. As Member States in particular are drawing up additional policies, insights on past developments and required changes should be a key source for decision-makers. This time-lag conundrum and the speed of change in data and policy is also why measuring progress at the level of enablers needs to happen regularly, with annual updates – so that new data and additional indicators can be built in, ensuring that policy-making is informed by the best information available on the underlying drivers of change.

3.4 Looking forward: recommendations for an improved official EU monitoring system to better inform policy choices

This assessment shows that, as the window to set in motion the necessary transformations towards climate neutrality closes, EU policy-making needs an overall tracking system that is capable of showing clearly and comprehensively where progress is not fast enough, or even goes in the wrong direction. Doing this on the level of objectives as well as enablers for specific building blocks (along traditional sectoral lines and across them) is key to identifying the areas

that most urgently in need of action, and revealing others that might lead to slow-down or blockage in the future. These insights can inform the formulation of new policies, the revision of existing policies to align them better with a path to climate neutrality, as well as the removal of policies setting the wrong incentives.

The assessment showed that the EU is already putting in place a governance system that puts it on track for climate neutrality, but which needs to continue developing apace. One of the innovations in recent years that has contributed to the positive assessment is the adoption of the EU Climate Law (see e.g., indicator on the '*uptake of EU and national independent scientific advisory bodies*'). The EU Climate Law has given the EC the obligation to assess progress towards climate neutrality (Article 6.1), but the lack of an adequate monitoring framework is an obvious blind spot. Without it, there is a risk that the official process cannot reveal exactly the kind of information needed for targeted policy action. ECNO has been set up to fulfil this function as long as the institutions are not doing so, and to help strengthen official processes moving forward, but would rather see this function filled by formal EU processes.

To sum up, this first assessment of EU progress towards climate neutrality leads to the following recommendations for the institutions to improve the EU's ability to manage its climate neutrality efforts.

- **GET THE DATA**: The EC must establish a common EU-wide progress tracking system based on a comprehensive set of indicators, designed to inform policy-making in a way that enhances the capacity to achieve climate neutrality. Indicators should therefore be linked to key enablers of the transition as well as to headline objectives. This must include means to close data gaps via new reporting obligations and adjusted data collection routines.
- **INTEGRATE SMARTLY**: The monitoring framework can be used to inform both planning and reporting and be applied for all Member States. Mutual referencing of the same parameters will allow for greater comparability, facilitate necessary evaluations, and increase transparency. Due to the overarching nature of the climate neutrality goal and its relevance for other policies, such a tracking system can also be integrated with other EU monitoring systems such as the 8th Environmental Action Programme and the European Semester, reducing overall effort and administrative burden for Member States and EU institutions alike – and allowing for decisions based on a joint fact base.
- **BRING IN EXPERTISE**: The monitoring framework should be developed using a transparent process, involving relevant stakeholders from different policy areas and areas of expertise, including the newly-established European Scientific Advisory Board on Climate Change. It must also be anchored in legislation (Governance Regulation and EU Climate Law), to ensure that its adoption and implementation are being adhered to.

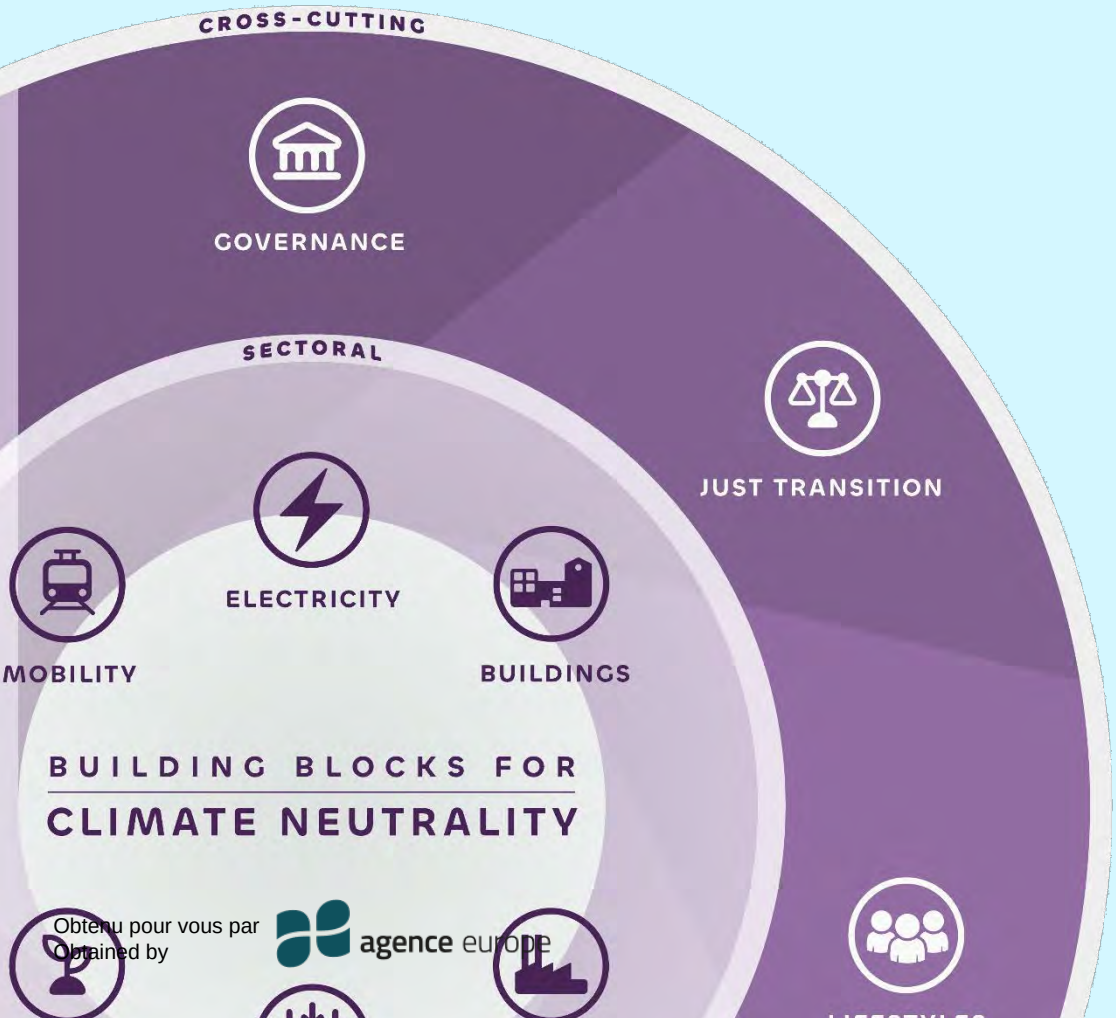
- **ASSESS REGULARLY**: Assessments of progress towards the key objectives and their enablers should take place annually (or at least every two years, in line with integrated national energy and climate progress reports (NECPRs) to ensure that policy actions are based on the best information available. Implementing this frequency formally requires a change to Article 6 of the EU Climate Law. Regular updates are also needed for the underlying pathways providing benchmark values. A formal update of the EU long-term strategy (EU LTS) is already overdue.
- **MAKE IT COUNT**: Having good progress information is particularly valuable if it is directly acted upon. EU decision-makers should consider integrating into the EU Climate Law a dedicated action trigger based on the results of the assessments. There are similar procedures in other important EU governance systems, which this could be modelled upon, such as the Alert Mechanism Report under the European Semester, which triggers in-depth reviews. Information from the tracking system could trigger a more detailed inspection to verify whether the lack of progress identified is of concern and to then facilitate appropriate action, if needed. Moreover, to use the information most effectively, a direct link could be established in the EU Climate Law between the progress assessment (Article 6.1) and the policy consistency assessments (Articles 6.2 and 7) – and to review clauses of individual pieces of legislation relevant to the achievement of climate neutrality.

A welcome **window of opportunity** to implement these recommendations for a better official EU monitoring system is coming up, through the imminent **review windows for the Governance Regulation and the EU Climate Law in 2024**. But there is no need to wait. Under the existing obligation for a progress assessment (Article 6.1 EU Climate Law), the EC can already kickstart the process of drawing up a thorough and effective system, involve relevant stakeholders (including Member States) and assessing the respective information needs as well as the potential reduce administrative effort across planning and reporting systems.

With this first in-depth assessment report, the European Climate Neutrality Observatory (ECNO) wants to inform a broader dialogue on how the EU can best track progress and what actions could be taken on the basis of its analysis. This can also contribute to efforts by EC to track progress and draw up an adequate system for regular assessments.

ECNO invites feedback from all interested parties on both methodology and the results. It seeks to further expand its understanding and refine the underlying approach to progressively improve the information for policy-makers from future assessments.

4. Deep dives: Detailed description and results of 13 building blocks for a climate neutral future



4.1 Electricity

Electricity supply plays a central role in decarbonising energy supply and its importance will only increase over time through sector coupling, i.e., the electrification of demand sectors. Emission reductions are mainly realised through the phase-out of fossil fuels and the build-up of renewables.

Overview

Global energy supply must be decarbonised by 2050 to stay within the limits of the Paris Agreement (IPCC, 2018b). Integral to that is the decarbonisation of electricity supply – as early as 2035 for advanced economies (IEA, 2021b). Such a timeline can be achieved within the EU without additional costs to the current plans (Ember, 2022b). The importance of electricity supply for decarbonisation will only increase as sector coupling progresses, i.e., as the demand sectors increasingly become electrified this further enables decarbonisation granted, they are being powered by a clean electricity system. Estimates for the share of electricity in final energy consumption project a rise from roughly 23% to around 50% in 2050 (EC, 2018c), and some are as high as 66%, depending on the pathway taken (Ember, 2022b). Meanwhile, improving the energy efficiency of electrical appliances in the demand sectors can help reduce electricity demand, ensuring the costs of electricity are minimised. The development in electricity supply is thus heavily dependent on and linked to the other climate neutral building blocks covering sectoral energy demand (i.e., buildings, mobility, industry) as well as societal norms and lifestyle.

Progress in this building block was too slow. While the overall emission trend is on track, important underlying drivers for the energy transitions must still accelerate – while emission reductions in the past were driven by a shift to gas and renewables, future emission reductions must rely almost entirely on renewables to enable the phase-out of fossil fuels. The share of fossil fuel power generation does not seem to be falling fast enough while renewable energy growth as the main driver for emission reduction has seen mixed progress. While solar energy has shown considerable growth in recent years, meeting the required growth rate, the expansion of wind energy needs to at least double to keep pace. Insufficient support schemes and problems with permitting were the main obstacles. Closely linked, fossil fuel phase-out needs to be sped up. It was hampered in recent years by a coal resurgence due to the gas crisis and nuclear and hydro shortages due to drought. Recent price levels delivered by the EU Emissions Trading System (ETS), could, if maintained at the high levels, provide an important incentive to accelerate coal phase-out further – and an EU phase-out target for fossil fuels would quicken the pace even more. The electricity market reform in the EU, including strengthening

interconnection and the intra-EU market, seems to be heading in the right direction, but data are largely lacking to track progress sufficiently. Grid investments are ongoing and have seen an increase in recent years, but that is not sufficient especially since significant gaps remain in interconnector investments, distribution grid investments and the digitalisation of the grid such as smart meters. There is also limited information on the trend of clean flexibility options, such as energy storage and demand-side flexibility, and the lack of existing regulations at the EU level, including targets, reveal a blind spot in EU regulations that the EU has only recently started to address.

4.1.1 Objectives and enablers

Objectives: Decarbonise electricity supply and phase out fossil fuels

The decarbonisation of electricity supply relies on a mix of supply options, principally renewable energy sources, such as wind and solar and to a lesser extent other low-carbon sources, such as nuclear and carbon capture and storage (CCS). The European Commission (EC) foresees renewable energy to provide 81% to 85% of the electricity supply in 2050 followed by nuclear with 12% to 15% (EC, 2018b). Other studies suggest an even larger role for renewable energy sources of 90% of electricity at the global level in 2050 (IEA, 2022f).

Selected indicator:

GHG emissions of electricity generation [Mt CO_2e]

The decarbonisation of electricity supply is measured with the indicator '*GHG emissions of electricity generation*'. The in-depth analysis accompanying the EU long-term net zero targets currently foresees the electricity supply sector to reach net zero by 2040 (EC, 2019a).

Climate neutrality requires a phase-out of fossil fuels in the power sector. Projections show that coal should be phased out as early as 2030 in advanced economies to be in line with a Paris compatible pathway (IEA, 2021b). An active management thereof should include a plan that provides a clear vision for all actors in the sector and guides investors away from brown infrastructure investment. Payment schemes may enable fossil fuel operators to retire their power plants before the end of their economic lifetime. The EU has not put forward a coal phase-out plan for the bloc at large, but individual Member States have done so – albeit with different timeframes between 2023 and 2038 (EC, 2023c). The EU has not put forward a coal phase-out plan for the bloc at large, but individual member states have done so – albeit with different timeframes between 2023 and 2038 (EC, 2023c). For other fossil fuels, such as gas but also oil, or fossil fuels a whole, a lot less countries have defined specific phase-out timelines.

This is in part because these 'bridge fuels' are often regarded as still playing a role in the transition toward low carbon sources. Moreover, the phase-out of fossil fuels has multiple implications for the economy and is a politically sensitive issue. The creation of green jobs is countered by just transition concerns surrounding the loss of jobs and implications for jobs and communities in geographical regions reliant on the current fossil fuel economy will need to be mitigated.

The indicator '*share of fossil fuel-fired power generation*' measures progress towards fossil fuel phase-out in the power sector. EU projections see the share of fossil fuels in power generation decrease to 18% by 2030 and 3% by 2050 (EC, 2020f).

Selected indicator:

Share of fossil fuel-fired power generation [% of electricity generation]

Enabler 1: Reform of electricity markets to enable participation of renewables

A significant increase in wind and solar electricity generation is needed in the EU to achieve the decarbonisation of the sector. The modelling underlying the EU long-term strategy (EU LTS) suggests that both technologies combined could cover between 66% and 72% of electricity supply by 2050 (EC, 2018c). Wind and solar have already reached grid parity in many constituencies (IRENA, 2021) and in 2022, even generated more electricity than coal or gas (Ember, 2023). However, these renewable electricity sources have uniquely different characteristics from the current base load technologies dominating the past power mix, and electricity markets in the EU have undergone significant changes to enable this transition (Agora Energiewende, 2019).The reform of the electricity market in Europe is a continuously ongoing process (EC, 2023f). At this current stage, several aspects are important to enable a larger share of renewables, as laid out by the EC:(EC, 2023f). At this current stage, several aspects are important to enable a larger share of renewables, as laid out by the EU Commission:

- Market design must enable the operation of highly flexible power plants (including storage) to compensate for the increasing variability of power supply caused by variable renewable energy sources. This can include capacity mechanisms or high temporal electricity prices.
- Market design should allow consumers to become more pro-active in contributing to the stability of the electricity system (demand-side management) (see also below).
- Cross border integration of European electricity markets at different temporal scales enables the largest degree of flexibility across different markets.

The electricity market reform attempts to address the current challenges related to these aspects; however, as the share of renewables increases, the challenges and associated market design will need to adjust further (De Vivero-Serrano et al., 2019). This has important implications on how to measure progress towards the integration of wind and solar—what is relevant in the next years will be very different from what will be relevant in the future.

Selected indicator:

Share of variable renewable energies in electricity generation [%]

Independent of where we are in the transition, progress can be measured by the indicator '*share of variable renewable energy sources in electricity generation*'. Based on the average share of variable renewables across scenarios in the EC 2030 impact assessment, the share of variable renewable sources in power generation will need to increase to 47% in 2030 and 67% in 2050 (EC, 2020f).

Regarding the current challenges, an important aspect to ease the need for flexibility is the integration of the European electricity market, grid, and system through cross border trading and capacity improvements. This can be measured with the indicator '*cross-zonal capacity*'. The EU has set itself a binding target related to cross-zonal capacity, whereby Transmission System Operators (TSOs) have to provide 70% electricity interconnector capacity for cross-zonal trading by the end of 2025 at the latest (Electricity Market Regulation). Unfortunately, there is currently no consistent approach towards tracking the progress towards this target at the EU level.

Selected indicator:

Electricity interconnector capacity availability for cross-zonal trading [%]

Enabler 2: Grid build-out, digitalisation and enhancement

The decarbonisation of electricity supply requires a massive upgrade of the European grid on both the transmission and distribution level. To enable greater visibility and participation of loads and generation at the distribution grid level, this must be accompanied by a digitalisation of the grid. As such, integration of the European electricity grids needs grid investments—in parallel to the integration of markets (see Enabler 1). The digitalisation of the grid is needed to enable the further integration of demand and supply as electrification progresses and the need for flexible demand growths (e.g., through smart meter). The indicator '*investment into the transmission and distribution grid*' measures the progress on both fronts. The EU suggests that

Selected indicator:

Investment into the transmission and distribution grid [EUR/year]

investment into the grid to meet the EU's 2030 targets amounts to EUR 584 billion between 2020 and 2030 (EC, 2022e) or between EUR 53 and 60 billion (with an average of EUR 57 billion across scenarios) per year in the same time period (EC, 2020f).

Selected indicator:

Share of electric smart meters [%]

The indicator '*share of electric smart meters*' provides tracks how far grid digitalisation is enabled across all Member States. The third energy package called for all Member States with a positive economic assessment of smart meters to roll out 80% of smart meters by 2020 (Electricity Market Directive). This target was not reached in most Member States and has not been replaced, but the existence of a new target notwithstanding, a nearly 100% share is desirable.

Enabler 3: Increasing demand and supply flexibility to enable uptake of variable renewable energies

The decarbonisation of electricity supply needs a paradigm shift away from a base-load-focused approach towards one with high flexibility to accommodate the raising share of variable renewable energy sources. In the current power plant park flexibility is provided largely by existing gas- or oil-based power plants to accommodate load following and the integration of variable renewables. Such flexibility providers may not be operated in a climate neutral power system due to slower respond rate of CCS units (Rúa et al., 2020). This means that flexible clean technologies need to be phased-in overtime to allow for the full decarbonisation of the sector. These include certain types of renewable energy sources, such as hydro-power and biomass/biogas-based plants but especially the use of storage technologies, such as pumped hydro storage, battery storage, or hydrogen storage (combined with hydrogen-based turbines). While some of these options are limited by the availability of natural resources, geographical characteristics and/or competing use applications, others come with high up-front costs that often cannot be recuperated in the current electricity market design. Identifying ways to enable the uptake of both technology types is central to the successful integration and further market penetration of variable renewable sources. The success of the power sector transformation hence also significantly depends on the ability to phase-in such technologies to provide flexibility on different timescales. We will measure this with the indicator '*battery storage and dispatchable renewable energy additions*'.

Selected indicator:

Battery storage and dispatchable renewable energy additions [GW/year]

Dispatchable power plants do not rely on fluctuating resources and can be scheduled and controlled by transmission system operators – for instance, to follow the electricity load. Both together are foreseen to reach a capacity of

around 287 GW in 2030 and 947 in 2050, whereby the role of battery storage will increase from 40% of that capacity to almost 80% (EC, 2020f).

In addition to a more flexible power plant park, an increasing flexibility of electricity demand is also needed to minimise costs, so that instead of installing new power plants or investing in new grid infrastructure, consumers are enabled to provide flexibility themselves (DNV, 2022).

Selected indicator:

Flexible power demand [TW/hour]

Demand-side flexibility options can happen at household or industrial scale and include smart power-to-heat, power-to-hydrogen, electric vehicles, smart appliances, and industrial demand response. These are enabled through the digitalisation of electricity supply (IRENA, 2019). The indicator 'flexible power demand' can measure progress on this front. Like for supply-side flexibility, the EU needs to develop frameworks, such as the Digitalisation Strategy (EC, 2020d), to enable flexible demand uptake. However, there is currently no data available on flexible demand at the EU level.

4.1.2 Progress towards climate neutrality

Progress towards the objectives: Decarbonise electricity supply and phase out fossil fuels

GHG emission from electricity generation

This indicator shows the past development of GHG emissions from electricity generation (EEA, 2023b) in comparison to the EU trajectory of reaching a reduction in emissions of 78% in 2030 compared to 2005 levels (EC, 2020f).

Data show an annual decrease of 60.5 Mt CO_2e between 2016 and 2021. This was faster than the benchmark trajectory, where the required annual decrease between 2021 and 2030 needs to be 50.3 Mt CO_2e, and thus on track.

The power sector is on track towards meeting the EU's GHG emission trajectory for the sector (EC, 2020f); emission reduction were decreased faster at 60.5 Mt CO_2e per year between 2016 and 2021 than the required 50.3 Mt CO_2e per year need from 2021 to 2040. This trend is also on track with a decarbonisation of the power sector by 2035 timelines suggested by others, such as the IEA (2021b).

Emissions in the sector are determined by two main factors: the demand for electricity (largely determined by other sectors) and the emission intensity of power production (largely determined by the power generation mix). Over the last two decades, electricity demand has fluctuated but overall, remained relatively stable, with 2021 seeing the same levels as 2005.

Recent years saw a decrease due to COVID-19 in 2020 (e.g., through remote work), followed by a recovery in 2021 and another decrease caused by high energy prices following the Russian war against Ukraine. It remains unclear whether these will have long-term impacts. It is more likely that electrification trends in other sectors will pick-up significantly in coming years, potentially leading to an increase in electricity demand. This foreseeable increase in electricity demand puts even more pressure on the second factor determining emissions in the sector: the emission intensity of power production. The emissions intensity of power production has seen a steady decrease over the past two decades but rebounded in 2021 and 2022 (Ember, 2022a). The decrease has been driven by increases in renewable energy generation and a switch to natural gas, which pushed coal out of the generation mix. However, the rebound in 2021 was caused by two factors: drought reduced power generation from hydro energy and an unexpectedly high number of downtimes of nuclear power plants, in particular in France (ACER, 2023). In 2022, the increase continued driven by the gas crisis following the Russian war against Ukraine, which pushed gas out of the generation mix, bringing in larger amounts of coal generation again. Especially the gas crisis led the EC to publish its REPowerEU plan (EC, 2022j) with measures that aim to increase the speed of the energy transition. However, it remains to be seen whether these measures will manage to turn around the trend.

Share of fossil fuel-fired power generation

This indicator shows past development in the share of fossil fuels in electricity generation (Eurostat, 2023f, 2023e) in comparison to the EU benchmark of reaching a share of 18% in 2030 (EC, 2020f).

Data show an annual decrease of 1.3%-points between 2016 and 2021 which was too slow. It has to reach an annual decrease of 2.5%-points between 2021 and 2030. This is 1.9 times faster than the past rate of progress.

The phasing out fossil fuels in the EU is happening too slowly. The share of fossil fuel power generation decreased by just 1.3%-point per year between 2016 and 2021, compared to a required decrease of 2.5%-points per year. The EU ETS is the main instrument incentivising fossil fuel phase-out, and despite generally positive developments in recent years, it has not managed to spur on the phase-out fast enough. The EU ETS saw a jump in the CO_2 price from previous levels of between 20 and 30 Euro/tCO_2 up until late 2020 to 60 to 100 Euro/tCO_2 in the beginning of 2022. Since 2022, the price has fluctuated around that level, caused by different factors, such as the temporary reverse switch from gas to coal in response to the gas prices, droughts causing hydro and nuclear power shortages, increasing electricity demand, and a proposal by the EU to fund coal-fired power plants with EUR 2 billion as part of the REPowerPlan (EC, 2022d). The latter could undermine the EU's own emission reduction efforts (CAT, 2022). The effect on coal capacity and generation was mixed – while coal power generation went up, many power plants are being retired and only Poland

added new generation (Beyond Fossil Fuels, 2022). Moving forward, a stable CO_2 price above EUR 50 and reaching EUR 100 could disincentivise investment in new power plants further and accelerate the phase-out of fossil fuel generation (Twidale et al., 2023).

Progress towards Enabler 1: Reform of electricity markets to enable participation of renewables

The share of variable renewable electricity generation has increased over the last decades and is heading in the right direction but still far too slow to enable an emission trajectory in line with the EUs own trajectory. The share of renewables in electricity generation grew at a rate of 1.5%-points between 2016 and 2021, which has to accelerate to 3.2%-points to be in line with the impact assessment of the EU's 2030 Climate Target Plan (EC, 2020f). While the European Council (EUCO) and European Parliament (EP) have agreed on updating the Renewable Energy Directive and targets , the policy regimes at the Member State level seem not adequate to enable an uptake in line with the EU's own objectives. General problems that can be observed across EU countries are: faulty designs; stop-and-go policies, which impact investor confidence; and problems with lengthy permitting procedures (IEA, 2022c). The EU is attempting to address the latter through Council Regulation (EU) 2022/2577 to accelerate the deployment of renewables. To become in line with the EU's own trajectory, renewable deployment should be at around 48 GW of solar PV and 36 GW of wind yearly, while only 41.4 GW of solar and 16 GW of wind (87% onshore) were added in 2022 (IEA, 2022c; SolarPower Europe, 2022; WindEurope, 2023). Progress on wind energy is thereby especially insufficient; while onshore wind has struggled to identify new sites, offshore wind is a relatively new technology and is still causing problems (CAT, 2022). There are signs that a change in the right direction is ongoing – investments in onshore wind are increasing, and while investments in offshore wind are currently decreasing, Member States are increasingly committing themselves to install more offshore wind (CAT, 2022). The development of solar energy was almost in line with what is

Share of variable renewable energies in electricity generation

This indicator shows past development in the generation share of variable renewable energy sources (wind and solar) (Eurostat, 2023f, 2023e) in comparison to the EU trajectory of reaching a 48% share in electricity consumption in 2030 (EC, 2020f).

The data show an annual increase of 1.5%-points between 2016 and 2021. To meet the benchmark, the required annual change between 2021 and 2030 needs to be 3.2%-points, which is 2 times faster than the current rate of progress.

needed, and industry's own projections suggest that this will continue at an even higher level (SolarPower Europe, 2022).

The progress of EU electricity market reforms to enable the uptake of variable renewables is difficult to track but can be largely characterised as too slow. This is due to the complexity associated with finding the right market design, one that fulfils multiple conditions simultaneously, e.g., energy security, energy equity, decarbonised supply, as well as the various market design options that exist (Nabe & Staschus, 2023). The proposed EU market design reform by the EC includes several measures that attempt to address protecting consumers against high electricity prices and continued support of variable renewables (EC, 2023u). Whether the EU manages to successfully address both remains to be seen, but the general intention to see the growth of renewables as an opportunity to overcome the existing energy crisis is integral to the proposal. Aspects highlighted in Section 0 as integral to supporting the market integration of variable renewables include the greater integration of European electricity markets, increases in flexible generation, and increase in demand-side management. All are part of the EU's proposal. The latter two are discussed below. The former, the integration of European electricity markets, is addressed by the EU target to make available at least 70% of cross-zonal capacity. However, progress on this front cannot be tracked due to a lack of harmonised monitoring between transmission system operators (TSOs). Indicative analysis shows that the levels remained the same between 2020 and 2021 (ACER, 2022), indicating that progress was too slow and that more action is needed. The problem of data quality and availability has also been identified as part of the latest proposal by the EU Commission (2023u). The problem of data quality and availability has also been identified as part of the latest proposal by the EC (2023u). The problem of data quality and availability has also been identified as part of the latest proposal by the EU Commission (2023u).

Electricity interconnector capacity for cross-zonal trading

The indicator measures in how far TSOs in countries are setting aside interconnector capacity for cross zonal trading. The EU set target for a minimum of 70% of electricity interconnector capacity for cross-zonal trading (ACER, 2022).

There is not enough data to track this indicator, but a qualitative comparison suggests that change is far too slow.

Progress towards Enabler 2: Grid build-out, digitalisation and enhancement

Investments in the power grid increased by an average of 4% per year between 2016 and 2021 and reached a level of EUR 66.3 billion in 2022 based on IEA data (IEA, 2022d). The EU published

investment figures that suggest that average annual investment must reach around EUR 57 billion per year (EC, 2020f) or EUR 584 billion over the time period between 2020 and 2030 to be in line with the 2030 climate target (EC, 2022e). However, these figures cannot be compared to the investment figures presented by the IEA due to differences in scope. Various publications hint to the scale of additional investments needed. The EU itself suggests that a 15% increase in investments compared to the baseline is needed to reach its 2030 targets (EC, 2020f), indicating that progress is rather too slow. Other sources point to a doubling of yearly investments until 2050 if electrification is to become a stronger backbone of the transition (Kreusel et al., 2022).

Investment into transmission and distribution grid

This indicator shows past development in investments in electricity grid infrastructure (transmission and distribution) (IEA, 2022d). While data for trend and a future benchmark are available (EC, 2020f), differences in how these are defined in terms of scope do not allow for a comparison.

Data show an annual increase of 5% between 2017 and 2022. This development was heading in the right direction but was too slow as the EU suggests a 15% increase in investments compared to its own baseline.

Various areas of the grid will need attention.
By 2030, interconnection capacity needs to increase by 1.7 times compared where it is now, albeit that heavily depends on how the future electricity grid will develop (Kreusel et al., 2022; Sensfuß et al., 2019). Similarly, investments into the distribution grid must increase, to connect renewables at the distribution level, which is currently a major bottleneck in the EU, and to enable electrification and demand-side management (IEA, 2022c). A major problem here is aging infrastructure and some actors suggest that an investment increase of between 50% to 70% is needed through 2030 (Rack, 2021). The EU itself estimated that of the required EUR 584 billion of total grid investments, around EUR 400 billion need to go into the distribution grid alone (including digitalisation). The EU has recognised the need for a coordinated approach and has set in place a planning process for transmission grids, developed a ten-year network

Share of electric smart meter in total meters

This indicator shows past development of the share of smart meters in electric meters (Berg Insight, 2022; EC, 2020c). While there is no official benchmark data, a share close to 100% would enable the digitalisation of the grid and thus the energy transition.

Data show an annual increase of 24% between 2014 and 2020, which was far too slow because a continuation of the trend would mean that the EU would reach a 100% diffusion only close to 2030.

development Plan (TYNDP), and is supporting the development of unified network codes (Kreusel et al., 2022).

The roll-out of smart meters can be regarded as one of the first essential steps to enable the digitalisation and thus participation of prosumers and demand-side adjustments. The spread of smart meters was, however, far too slow, reaching only an annual growth rate of 23% per year over the past years which means that, if this trend continues, the EU will reach a 100% share of smart meters only around 2030. This hints to the fact that the digitalisation needs to speed up significantly. For comparison, other jurisdictions such as in California reached a nearly 100% roll-out of smart meters today (PG&E, 2012). The EC is currently developing indicators to monitor the future digitalisation of the grid and plans to support European Union Agency for the Cooperation of Energy Regulators (ACER) and National regulatory authorities (NRAs) to develop smart grid indicators and benchmarks, which can be used in the future to track the progress of the digitalisation of grids (EC, 2022e).

Progress towards Enabler 3: Increasing demand and supply flexibility to enable uptake of variable renewable energy sources

Up until the energy crisis, the EU put an emphasis on gas as the main source for flexibility in the power supply. The recent energy crisis has intensified the need to find solutions that reduce gas demand, but other supply-side flexibility options, such as energy storage have only been marginally part of the solution so far. Along these lines, the EU was criticised for not setting explicit targets for storage in the REPowerEU plan, or any earlier communications for that matter (Colthorpe, 2022). The EUs efforts focused mainly on providing better information for storage technologies (EC, 2023h), and only recently shifted to providing guidance on how EU countries can support energy storage (EC, 2023d). The lack of ambition is paralleled by a lack of transparency. Our analysis shows, while the growth of dispatchable renewables is in line with the indicative low levels projected by the EU of 173 GW there is not sufficient data for installed storage capacity within the EU to judge whether the current

Battery storage and dispatchable renewable energy additions

This indicator shows past development of the clean supply-side flexibility options including storage and dispatchable renewables in comparison to the EU trajectory of reaching 287 GW in 2030.

There is no historical data for the clean supply-side flexibility options as there is not sufficient data available for storage capacities. The data for dispatchable renewable sources (EC, 2020f) showed an annual increase of 0.3 GW between 2016 and 2021, which is on track when compared to the indicative benchmark of reaching 173 GW in 2030 requiring no further increase.

trend is aligned with the future needs of 114 GW. Only the US DOE provides freely available data on storage capacities, which is outdated and contains only scattered national level data that cannot be combined into one cohesive EU-wide dataset. This is a significant data gap as energy storage technologies will play an important role in particular after 2030 and must undergo significant growth until then (see also section 0).

There is also insufficient data available to help judge the status and progress of demand-side flexibility (DNV, 2022). Existing data from the IEA provides one indicative data point, but without further data it remains unclear what the trend looks like. The data point suggests that in 2017 the total flexible load available in Europe amounted to around 20% of total electricity generation, providing an indication of the scale of potential that exists. Additionally, there is no data on the market participation of demand flexibility options. While the existing EU Electricity Market Directive calls on Member States to support demand-side flexibility, and the proposed amendment further enables EU countries develop support schemes for demand flexibility (EC, 2023t), it remains to be seen how effective these will be in guiding EU countries. These reforms are critical as the lack of policy-making is the major hurdle to allow demand-side management to compete with supply-side flexibility (IEA, 2018). In the EC's proposal there are several elements that could overcome this hurdle, such as the call to define a national objective and/or the (re)design of capacity mechanisms to accommodate demand-side management.

Flexible power demand

This indicator shows past development of flexible power demand in the EU (IEA, 2018).

Data is insufficient as there is only one data point available, and hence no trend can be derived.

4.1.3 Conclusions and recommendations

Renewable electricity generation must further accelerate to overcome the energy crisis and get the EU on track to achieving climate neutrality

The last two years have seen a slowdown in the decrease of sectoral emissions due to the energy crisis and extended drought periods, which has led to an increase in coal power generation. Measures undertaken to address the energy crisis, such as under REPowerEU, need to be scrutinized with a view to the long-term transition. Rather than supporting existing coal-fired power plants further, as currently proposed, energy efficiency efforts should be intensified,

and the uptake of renewables fast-tracked. The EU must accelerate the transition to renewable power generation, not rely on fossil fuel power generation as a fallback.

While the EU has recently updated its 2030 renewable target, renewable uptake is hampered by flawed and insufficiently ambitious policy regimes at Member State level, affecting especially wind energy. EU efforts to overcome barriers, such as the existing siting problems for onshore wind or the technological complications associated with offshore wind need to be continued and intensified. Regular ongoing monitoring and, if necessary, the revision of EU measures should be applied to guarantee these are effective. Member States must ensure that reforms to national renewable support schemes, that are often ongoing as a reaction to the high energy prices following the energy crisis, lead to a higher uptake of renewable energies in line with the trajectory described in the EU's own plans.

Coordination and scale-up of grid and clean flexibility options to ensure a secure decarbonisation of the electricity system

While grid investments have increased in recent years and the overall amount is not far off from where they should be to be in line with the EU's own plans, significant investment gaps exist suggesting that funds are not flowing where they are needed most. and what the impact of an intensified electrification of the demand sectors would be. Areas that require ongoing investment are the distribution grids, enabling digitalisation, and interconnection between EU countries. In addition, the EU needs to continue and intensify its shift of focus from existing electricity supply-side flexibility options, especially natural gas, towards clean supply-side options, such as dispatchable renewables and energy storage. Especially energy storage technologies require clearer targets and incentive mechanisms, both at the EU as well as the Member State level. Recent efforts by the EU go in the right direction but need to be followed through.

Efforts on grid and flexibility options should be coordinated to ensure the most effective use of available public and private investment. Clarification is needed about the role of demand-side flexibility options is and how these can be intensified to allow them to compete with supply-side flexibility options. The TYNDP needs alignment with the long-term goal of reaching a clean energy system.

Box 2: Highlights from the assessment of Electricity

The electricity sector emission trajectory is on track, but underlying drivers are not

In the past, emission reductions in the sector were driven by a shift to gas from coal together with a renewable energy uptake. To sustain this trend moving forward, renewable uptake needs to be speed up further, from 1.5% of new generation p.a. to 3.2% p.a., and the fossil fuel phase-out accelerated.

To speed up renewables uptake, policies in EU countries need reform, especially for wind

While solar development is largely on track, a significant increase in efforts is needs to increase wind capacity. Obstacles keeping wind from growing faster, such as citing issues, need to be overcome even faster, and renewable policies in EU countries need to be reformed to enable this uptake.

The EU needs to continue and intensify the shift from fossil-based electricity supply-side flexibility options, especially natural gas, towards clean supply-side options such as energy storage or and energy. Recent efforts by the EU to encourage EU countries to incentivise these need to be followed through with policy development.

A coordinated and well-funded approach to grid extension is needed across the EU

While grid investments have been on the rise in recent years, there remain significant gaps in certain areas including the distribution grid, a digitalisation of the grid as well as transmission capacity between EU countries. Resources need to be made available to further develop the grid of the future.

A shift from existing gas as a flexibility option to clean option is needed

The EU needs to continue and intensify the shift from fossil-based electricity supply-side flexibility options, especially natural gas, towards clean supply-side options such as energy storage or and energy. Recent efforts by the EU to encourage EU countries to incentivise these need to be followed through with policy development.

4.2 Mobility

Mobility is essential for connecting people and sustaining economies. For a transformative shift in the transport sector, reducing motorised transportation, promoting clean modes, and decarbonising remaining transport are essential.

Overview

Mobility is more than the simple act of transporting people and goods. Instead, it is an integral part of our lifestyles: it connects people with each other, allows daily commutes to work and education, brings us to our leisure activities, and assures that global supply chains can function. It is thus an important pillar of the economy. In the EU, the sector contributes to 5% of the GDP, employs 10 million people, and is the second-largest area of expenditure (EC, 2020h). The EU Green Deal outlines that a shift in the 'existing paradigm of incremental change to fundamental transformation' (EC, 2021o) has to happen. In the context of the transport sector this means three things: (1) motorised transportation needs to be minimised and reduced as far as possible (i.e., avoid/reduce), (2) necessary transportation should be shifted from private, motorised vehicles to public, and non-motorised low-carbon modes of transport (i.e., shift) and (3) and remaining road, air, and water transport needs to be decarbonised by shifting the power source from fossil fuels to clean electricity and sustainable fuels (i.e., improve).

Progress in the mobility sector is far too slow, with none of the three key enablers on track to meet the EU's climate neutrality targets. The reduction in transport volume (1), which only briefly occurred during the COVID-19 pandemic, does not seem to be sustained as both total passenger kilometres and freight volumes seem to rebound to continue to grow at a pace that is insufficient to avoid disastrous global warming. The shift from private, motorised transport to public, low-carbon modes (2) is even more concerning. Instead of reducing the share of road transport and increasing rail usage, both freight and passenger transport are moving in the wrong direction, exacerbating the problem. However, there are some positive developments, particularly in the uptake of electric mobility and clean vehicles (3). The adoption of these technologies is increasing exponentially, with record-high levels of 22% of passenger vehicle sales in 2022. While this trend is promising, the overall share of the passenger fleet still remains below 3%, indicating the need for accelerated progress.

This situation reflects the current EU policies, which place a strong emphasis on improving the efficiency of cars through measures like phasing out combustion engines. Such policies achieve

the greatest carbon reduction and are best aligned with the TEU subsidiarity principle. Policies to encourage modal shift are only starting to emerge, which means the necessary shift may have already begun, albeit with a lag in visible effects. Achieving an overall reduction in transport requires policies that extend beyond the transport sector and encompass urban planning and local industries. Although more challenging to address, the EU must now implement comprehensive policies that encompass all elements simultaneously if it is serious about meeting its targets. Time is running out, and urgent action is needed to ensure the EU stays on track with its own climate goals.

4.2.1 Objectives and enablers

To achieve climate neutrality by 2050, and to be in line with the EU Green Deal's 90% reduction target for transport-related GHG emissions by 2050, the sector must decarbonise quickly (EC, 2020i). Hence '*overall emissions in the transport sector*' is one of the key objective indicators. To achieve such reductions the EC has laid out milestones for 2030, which amongst other things include a drastic scale-up of electric vehicles (EVs) to at least 30 million, a doubling of high-speed rail traffic, and an implementation of 500 km carbon neutral public transport. Later in the coming decades it also aims at shifting more freight traffic to rail and scaling up zero-emission vessels and aircrafts (EC, 2021o).

Selected indicator:

GHG emissions from transport [Mt CO_2e]

Population growth, which is projected to reach a peak in the EU in 2030 (Eurostat, 2019), increases the challenge to reduce absolute emissions in the transport sector. The indicator '*carbon intensity of passenger transport*' shows emissions by passenger kilometre, enabling a look at transport emissions disaggregated from the external demand factor. This analysis could be expanded to include the carbon intensity of freight transport (in gCO_2 / tonne-km) but for now the focus is non passenger transport as the subsector accounts for roughly three quarters of the sector's emissions and low-carbon solutions are more readily available (EEA, 2023c).

Selected indicator:

Carbon intensity of passenger transport [gCO_2 / passenger-km]

Enabler 1: Manage motorised transport demand

Rural landscapes but also the outskirts of European cities often developed around private vehicle use in such a way that life without access to an automobile is challenging. Continuous improvements in road infrastructure have led to people getting increasingly accustomed to

travelling longer distances on a daily basis. Interestingly, as the speed of traffic increased throughout history, distances grew simultaneously (SES, 2018), hence passenger kilometres are constantly increasing. One way to reverse this trend of travel time and distance is by clever urban and regional planning that prioritises shorter distances and allows non-motorised transport such as cycling and walking to become feasible alternatives. European cities are already leading this change. For example, in Copenhagen more than half of the population uses non-motorised means for the commute to work and school (49% of the population cycles and another 6% walk) (City of Copenhagen, 2019). To assess this across the EU, '*total passenger transport volume*' shows the average distance travelled per passenger with motorised transport options. This indicator only looks at absolute values and does not consider how many people travel with the same vehicle, including public transport or car-sharing.

Selected indicator:

Share of passenger transport volume by mode [%]

Globalisation has increased the importance of freight transport and global supply chains. Vessels and ports are becoming larger as are the volumes of freight transport (Eurostat, 2022d). Reversing this trend is difficult, as it demands structural change and potentially a perceived cut in living standards. Consumerism in its conventional and emerging forms, such as on-demand delivery services, cannot be sustained at current levels if freight volume is to decrease. Nonetheless, in addition to shifting freight transport to rail and other zero emission modes of transport, a decrease in overall freight volume is necessary. '*Total freight transport volume*' shows developments on this front.

Selected indicator:

Total freight transport volume [million tonne-km]

A major issue with the increase of transportation is that the demand for materials will likely rise, which could potentially strain resources and increase environmental pressures. It is therefore crucial to adopt sustainable practices and circular economy principles as well as to promote resource efficiency, recycling, and the use of alternative materials. These include improving material recovery from end-of-life vehicles, investing in research and development of new materials, and exploring ways to reduce reliance on critical resources.

Enabler 2: Shift to public mobility

A reduction in car dependency, which is especially high in the EU, and a shift to other transport modes is necessary to reduce overall emissions in the sector. More environmentally friendly modes, such as buses, are more efficient because they transport larger numbers of people, and

some modes also have more sustainable drivetrains, such as electric trains. The relevant indicator here is '*share of passenger transport volume by mode*', whereby the impact assessment of the EU LTS outlines the required changes in road, rail, aviation, and inland navigation (EC, 2018c).

However, the private passenger car is much more than a means to move people. It impacts people's view on work, family-life, leisure, and other social aspects of life. Cars have also increased urban sprawls, which in turn have increased the necessity for cars, with social impacts on the work and housing markets. They are also private property and major goods of individual consumption and hence have a deeper symbolic meaning, often related to social status (Urry, 2004). These points make a shift away from the use of private vehicles extremely challenging. However, using cars less, i.e., making fewer trips and traveling shorter distances while shifting and connecting to other means of transport, could cut emissions in the sector without completely giving up the benefits of a private vehicle.

Similarly, we also consider the '*share of freight transport volume by mode*', as heavy goods vehicles account for 28% of emissions from road transport (Transport & Environment, 2022) followed by aviation and shipping. Especially the shift from road to rail transport is of importance here, and also pursued by the EU with a goal to increase rail freight traffic by 50% by 2030 and double it by 2050 (EC, 2021o). The related indicator to show progress towards these targets is '*share of freight transport volume by mode*'. The impact assessment of the EU LTS outlines the same required changes for rail as well as benchmarks for road, aviation, and inland navigation (EC, 2018c).

Selected indicator:

Share of freight transport volume by mode [%]

Enabler 3: Implement zero emission and low carbon transport

A shift to zero-emission and low-carbon transportation to decarbonise the modes of transport that are currently in use is probably the most enabling transformation for the sector. This includes, e.g., replacing gasoline or diesel-powered internal combustion engines (ICE) with electric batteries to make EVs or replacing diesel, kerosene, and heavy fuel oils with clean fuels. Cars and vans with ICEs can easily be replaced by fully electric motors, which is shown in the exponential increase of battery EV sales in the EU that increased from less than 2% in 2019 to over 12% in 2022 (EAFO, 2023). In addition,

Selected indicator:

Share of EVs in passenger car stock [%]

EVs consume roughly one third of the energy that ICE vehicles do, and their lifecycle emissions are lower already with today's electricity mix (Bieker, 2021) (Braun & Rid, 2017). Full decarbonisation through electrification is, however, only possible if the required electricity comes from clean sources. The EU aims at reaching at least 30 million zero-emission cars by 2030 (EC, 2021o). To accelerate the production and sale of EVs, the EU passed a law in October 2022 requiring all newly registered cars and vans to be zero-emissions vehicles by 2035 and further stipulating that the CO_2 emissions from new cars and vans must decrease by 55% and 50% by 2030, respectively (EC, 2022l). We track the phase-out of ICEs by looking at both cars and vans, i.e., the '*share of EVs in passenger car stock*'.

Trucks, busses, and coaches (heavy-goods vehicles) are expected to transition to electric batteries but also other powertrain technologies, such as hydrogen-powered fuel cells, as the battery weight needed to power such vehicles and recharging times are major limitations. The related indicator here is '*share of zero-emission vehicles (ZEV) in heavy-goods vehicle stock*'.

In addition, aviation and shipping must move to cleaner fuels. For shipping, zero-emission fuels (ZEF) include green hydrogen, ammonia, and captured CO_2, sustainable aviation fuels (SAF) are similar and mainly made from biomass, alcohol, or electricity. While green hydrogen and ammonia are not yet available on scale, the use of biofuels is highly controversial due to its impacts on land use and biodiversity (Al-Enazi et al., 2021). Related indicators, such as the 'share of sustainable aviation fuels and share of zero-emission shipping fuels in total fuel use' are not yet included due to their early stage of progress but are under consideration for future publications.

Selected indicator:

Share of zero-emission vehicles (ZEV) in heavy-goods vehicle stock [%]

4.2.2 Progress towards climate neutrality

Progress towards the objectives

Whereas overall emissions in the European Union decreased by 32% between 1990 and 2020, the transport sector was the only sector that saw a rise in emissions (7% increase) (WEF, 2022). In 2019, before the COVID-19 pandemic, domestic transport was the second largest source of emissions in the EU, accounting for a 22% share of all GHG emissions (EEA, 2023b). GHG emissions in the transport sector have steadily grown until 2007 and after a decreasing trend until 2013, started rising steadily again until 2019 (EEA, 2023b).

GHG emissions from transport

This indicator shows past development in EU transport sector GHG emissions (EEA, 2023b) in comparison to the EU target of reducing CO2 emissions from transport by 92% in 2050 relative to 2005 (1.5TECH scenario outlined in LTS) (EC, 2018c).

Data show an annual decrease of 25 Mt CO_2e between 2016 and 2021. To meet the target, the required annual change between 2021 and 2050 needs to be 27 Mt CO_2e, which is 1.07 times faster than the current rate of progress.

Restrictions and lifestyle changes during the COVID-19 pandemic had strong impacts on mobility and emissions in the transport sector, leading to emissions levels in 2020 as low as in 1995. Although there was a rebound in 2021, not all restrictions have loosened, leading to emissions staying lower than in previous years, which results in an overall negative emissions trend. Assuming linear continuation of this trend, speed of emission reductions would need to accelerate 1.07-fold to fully meet the target of a 92% reduction by 2050 as outlined in the impact assessment of the EU LTS (EC, 2018c). This would be translated into the too slow category. Due to the strong impact of COVID-19, however, and the fact that the indicator was going into the wrong direction before the pandemic, the category of this indicator is amended with expert judgement to far too slow. To turn this around, a set of actions are needed such as a reduction of overall transport volume, a shift from private, motorized transport to public, unmotorized transport and a shift to more sustainable power sources.

Decreasing the carbon intensity of passenger transport should also be a main goal of EU's transport policies. Carbon intensity is a composite value of emissions by passenger kilometres; hence it takes into account several metrics including carbon intensity (and drivetrain) of vehicles, modal split, occupancy rates, vehicle kilometres, etc. Little data on EU level is available for this indicator. Passenger kilometres in the EU (see enabler 1, indicator 1) and modal split (see enabler 2, indicator 1) have not moved into a positive direction in pre-pandemic times. Similarly, occupancy rates in the EU decreased from over 2 in the 1970s to 1.5 in the 1990s and (EEA, 2000), more recent data is not available. Data in other countries (i.e. Ireland) show that carbon intensity in private cars has remained stable (O'Riordan et al., 2022). Due to a lack of data, this indicator is rated as insufficient data.

Carbon intensity of passenger transport

This indicator shows past development in EU emissions intensity of passenger transport. No benchmark is available from an official EU source.

There is currently no EU-wide aggregated data available on carbon intensity of passenger transport. Data is therefore insufficient to assess the progress of this indicator.

Progress towards enabler 1: Manage motorised transport demand

The EU has not set official targets on the levels of passenger and freight transport volume that it wants to reach / aim for. In its impact assessment of the EU LTS (EC, 2018c) it however models scenarios that reach net zero emissions in 2050. In those scenarios, it allows freight transport volume to grow by 50% to 51%, and passenger transport by 28% to 32% (compared to 2015); both only slightly lower than the expected growth in the baseline scenario (54% and 36% respectively).

Current trends of passenger volume actually show a decline. This is however a result of substantially lower passenger transport volumes during the COVID-19 pandemic in 2020, before which, a steady increase, at more than twice the allowable rate could be observed. As it is unclear whether the linear

Total passenger transport volume

This indicator shows past development in the growth of passenger transport volume (Eurostat, 2023n, 2023j) in comparison to 2050 targets derived from the most stringent transport activity growth rates by modes outlined in the impact assessment of the EU LTS (EC, 2018c).

Data show an annual decline of 174 billion passenger-km between 2015 and 2020. To meet the target, the required annual change between 2020 and 2050 could increase by 101 billion passenger-km, which means that this indicator is on track.

trend continues, a slight rebound occurs or the rebound occurs at pre pandemic levels, we make an expert judgement and rate this indicator as too slow. To actively reduce passenger kilometres, the EU must put stronger emphasis on smart urban planning, where working and living in proximity becomes possible. Policies to reverting urban sprawl can also lead to shorter commuting distances. The COVID-19 pandemic showed that less travel, especially on road and air, is possible, and while it is yet to be seen whether remote work and home office will lead to lasting change, it shows that policies in the work sector can have positive impacts on transport emissions (EEA, 2022e). It must however also be noted that due to the heterogeneity of EU countries, some have higher levels of passenger-km/capita and should strive to reduce their levels while others actually have some catching up to do.

Total freight transport volume

This indicator shows past development in the growth of freight transport volume (Eurostat, 2022j, 2023e, 2023n) in comparison to 2050 targets derived from the most stringent transport activity growth rates by modes outlined in the impact assessment of the EU LTS (EC, 2018c).

The data show an annual increase of 38.6 billion tonne-km between 2016 and 2021. To meet the target, the required annual change between 2021 and 2030 must be reduced to 26.8 billion tonne-km.

Freight transport was less impacted by the pandemic - only a small dip occurred in 2020, which was followed by record high levels of transported goods in 2021. Assuming a continuation of the linear trend, the freight transport sector would surpass the targeted goods volume in 2050. Its yearly pace of growth would need to be reduced from an annual increase of 38.6 to 26.8 billion tonne-km to meet the target; it is therefore decreasing too slowly. As with passenger kilometres, the policies that will reduce freight volumes are also only indirectly linked to the transport sector. The EU must instead focus on policies that promote local sourcing and manufacturing, to avoid long supply chains. Land-use planning can also help to cluster businesses in certain areas to shorten supply chains.

Progress towards enabler 2: Shift to public mobility

Data to assess a shift towards public and non-motorised mobility is relatively difficult to obtain, targets remain vague and it is often unclear what they encompass. Nevertheless, a set of targets are defined as, for example, outlined in the mobility strategy where the EU states that it aims at doubling high-speed rail traffic by 2030 and tripling it by 2050, doubling freight rail traffic by

2050 and making all scheduled collective travel of under 500 km carbon neutral by 2030 (EC, 2021o). Here, however, we again refer to the impact assessment of the EU LTS (EC, 2018c), which lays out a breakout by mode, with growth rates of road, rail, navigation and aviation. Unfortunately, it does not lay out shares of public transport. However, modes that are not on roads are predominantly public, while road vehicles have a very high private share. For simplicity, we focus here on rail and road for passenger transport, which are both currently heading into the wrong direction. In 2020, due to the COVID-19 pandemic, the share of passenger mobility on road reached record highs, compensating for the avoided share in air traffic. Before that, the share of transport on road was decreasing slowly, and on track to reaching the target of 75% of all passenger transport in 2050. Similarly, rail transport saw a dip in 2020 after gradually but very slowly growing. Even then, however, the rate of growth would have had to increase almost 4-fold to achieve 10% of passenger kilometres on rail.

Share of passenger transport volume by mode (road)

This indicator shows past development in the share of passenger transport on road (Eurostat, 2023n, 2023j) in comparison to the EU target of not surpassing a 75% share of passenger transport in 2050 (EC, 2018c).

The data show an annual increase of 1%-points between 2015 and 2020. To meet the target, the required annual change between 2020 and 2050 needs to be an annual decrease of 0.5%-points, which points into the opposite direction than the current rate of progress.

Nonetheless, the EU, governments, and the private sector can do a lot to accelerate modal shifts and reduce travel kilometres. Many European cities grew organically and doing active urban planning now is difficult but not impossible. Investments in infrastructure, especially bike-lanes and rail have shown to lead to positive transformations. Employers can also do their bits by incentivising such modes by i.e. providing their employees monthly passes for the cities public transit system or providing company bicycles instead of company cars. This is also where governments can come in, tax and pricing schemes (such as those of company cars) should always support environmental objectives.

Some European countries are already undertaking policies to push for this shift. Germany, for example, introduced a nationwide monthly transportation pass for EUR 9 over the summer months of 2022, mainly to reduce dependency on Russian fossil fuels and support people in light of inflation. Based on its success, it introduced a follow-up nationwide monthly 49EUR-ticket on May 1st 2023, which is still highly subsidised and the German government is set to invest EUR 1.5 billion yearly, while the federal states bring up the same amount (Bundesregierung, 2023). The EC also seeks ways to incentivise modal shifts to rail such as

making cross-border tickets easier to use and buy, and the EC plans to propose regulatory measures to enable innovative and flexible tickets that combine transport modes (EC, 2021o).

Freight transport was less impacted by the pandemic as the entire sector took a dip but this was not reflected in modal shares. Since 2011 traffic on rail has however been decreasing, the same year that the shares of freight transport on roads started growing again. The targets derived from the impact assessment of the EU LTS (EC, 2018c) state that at least 24% of freight transport must be on rail by 2050 and at most 69% on road, currently, however, we are heading into the wrong direction to 6% and 95% respectively. Bringing freight transport from the road to rail is another challenge. While Europe has a substantially better network of passenger transport than the USA, its freight railways are much less productive and efficient while costing much more because, different to the USA, freight and passenger traffic share the same rail networks in Europe. Therefore, EU freight rail has much lower flexibility and freight is therefore often moved by night and on shorter trains (Clausen & Voll, 2013; Furtado, 2013). Further expansion of rail infrastructure is therefore of critical importance.

Share of freight transport volume by mode (road)

This indicator shows past development in the share of freight transport on road (Eurostat, 2022j, 2023e, 2023n) in comparison to the EU target of not surpassing a 69% share of passenger transport in 2050 (EC, 2018c).

The data show an annual increase of 0.6%-points between 2015 and 2020. To meet the target, the required annual change between 2020 and 2050 needs to be an annual decrease of 0.3%-points, which points into the opposite direction than the current rate of progress.

Progress towards enabler 3: Implement zero emission and low carbon transport

In its mobility strategy (EC, 2021o) the EU states that it aims at reaching at least 30 million zero-emission cars by 2030 and that ‘by 2050 nearly all cars, vans, buses as well as new heavy-duty vehicles will be zero-emission”. In its long-term strategy (EC, 2018c) it elaborates that to reach net zero emissions by 2050 the share of battery electric and plug-in hybrid cars would be 82% (with another 16% with fuel-cell drivetrains) in 2050.

To achieve this, the rate of progress in the growth of EV stock needs to be seven times faster than the average rate of growth of the past five years, assuming linear growth, making the indicator Far Too Slow. However, the share of EVs in the yearly car sales in the EU has started to increase rapidly over the past years, reaching 22% or almost 6 million in the EU in 2022 (EAFO, 2023). Because replacing an entire fleet of combustibles takes time, there is a lag before this growth can be observed in the overall vehicle fleet. Hence, the share of EVs in the vehicle stock remains limited with only 2.3% of all cars on the road being powered by clean drivetrains (battery electric, plug-in hybrid, or hydrogen) (EAFO, 2023).

Share of EVs in passenger car stock

This indicator shows past development in the uptake of electric vehicles in the passenger car fleet (EAFO, 2023) in comparison to the EU target of reaching 82% share in electric vehicles in 2050 (EC, 2018c).

Data show an annual increase of 0.41%-points between 2017 and 2022. To meet the target, the required annual change between 2022 and 2050 needs to be 2.8%-points, which is 7 times faster than the current rate of progress.

In this context, it is worth noting that EV deployment is expected to follow an S-curve, where the technology is currently in the breakthrough stage of adoption. In fact, signs of exponential change are already visible; despite the seemingly low values in 2021, the fleet size has increased 5-fold in only 4 years and growth rates are steadily increasing (EAFO, 2023). Progress in this indicator could thus change quickly. Europe is a frontrunner in EV deployment, of the 13 countries with the largest share of EVs in their fleet, 12 are within Europe (although non-EU countries Norway and Iceland are leading the ranking) (IEA, 2023b).

The transition for freight transport is occurring significantly slower than that of passenger transport, mainly due to the slower electrification and the widespread use of diesel as a fuel source. The clean heavy duty vehicle fleet in the EU remains small at only 0.06% (IEA, 2023b), and although targets laid out in the long-term strategy are merely 40% (battery, plug-in hybrid and fuel cell combined) (EC,

Share of zero emission vehicles (ZEV) in heavy-goods vehicle stock

This indicator shows past development in the uptake of zero emissions vehicles in the heavy-goods vehicle fleet (IEA, 2023b) in comparison to the more stringent end of EU target of reaching a combined 40% share in vehicles powered by batteries or fuel cells in 2050 (EC, 2018c).

Data show an annual increase of 0.012%-points between 2017 and 2022. To meet the target, the required annual change between 2022 and 2050 needs to be 1.4%-points, which is 122 times faster than the current rate of progress.

2018c), stocks would need to grow 122-fold to be aligned with climate neutrality, hence they are growing far too slow. With strong support from governments, collaboration across the value chain, and more official goals and targets, shares of clean trucks could start increasing exponentially and eventually outperform the growth of the entire sector, which is now still leading to continuously growing GHG emissions (EC, 2023a). The EC has seen this need and is currently in the process of proposing stronger CO_2 standards, which are in line with a 45% reduction of emissions in 2030 (versus 2019), standards that are subject to continuously become more stringent, culminating at 90% emission reductions for new trucks by 2040 (EC, 2023a).

4.2.3 Conclusions and recommendations

Emissions from the mobility sector must, together with the power sector, lead the European decarbonisation efforts. For both sectors, at least if aviation and shipping are excluded, solutions are readily available. A lack of political will is holding the continent back. The EU, as one of the richest regions on the planet, should lead the change. When assessing the sector it quickly becomes clear that more concerted action is needed to bring the EU on a trajectory that is in line with its own goal of reaching climate neutrality in 2050.

Data gaps and impacts of the COVID-19 pandemic make it difficult to make solid statements on the state of the mobility sector

Data of most indicators in the mobility sector show at least some progress into the right direction, which is misleading, as the COVID-19 pandemic affected the sector disproportionally in 2020. Many measures related to the pandemic lasted well into 2021, delaying rebound effects. Hence, many trends now falsely point into the desired direction and it is extremely difficult to understand the upcoming direction and magnitude of trends. It also differs per subsector and mode; while for example flexible workplaces and hence less commuting can at least to some extent be expected to remain, industry has quickly ramped back up and with it old patterns in freight transport. In addition, a lot of data is not available for all countries or not readily available at all, requiring a lot of processing. Processing data from different sources, which also don't necessarily fully align in terms of country and mode coverage, is always only an approximation and can be error prone, hence, the data and numeric conclusions must be viewed with caution.

The uptake of electric mobility is promising, but only targeting sales will not automatically result in a clean vehicle fleet

The most positive development that can be observed without COVID-19 caveats in the mobility sector is the uptake of electric vehicles, especially light-duty passenger vehicles, where sales

have reached a record high 22%. Observed non-linear growth suggests that fast growth will even increase (EAFO, 2023). Purchase subsidies in many EU countries, investments in charging infrastructure and other incentives both financial and behavioural have made this impressive uptake possible, as has the relative prosperity of European countries in comparison to a large number of other regions.

Nevertheless, the sales shares still only mean that one in five new vehicles sold does not operate on fossil fuels, and in absolute numbers this only translates to a vehicle stock of 2.3% or slightly short of 6 million cars (EAFO, 2023). To really replace current fleet of cars, incentives must not only target sales but also stock turnover. With its policies, the EU is mainly targeting the first; the proposed ground-breaking ban of sales of new combustion engines by 2035 leaves old, inefficient vehicles untouched, as do the proposed stronger emissions standards for heavy goods vehicles, which aim at new vehicles only.

Electric mobility is only one part of the puzzle. In order to accelerate emission reductions, stronger incentives for modal shifts and less mobility are needed

Although EV sales shares are indeed promising, the mobility sector can only fully decarbonise if this is coupled with overall declines in transport volumes and larger shares of public and non-motorised mobility, both of which, when looking at pre pandemic data, were showing trends far from where the EU should be heading to. As these transitions go beyond technological innovation, it is a bit trickier to incentivise the shift.

The EU, governments, and the private sector can do a lot to accelerate modal shifts and reduce travel kilometres. Policies related to active urban planning, incentivising local industries, investing in infrastructure, especially bike-lanes and rail, or subsidising low emission modes such as train travel by introducing smart tax and pricing schemes, are just a few measures that have locally shown to lead to positive transformations. The EC has already recognised this need, as it stated in its mobility strategy that it ‘will propose regulatory measures to enable innovative and flexible tickets that combine various transport modes” (EC, 2021o).

Box 3: Highlights from the assessment of Mobility

Trends in modal shares are going into the right direction

Already before COVID-19, the shares of passenger transport on roads were steadily declining, heading towards levels far below the anticipated targets. Nevertheless, the reduction in road transport was almost fully compensated by growth in the even more environmentally unfriendly air traffic.

EV sales have reached record levels in 2022

Sales of electric cars have reached 22% in 2022 in the EU27, far above the global average of 14%. Of the 14 countries with the highest sales shares only one lies outside of Europe.

Promising policies are being proposed and implemented on the EU level

Although not quite on track yet, the sector can be expected to accelerate further in the right direction, as positive developments on the policy front are observed. Most prominent of these are the phase-out of combustion engines but also the new emissions standards for heavy goods transport. Efforts towards larger transport volumes on rail can also have significant impacts on the sector's overall emissions.

COVID-19 showed that change is possible

Emissions in the sector dropped substantially in 2020 and subsequent years due to the COVID-19 pandemic. Although this was followed by strong rebounds, it showed that less travel, especially on road and air, is possible, and certain lasting changes, such as remote work and home office, have shown that behavioural change is not just possible but can have positive impacts on the environment as well. In addition, those changes are not expected to be fully reversed leading to less overall commuting travel.

4.3 Industry

Industry is an indispensable element of the EU's economy. However, the sector is facing complex decarbonisation challenges requiring a shift in the mix of energy and applied feedstocks, partly deep modifications to technological processes and efforts in terms of circular economy.

Overview

Industry[1] constitutes the backbone of the EU economy, contributing about 20% to the gross domestic product (GDP) of the bloc in 2021 (Eurostat, 2021b). At the same time, its direct GHG emissions were equal to 23% of total EU emissions in 2021, pointing to the need for substantial reductions to achieve the EU's climate neutrality target in 2050. However, there are major challenges for industry's decarbonisation as industrial emissions come not only from fossil fuel combustion, but also from industrial processes themselves. Several branches within the sector (such as steel, cement, and basic chemicals) require very high temperatures and/or use fossil fuels as an input in the production process. For this reason, the decarbonisation of industry requires a shift in the mix of energy and applied feedstocks and can require deep modifications to technological processes. According to the impact assessment of the EU 2030 Climate Target Plan (EC, 2020f), transformation of industry leading to its compatibility with a climate neutral economy will require increased efforts in terms of circular economy; energy efficiency; energy system integration; the uptake of renewable heat, electricity, and hydrogen; as well as carbon capture and storage (CCS).

The transformation of industry to make the sector compatible with climate neutrality has progressed far too slowly. The reduction of industrial GHG emissions must accelerate by 2.7 times to meet the emissions targets implied by the EC's modelling. Simultaneously, the share of clean energy carriers in the total final consumption of energy in industry has been almost stagnant, and in fact showed a downward trend in the last five years for which the data is available, even if the overall long-term tendency remains positive. These developments are accompanied by unsatisfactory changes in the enabling conditions: sluggish uptake of circularity,

[1] Industry is defined consistently with European Classification of Economic Activities nomenclature as manufacturing industries and construction, i.e. sections C and F in Eurostat's NACE Rev. 2.

hindered changes in terms of energy efficiency, and impossible to monitor deployment of clean energy carriers along with the necessary infrastructure (due to data limitations). Therefore, going forward, much more robust policy intervention is needed to steer changes in the industry sector to facilitate its decarbonisation. The EU has already undertaken action in this respect, e.g., by reinforcing the EU ETS and introducing sectoral renewable energy shares (RES) and renewable liquid and gaseous fuels of non-biological origin (RFNBO) ('green hydrogen') target within the 'Fit for 55' package, as well as by announcing a Green Deal Industrial Plan for the Net-Zero Age (EC, 2023b, 2023r). Still, effective implementation of the agreed policies and further development of the strategic initiatives enabling industrial decarbonisation in Europe will be necessary for the sector to maintain its role as one of the cornerstones of the EU economy while simultaneously reducing its negative impact on the climate.

4.3.1 Objectives and enablers

Objectives: Progressing towards net zero industrial GHG emissions with clean energy carriers

Selected indicator:

GHG emissions from industry [Mt CO_2e]

Reducing GHG emissions from industry is required for the sector to contribute to the transition to climate neutrality. According to the impact assessment of the 2030 Climate Target Plan (EC, 2020f), emission reductions from industry must reach 18–25% in 2030 and 96–98% in 2050, compared to 2015-levels. The related indicator for measuring progress in this aspect is '*GHG emissions from industry*'. The indicator is split into two sub-indicators:

- process emissions – emissions occurring as a result of intentional and unintentional reactions between substances or their transformation, including the chemical or electrolytic reduction of metal ores, the thermal decomposition of substances, and the formation of substances for use as product or feedstock (EC, 2007);
- emissions related to energy use – emissions created in fuel combustion processes.

The split allows monitoring of whether progress is observed equally in those branches of industry that require the implementation of significant modifications to the production process for successful decarbonisation (i.e., steel, cement).

Industry needs to switch to clean energy carriers to allow for the required emission reductions from fuel combustion. The overall reduction in GHG emissions can be achieved by several important drivers of partial improvement besides the phase-out of fossil fuels, including e.g., coal-to-gas switch, changes in business structure, etc. However, these factors do yet not lay the essential foundation for reaching net zero emissions in 2050. This can only be achieved through a deep transformation of the energy and feedstock mix for the sector with direct use of fossil fuels in industry dropping to less than 20% (Tsiropoulos et al., 2020). The related indicator to monitor advancement in this area is '*share of clean energy carriers in energy and feedstock use*', which is a combination of the share of clean energy carriers in total fuel use and the share of clean energy carriers in feedstocks. It thus allows for a more thorough analysis of decarbonisation of different industry sections.

Selected indicator:

Share of clean energy carrier in energy and feedstock use [%]

Enabler 1: Availability of clean energies and infrastructure

Businesses need access to sufficient clean energies/feedstocks and related energy infrastructure to enable the industrial transformation. The decarbonisation of industry will rely mostly on electricity, ambient heat, biomass, synthetic fuels, and hydrogen, and to a lesser extent on other renewables, such as solar or geothermal energy (Tsiropoulos et al., 2020). EU policy emphasises that electrification, smart gas grids, and the development of networks for CO_2 transport will be further important factors in driving the EU transition to a decarbonised economy, which is outlined in the three priority thematic areas of the Trans-European Networks for Energy (TEN-E) Regulation.

There are several potential indicators that could be used to accurately measure progress in terms of the availability of clean energies and infrastructure. ECNO focuses on two crucial factors: the production of green hydrogen and the availability of carbon capture and storage (CCS) infrastructure. The first indicator '*annual production of renewable hydrogen for industrial use*' shows the EU production of hydrogen, which should be used mostly in industry for no-regret applications (Agora Energiewende, 2021). The second indicator 'CO_2 *injection capacity*' shows the developments of CCS implementation with a focus on permanently stored emissions. The EC just proposed to reach 50 Mt CO_2e captured and stored in 2030 (EC,

Selected indicator:

Annual production of renewable hydrogen for industrial use [Mt]

Selected indicator:

CO_2 injection capacity [Mt]

2023b). However, data are not collected in a comprehensive and harmonised way across the Member States yet.

Enabler 2: Circular economy

The circular economy is 'an economy where the value of products, materials, and resources is maintained in the economy for as long as possible and the generation of waste is minimised'. A circular economy is centred around three key principles: (1) reduce, (2) reuse, and (3) recycle. It allows an extension of the life cycle of products, the minimisation of waste and the creation of further value through recycling. It can also help to reduce pressure on limited natural resources. These qualities make the circular economy a potentially highly cost-effective means of reducing GHG emissions from industry, as they imply lower upstream emissions and lower overall energy and feedstock input. However, quantification of the scale of GHG impacts caused by circular actions is very challenging, as the 'diverse nature of the circular economy makes evaluating its full impact on GHG emissions complex and expensive' (Trinomics, 2018). Nevertheless, the EC published circular economy indicators for the first time in 2018 in four key areas: (1) production and consumption, (2) waste management, (3) secondary raw materials, and (4) competitiveness and innovation. In 2023, Eurostat announced a revision of the circularity monitoring framework, aligning it with the requirements of the new Circular Economy Action Plan (EC, 2020c).

A key indicator is the '*circular material use rate*', which is defined as the share of material recycled and fed back into the economy. It reflects efforts to collect waste for recycling and recovery thus saving on the extraction and processing of primary raw materials (Eurostat, 2021a). The Circular Economy Action Plan (EC, 2020c) outlines a target to double the EU's circular material use rate by 2030 (relative to 2020).

Selected indicator:

Circular material use rate [%]

In addition, resource productivity, defined as the ratio of gross domestic product (GDP) to domestic material consumption allows monitoring of the economic growth per unit of resources (Eurostat, 2022g). This shows how efficiently resources are used in a broader sense – not only measured by the amount of waste but also by the value of the output. Resource productivity is measured in purchasing power standard, and thus it is adjusted for general inflation but does not capture sector-specific inflation.

Selected indicator:

Resource productivity [PPS/kg]

Enabler 3: Energy efficient industrial processes

Increasing the energy efficiency of industrial processes can serve as an indirect means of reducing GHG emissions from industry. That is because lowering the energy needs of the sector would lead to lowering its fossil fuel use even without making any meaningful changes to the energy mix. Increasing the energy efficiency of industrial processes also has the positive externality of saving more affordable clean energy for other economic sectors. In the past decade, industry has made significant progress in terms of optimising production with respect to energy use, but a significant potential for further energy savings remains (EC, 2021g).

Selected indicators:

Final energy consumed in industry [Mtoe]

Energy intensity of output [Mtoe/EUR]

The related indicator here is '*final energy consumed in industry*'. The impact assessment of the 2030 Climate Target Plan (EC, 2020f) shows that final energy consumption in industry should be 22–28% lower in 2030 and 22–30% lower in 2050 relative to 2005. In addition, '*energy intensity of output*' shows the amount of energy used to produce a given level of output. Monitoring changes on this indicator will help to distinguish between lower energy consumption in industry resulting from a reduction in economic activity and that resulting from the actual enhancement of energy efficiency in industrial processes.

4.3.2 Progress towards climate neutrality

Progress towards the objectives: Progressing towards net zero industrial GHG emissions with clean energy carriers

The trajectory of the industrial emissions is heading in the right direction, but the rate of progress is far too slow to meet the industrial emission targets implied by the impact assessment to the Climate Target Plan (EC, 2020f). Here, a successful industry decarbonisation scenario assumes the reduction of emissions by ca. 22% in 2030 and by ca. 97% in 2050 (relative to 2015 levels). Past development of both components of industrial emissions: energy use and product use emissions[2], follow similar path in the period since the data started to be reported in

[2] Average share of process emissions in the overall aggregate in the period 2001-2021 was equal to 43.2%.

1990; nevertheless, the smaller scale of process emission reduction over that period (28.5%, compared to 39.7% of reduction in energy use emissions) shows that there is higher persistence of process emissions in the hard-to-abate sectors (such as e.g. steel, cement, and basic chemicals). Gradual decrease until 2007 was followed by a more sudden drop in the next two years, a consequence of an economic downturn in that period. After subsequent rise in 2010, both kinds of emissions were subject to slow decrease again, with a small uptick in 2021. The aggregate emissions decreased between 2016 and 2021 by 9.5 Mt CO_2e; starting from 2021, the reductions have to increase to 25.3 Mt which is 2.7 times faster to achieve the target.

GHG emissions from industry

This indicator shows past development in net-zero industrial GHG emissions (EEA, 2023b) in comparison to the EU target of reaching industrial emissions levels of 23.1 Mt CO_2e in 2050 (EC, 2020f).

The data show an annual decrease of 9.5 Mt CO_2e between 2016 and 2021. To meet the target, the required annual change between 2021 and 2030 needs to be 2.7 times faster than the current rate of progress.

The objective of increasing the share of clean energy carriers in the energy mix, is measured by an indicator that is limited in its scope, meaning it takes into account only a share of electricity, renewables and biofuels in the industry's final consumption of energy (Eurostat, 2023b). Other energy carriers which can be considered 'clean' (e.g. green hydrogen) are not covered due to lack of data coverage in the Eurostat dataset. The indicator, over longer time horizon, shows very gradual and slow increase (from the value of 22.8% in 1990 to 31.2% in 2021); however, in the period 2016-2021 part of the earlier progress was cancelled out, and the average annual rate of change for that time is equivalent to the decrease of 0.1%, which means that the changes in the indicator values have to reverse direction in order to be compatible with climate neutrality. The decrease in the share of clean energy carriers accompanying the reduction of the GHG emissions in industry shows that in the medium term, emissions can drop without meaningful transformation of the energy mix, and thus both indicators require monitoring.

Share of clean energy carrier in energy and feedstock use

This indicator shows past development in share of clean energy carrier in energy and feedstock use (Eurostat, 2023b). No benchmark is available from an official EU source.

The data show an annual decrease of 0.1% between 2016 and 2021. This development was heading in the wrong direction.

Progress towards enabler 1: Availability of clean energies and infrastructure

Currently there are no available indicators at the EU level that can be used to assess the availability of clean energies and infrastructure relevant for deployment of key industrial decarbonisation technologies. Since without consistent tracking of the policy outcomes it is not possible to design effective strategic and support policies, establishing comprehensive monitoring framework in this area should become one of the priorities for European policy-makers. This is important especially in the light of EU's recent legislative acts (REPowerEU (EC, 2022j) and Net Zero Industry Act (EC, 2023r)), which contain official targets related to availability of clean energies and infrastructure, such as 10 Mt of annual production of renewable hydrogen for industrial use (a recent study by Agora Energiewende (2023) shows that reaching this target may be equivalent to exceeding the actual needs of the sector in 2030) and 50 Mt of annual CO_2 injection capacity, both to be reached by 2030.

Annual production of renewable hydrogen for industrial use

For now, there is no EU-wide aggregated data on annual production of renewable hydrogen for industrial use.

CO_2 injection capacity

For now, there is no EU-wide aggregated data on CO_2 injection capacity.

For now, there is no EU-wide aggregated data on CO2 injection capacity.

Progress towards enabler 2: Circular economy

Circular material use rate had been growing quite slowly since 2004, when the data started to be reported, until 2018. Since then, it has been stagnant until 2021 at the value of 11.7%, temporarily increasing to 12% in 2019. That is equivalent to average annual increase of 0.1%-points between 2016 and 2021. The progress in terms of this indicator is far too slow to meet the target implied by the Circular Economy Action Plan (EC, 2020c), which assumed doubling the 2020 value by 2030. For that requirement to be met, the rate of increase would have to be 24 times higher than in the period 2016-2021. The regulatory and advisory actions undertaken under the Circular Economy Action Plan (such as e.g. revision of EU rules on Packaging and Packaging Waste, proposal for a Directive on green claims or revision of the Industrial Emissions Directive) should in the future support acceleration of progress towards more circular economy; however, since most of the actions were implemented only in 2021 or later, it is expected that the effect of these initiatives is not reflected in data yet.

Circular material use rate

This indicator shows past development in in circular material use rate (Eurostat, 2021a) in comparison to the EU target of doubling circular material use rate in 2030 from 2020 levels (EC, 2020c).

The data show an annual increase of 0.1% between 2016 and 2021. To meet the target, the required annual change between 2021 and 2030 needs to be 24 times faster than the current rate of progress.

Resource productivity

This indicator shows past development in resource productivity. No benchmark is available from an official EU source.

The data show an annual increase of 2.0% between 2016 and 2021. This development was heading in the right direction but should accelerate in the future.

Resource productivity, which is a measure on the amount of materials used per unit of GDP, is an important indicator under UN's Sustainable Development Goals, included in Goal 12 – responsible consumption and production. Resource productivity has experienced slowing growth since 2000, when the data was first recorded. Average annual rate of increase for the whole period since 2000 was 3.2%, with pace of improvement falling in the period 2016-2021 to 2.0%. While general direction of changes of this indicator is a positive development, its slower improvement in the recent past is concerning.

Progress towards enabler 3: Energy efficient industrial processes

Energy efficiency plays an important role in industry decarbonisation, with a potential to deliver relatively fast and cheap reductions in GHG emissions. However, the data about final energy consumption in industry for the past 20 years show that progress in terms of energy efficiency in industry is limited. Since 1993, the amount of energy consumed by industry had been growing, until it dropped by 15% in the period of 2007 to 2009, which reflects economic downturn of that period. This positive development was partially offset in the following years, although the amount of energy consumed in industry has never come back to its 2007 peak. Value of the indicator has not formed a clear trend since then, hovering around similar level for a decade, with minor annual changes amounting to an average annual decrease of 0.01% between 2016 and 2021. This development is concerning and the pace of changes is far too slow.

Final energy consumption in industry

This indicator shows past development in final energy consumption in industry (Eurostat, 2023b). No benchmark is available from an official EU source.

The data show an annual decrease of 0.1% between 2016 and 2021. This development was far too slow.

Another measure chosen to monitor progress in implementation of energy efficiency in industry is energy intensity of output. In the last 5 years, the amount of energy needed to produce one unit of GDP has been falling slowly but steadily, with average annual decrease of 0.6% between 2016 and 2021. The rate of economic growth in industry over this period was faster than the rate of increase in final energy consumption, which is why the indicator's value dropped. Although the direction of changes of the indicator is compatible with climate targets of the EU, the pace of progress is far too slow.

Energy intensity of output

This indicator shows past development in the energy intensity of output (Eurostat, 2023b). No benchmark is available from an official EU source.

The data show an annual decrease of 0.6% between 2016 and 2021. This development was heading in the right direction but was far too slow.

4.3.3 Conclusions and recommendations

The analysis of the set of chosen indicators leads to a conclusion that transformation of the industry sector has been stagnant, and that additional efforts on many fronts are needed to

stimulate structural shifts in industry, which would allow this sector to become compatible with climate neutrality until 2050.

Industrial emissions are declining too slowly, while structural changes in industrial energy mix are stagnant

Emissions of GHG from the industry sector decreased annually on average by 9.5 Mt CO_2e between 2016 and 2021, which is insufficient to meet the implied policy targets. To make it possible, the required annual change between 2021 and 2030 needs to be 25.3 Mt CO_2e, which is 2.7 times faster than the current rate of progress. Simultaneously, there is no sign of progress in terms of increasing share of clean energy carriers used by industry, which could signal upcoming acceleration of GHG emission reduction. The share of clean energies in final energy consumption in industry fell on average by 0.1% annually in the period 2016-2021, reaching 31.2%. However, it is worth to note that long-term tendency is favourable, and the stagnation of progress came only at the end of whole inspected period (1990-2021). Another caveat to the analysis of this indicator lies in the fact that – due to data limitations – it takes into account only electricity, renewables and biofuels as 'clean energy carriers'. In the future, ECNO intends to also include green hydrogen in this category, which is bound to play an important role in the industrial decarbonisation. However, for this report, even if currently available Eurostat databases made it possible to track green hydrogen consumption, it would not have a significant impact on our conclusions, as it remained a niche energy option in the assessed period.

Public statistics need to be extended to allow monitoring of the developments in the area of availability of clean energies and infrastructure

For now, there are many aspects of industrial transformation which are not covered by systematic monitoring framework. ECNO's preference would be to track annual production of renewable hydrogen for industrial use and CO_2 injection capacity, but there are many potential related indicators that could be of value both for policy-makers and economic agents (such as percent of industrial sites using CCUS technologies/hydrogen, percentage of emissions covered by CCUS, hydrogen network capacity etc.), so that they can make knowledge-based decisions which are simultaneously best choices for climate protection. Therefore, ECNO's recommendation is to start developing monitoring framework related to the industry decarbonisation, especially in the light of adoption of official EU targets related to this area.

Enabling conditions for industry transformation need to improve faster

Progress in terms of both measurable industrial enablers – circular economy and energy efficient industrial processes – was far too slow. There is a potential for faster improvement of circularity indicators, since the EU policies implemented in the last three years under the Circular Economy Action Plan (EC, 2020c) and actions planned in the future under this framework should enhance circularity's uptake. What remains concerning is a very slow rate of decrease of final energy consumption in industry and the energy intensity of output. However, significant changes of enabling conditions for industry would require structural shift in industrial processes, which would in turn call for increased investment of both government and private sector. Implementation of policies supporting such investment is another recommendation in the area of industry decarbonisation.

Investment in industry decarbonisation should come as soon as possible ahead of the phase-out of ETS free allowances

One of the most impactful policy tools used by the EU in order to facilitate transition towards climate neutrality (including industry decarbonisation) is the EU ETS system. The system's recent revision, adopted in 2021, aimed at aligning the scheme with 2030 target of reducing emissions by 55% in 2030 (relative to 1990 levels). The revision introduced a plan of gradual phase-out of free emission allowances in many industrial sectors in the period of 2026-2034, which is expected to drive up carbon price in industry. For that reason, a key policy challenge is to ensure that EU industry invests in decarbonisation as soon as possible, before these changes of market conditions start to realise, in order to avoid abrupt price adjustments in the industrial goods markets in the future.

Box 4: Highlights from the assessment of Industry

Industrial emissions are declining too slowly, while structural changes in industrial energy mix are stagnant

Between 2016 and 2021 GHG emissions from the industry sector decreased on average at a slow rate of 0.5% annually, which is far too slow to meet the implied policy targets for industry. Simultaneously, share of clean energies used in industry hardly changed, indicating that so far there was no sign of upcoming acceleration of industrial emissions reduction. It is worth to note though that analysis of the data over a much longer time horizon shows that positive changes in both areas do occur; however, their pace is slowing down.

Currently available statistics do not allow to monitor developments in the area of availability of clean energies and infrastructure

So far, there are many aspects of industrial decarbonisation which are not covered by systematic monitoring framework. Availability of such indicators as e.g. annual production of renewable hydrogen for industrial use, CO_2 injection capacity, percent of industrial sites using CCUS technologies/hydrogen etc. would allow policy-makers and economic agents make knowledge-based decisions, which are simultaneously best choices for climate protection. Widening public statistics is especially important in the light of adoption of EU targets related to this area.

Industrial emissions reduction could be stimulated if more progress in terms of circular economy adoption and energy efficiency was achieved

So far, there are many aspects of industrial decarbonisation which are not covered by systematic monitoring framework. Availability of such indicators as e.g. annual production of renewable hydrogen for industrial use, CO_2 injection capacity, percent of industrial sites using CCUS technologies/hydrogen etc. would allow policy-makers and economic agents make knowledge-based decisions, which are simultaneously best choices for climate protection. Widening public statistics is especially important in the light of adoption of EU targets related to this area.

4.4 Buildings

The buildings element covers the main stages of the buildings cycle, from materials production to energy demand for various end-uses: heating, cooling, cooking, lighting, ventilation, and appliances. They decarbonisation depend on reducing the demand for heating and cooling services, improving energy performance, and shifting the remaining energy demand to renewable heating or cooling systems.

Overview

The buildings element covers the main stages of the buildings cycle, from materials production to energy demand for various end-uses (heating, cooling, cooking, lighting, ventilation, and appliances). It also connects to electricity demand and the related indirect emissions, but these are formally covered under section 4.1. Existing buildings must become near-zero energy buildings with fully decarbonised heating and cooling by 2050 at the latest. And latest by 2030, new constructions must be zero-emissions buildings to avoid having to renovate those again by 2050 (EC, 2023q). The main EU policy instruments for decarbonising buildings are the Energy Performance for Buildings Directive (EPBD) and the Renewable Energy Directive (RED III). An amendment to further enhance the policy measures is currently under review after being accepted by the European Parliament (EP) (EC, 2023g). The EC's new proposal aims to contribute to reaching the target of at least -60% emission reductions by 2030 in the buildings sector in comparison to 2015 and achieve climate neutrality by 2050. This move by policy-makers rightly acknowledges the key role buildings should play in the clean energy transition and achieving EU climate goals by 2030 and carbon neutrality by 2050. And latest by 2030, new constructions must be zero-emissions buildings to avoid having to renovate those again by 2050 (EC, 2023q). The main EU policy instruments for decarbonising buildings are the Energy Performance for Buildings Directive (EPBD) and the Renewable Energy Directive (RED III). An amendment to further enhance the policy measures is currently under review after being accepted by the EP (EC, 2023g). The EC's new proposal aims to contribute to reaching the target of at least -60% emission reductions by 2030 in the buildings sector in comparison to 2015 and achieve climate neutrality by 2050. This move by policy-makers rightly acknowledges the key role buildings should play in the clean energy transition and achieving EU climate goals by 2030 and carbon neutrality by 2050.

The buildings sector is far too slow in its progress to meet the EU's overall climate neutrality objectives. Direct emissions, referring to fuel combustion in buildings, must decrease by 60% by 2030 compared to 2015. Between 2015 and 2021, direct emissions have decreased only by 6%. This recent historical trend show that reductions must occur 7.5 times faster between 2021 and

2030. To achieve this, the current energy renovation rate of building stocks needs to increase significantly to at least 2% to 3%, aiming to at least double the historical energy renovation rate. The only historical data of this annual rate was estimated at 1%, on average, from 2012 to 2016. Only about one fifth of this rate was deep renovations, while 'one-off' deep renovations must be more widespread. There is not enough complete, reliable, and recent data to analyse the recent change of the renovation rate or renovation depth. The historical trend in the share of renewable energy in heating and cooling is in the right direction but needs to be 6.8 times faster than the current rate of progress to phase out fossil fuels by 2040, as proposed by the EC (2022g). Trend in energy consumption for heating and cooling is on track to meet the buildings efficiency objective of -18% in 2030 compared to 2015 level, but this target can be considered unambitious seen the 60% emissions requirement. Trend in demand for buildings material, mainly linked to the demand for new buildings, needs a U-turn to ensure the decrease of embodied emissions.

4.4.1 Objectives and enablers

Objectives: Reducing buildings emissions and limiting embodied emissions

The building sector is a significant contributor to GHG emissions, accounting for around one-third of energy-related EU emissions (EEA, 2022a). These emissions are partly due to the direct use of fossil fuel energy in buildings and partly due to the production of electricity and heat used in buildings. The combination of these two emission sources equals the operational emissions. A shift in energy vector for heating and cooling to heat pumps that run on electricity needs to go hand in hand with higher production of decarbonised electricity, but their higher efficiency also supports an overall trend to reduce energy consumption. The indicator *'GHG emissions from direct buildings energy use*' measures the evolution of buildings' emissions focusing on emissions produced on site**.**

The 'Reduce-Improve-Shift' approach when applied to buildings means looking first at (i) reducing the demand for additional buildings as well as limiting the demand for heating and cooling services, then (ii) improving the energy performance of remaining surface areas by renovating the building stock, and finally (iii) shifting the remaining energy demand to renewable heating or cooling systems. Implementing the improvements in this sequence is important as it avoids over-dimensioning of systems and stabilises the demand for heating, as well as minimising the amount of materials and energy required for the buildings sector.

Reduction targets for these emissions in buildings are set based on the revision of the EPBD mentioned above which defines high level targets with the aim to reach the target of at least -60% emission reductions by 2030 in comparison to 2015 and achieve climate neutrality by 2050. The EPBD also adds more concrete standards to be achieved for the buildings stock, with the highest consuming buildings obliged to renovate to achieve better energy performance.[3]

Selected indicator:

GHG emissions from direct buildings energy use [Mt CO_2e]

Direct buildings emissions do not include embodied emissions from production, construction, renovation, and end-of-life. The buildings sector is responsible for 30% of the generation of waste and consumes 50% of the use of materials in the EU by weight (BPIE, 2022). The relative importance of embodied emissions is expected to grow as more buildings are constructed and renovated to higher efficiency standards. Reducing as much as possible the demand for products and materials avoids a large increase in industrial production, particularly in certain sectors which are notably hard to abate, like cement, steel and the petrochemical industry that provides a large share of the raw materials for insulation. Embodied emissions also capture the risk of carbon leakage, with potential imports of these products from other countries without the same levels of ambition.

Given how carbon intensive the production of steel and cement currently are, we have to strive to limit their use, while recognising that the amount of insulation material will logically increase. This can be encouraged by right-sizing the structural elements instead of over-sizing, as well as a clear support for deep retrofits instead of destruction, landfilling and rebuilding. The shift to alternative and more sustainable materials like wood can also support the reduction of more polluting ones like steel and cement and encourage the longer term storage of biomass in buildings. It is important to note that more wood use in buildings can increase competition for land and potentially raise the risks of not reaching the goals on biodiversity. Other biomaterials may also serve as alternatives while adding less pressure on land use, like straw

Selected indicator:

Demand for building blocks and bricks of cement or concrete [Mt]

[3] The Effort Sharing Decision and the EU ETS Directives also impact the buildings sector. The Effort Sharing Decision (ESD) covers emissions from fossil fuels used in buildings and sets individual national targets for sectors currently not included in the EU Emission Trading System (ETS); the EU ETS for road transport and building will start end of the 2020's. The EU ETS Directive currently covers emissions from electricity generation used in buildings, which power producers are subject to.

bales. Policies encouraging circular economy practices such as the reuse of scrap materials must also support these trends. The indicator '*demand for building blocks and bricks of cement or concrete*' is a good proxy for the evolution of buildings' embodied emissions as it focuses on one of the most emitting materials that is particularly required for new buildings.

Enabler 1: Reducing demand for heating and cooling services

Total energy demand for space heating and cooling is driven by two factors – the amount of space that is heated or cooled, and the energy required to reach the desired temperature in that space. Reducing energy demand makes it easier to reduce both direct emissions and those from electricity production.

Selected indicator:

Average space per capita [m²/cap]

Demand reductions can be realised by decreasing the ratio between the heated/cooled surface of buildings per capita thereby reducing the buildings space that is unused. One option is to increase the number of houses or flats that are shared, for example with initiatives like shared living, or students renting rooms in older people's homes. Shared housing or offices can lead not only to reduced energy use, but also reduces the need for new builds altogether and therefore the need for producing new raw materials and their embedded emissions. It is worth noting that floor space per capita is currently highly variable across the EU, including between countries, and policies will need to cater for this variety, with parts of the population using more than the optimal average while others will justifiably want to increase their living space.

Selected indicator:

Energy consumed for heating and cooling related to living space [kWh/m²]

The indicator '*energy consumed for heating and cooling*' tracks the evolution of demand which can be reduced through both technical changes and behavioural change. On the behavioural side, this can capture improvements like opting for a lower comfort temperature (e.g., by heating bodies more directly instead of heating the whole room (Dartevelle et al., 2022), but also heating only the rooms where people actually spend time in their houses or in office buildings. These behavioural factors are important as they reduce the size of the technical challenge, but this indicator will also reflect energy efficiency measures in terms of improved insulation (and ventilation), which is clearly one of the major levers for the decarbonisation of the buildings stock, both through retrofits and the design of new builds.

Enabler 2: Plan and facilitate the renovation of buildings

The focus here is set on the need to increase the renovation of existing buildings as well as the depth of these renovations. Indeed, with a population that will be progressively stabilising in Europe, the share of new buildings will continue to decrease compared to the need for renovations of the existing stock. Additionally, the technical challenges to achieve zero emissions standards in new builds is lower, and the existing regulation is already setting a good framework.

Large-scale renovation is needed on the entire buildings stock to reach very low energy consumption levels by 2050, also called Near-Zero Emissions Buildings (NZEB). The benefits of (deep) renovation[4] are clear, both on the technical front (it reduces the need for larger heating installations with higher peaks in energy demand) and on the macro-economic front (investing in improvements of the European buildings stock rather than buying fossil-fuel energy from outside Europe has a strong positive impact on the economy) (de Jong, 2023). Energy renovation has strong co-benefits (IEA, 2017) for inhabitants, through increases in user comfort and air quality, and at the societal and macroeconomic level, such as job creation, reduced energy poverty, energy security, and health benefits.

To scale this up, many countries are experimenting with deep buildings retrofits initiatives, testing new business models like district renovation, as well as new industrial practices to make renovation cheaper and less cumbersome for citizens (Energiesprong, 2023).

Selected indicator:

Investments for energy renovation (public and private) [EUR]

The first indicator for this enabler is '*investments for energy renovation (public and private)*', as both the private sector and public institutions must increase their investments in buildings. The contribution of the public sector is key to support the economic viability of buildings energy efficiency and the speed of implementation. Investing in energy efficiency requires significant upfront investments and not all citizens have sufficient savings to do so (Eurostat, 2023k). The strategy should be dual, by striving to reduce the average costs of renovation (joint renovation in neighbourhoods, industrialisation, with public funds providing security and

[4] Deep renovation is a process of capturing, in one or, when not possible, a few steps, the full potential of a building to reduce its energy demand, based on its typology and climatic zone. It achieves the highest possible energy savings and leads to a very high energy performance, with the remaining minimal energy needs fully covered by renewable energy (BPIE, 2021)

confidence to these nascent industries), and ensuring sufficient leverage of private investments when they are available (Economidou et al., 2019). This indicator currently has a severe limitation in tracking progress as it is hard to take out the impact of inflation.

Selected indicator:

Average (and deep) renovation rate [%]

The second indicator simply follows the speed at which buildings are renovated each year. Many studies indicate the need to increase the current renovation rate, estimated at around 1% of the stock, to 2 or 3% of the stock, and to increase the depth of these renovations. The indicators covered are therefore the '*average renovation rate'* and the '*rate of deep renovation*'.

Enabler 3: Accelerate the technology switch

Besides energy efficiency, the decarbonisation of the remaining energy needs requires a technology switch from fossil fuels used for space and water heating to clean energy sources. The indicator covers a wide range of options to provide energy for heating and cooling including solar thermal, geothermal energy, heat pumps which use electricity and capture ambient heat, solid, liquid, and gaseous biofuels, and the renewable part of waste. Many cities have already pledged for net zero carbon buildings in 2050 with clean heat (World GBC, 2023).

Therefore, the indicator '*share of renewables in heating and cooling*' shows the progress on the conversion of buildings energy production using non-fossil technologies (Eurostat, 2023e). The way that this official indicator is reported underestimates the role of heat pumps and overestimates the use of biomass (Gibb et al., 2022). This bias is considered in the following analysis, especially regarding the recent significant growth in heat pumps (Azau, 2023).

Selected indicator:

Share of renewable energies in heating and cooling [%]

4.4.2 Progress towards climate neutrality

Progress towards the objectives

Between 2005 and 2021, the direct GHG emissions from buildings in the EU decreased by 20% (EEA, 2022a). This trend reflects the EU's decarbonisation strategy, which includes the improvement of energy efficiency and the electrification of end-uses in the residential sector. However, the speed of change has decreased over time, and between 2016 and 2021, direct

emissions have decreased only by 3%. The pace of change would need to increase significantly from a past annual reduction of 5 Mt CO_2e to 35 Mt CO_2e starting in 2021 to meet the overall 2030 GHG emissions target: the objective for the buildings sector is to reduce its own emissions by 60% when compared to 2015 to support the achievement of the 2030 climate target, as stated in the EU Renovation Wave (EC, 2020b). To achieve this, the current energy renovation rate of building stocks needs to increase significantly, it needs a fuel switch as well as demand reductions (see also sections on enablers).

Buildings direct GHG emissions

Buildings direct emissions are the aggregate GHGs emissions of the category commercial/institutional and residential buildings (EEA, 2022b). The target is a 60% reduction between 2015 and 2030 (EC, 2020b).

The data shows past progress of 5 Mt CO_2e between 2016 and 2021. To meet the target, the required annual change between 2021 and 2030 need to be 7.5 times faster than the past rate of progress.

While the current building stock is the priority, as it is poorly insulated and will represent the bulk of the buildings in 2050, in the past years the reductions in energy use in existing buildings have been partly offset by an increase in the number of dwellings and by a larger average floor area in buildings.

Demand for building blocks and bricks of cement or concrete

The demand for building blocks and bricks of cement or concrete is approximated by summing the annual production and the imports minus the exports (Eurostat, 2023m).

The data shows an increase of 1% per year between 2016 and 2021. Although there is no target on this indicator, its increase is not aligned with the need for decreasing material demand for new buildings floor area, and their related embodied emissions.

Limiting the demand of material with high carbon intensity is the second objective of this element. The largest contribution to the embodied emissions of a building is caused by its initial construction, of which the biggest elements are in general structural components that contain steel or cement. Building blocks and bricks of cement or concrete are mainly used for new buildings and have increased by 30% from 2015 to 2021. Over the same period, the trendline shows an average increase of 1% per year, which shows that this indicator is going in the wrong direction.

Progress towards enabler 1: Reducing demand for heating and cooling services

The average floor space per capita increased between 2011 and 2015. The floor area data published by the EC needs to be updated to reflect the historical trend beyond 2015; there is a lack of recent floor area data at the European level. Additionally, as shown just above, the building blocks material demand increased between 2015 and 2021, suggesting an increase in demand for new buildings. The recent increase in new buildings is not to accommodate population growth, which is starting to stabilise (Eurostat, 2022h), and only to a limited extent to replace old, energy inefficient buildings.

Average space per capita

The average space per capita is the ratio between the total surface of buildings (residential and services) and the population (EC, 2023j).

Data show an annual increase of 0.25 m²/capita between 2011 and 2015. Although there is no target on this indicator, the past increase is not aligned with the need to reduce heating and cooling services.

Energy consumed for heating and cooling related to living space

The average final energy consumption for space heating and cooling is obtained by dividing the total normalised consumption for space heating and cooling by the total buildings area (Eurostat, 2023e; Mantzos et al., 2018). The EU target is a decrease of 18% between 2015 and 2030 (EC, 2020b).

The energy consumption for heating and cooling in 2015 (106 kWh/m²) decreased by 5% compared to 2010 level (112 kWh/m²) which equals an annual reduction of 1.5 kWh/m2 and put the indicator on track towards the target.

The demand for average space per person is a powerful lever for reducing emissions as it reduces (i) the space to be heated or cooled, (ii) the number of buildings to be insulated, and (iii) the demand for new buildings and the associated embodied emissions. Some preliminary studies estimate that the recent decline in office space experienced during the Covid crisis could continue to reduce office floor area by 10% between 2020 and 2030.

For specific space heating and cooling energy consumption, the Renovation Wave (EC, 2020b) target of -18% between 2015 and 2030 could be achieved by following the trend of recent years. The target could be exceeded if the renovation rate and renovation depth targets are met by 2030. However, the potential energy gains from renovation are uncertain as behaviours tend to shift when the energy bills decrease and could offset the gains from energy efficiency (Brockway et al., 2021). For example, more efficient LED lamps can lead

to an increase in the amount of lighting demand, or lower energy costs for housing can lead to a rebound in activities outside of the home, like more international travel.

Progress towards enabler 2: Plan and facilitate the renovation of buildings

The annual investments in energy renovation increased by 18% between 2012 and 2016 from EUR 258 billion to EUR 305 billion. Annual investments in renovation are obviously crucial to reflect the increase in the number of energy renovations and particularly deep renovations. The growth in these investments must increase, and it needs to be higher than the inflation in the costs of these materials, particularly seen the recent price increases in building materials across Europe with the energy crisis. To analyse these recent effects, there is a need for more complete, reliable and recent data.

Investments for energy renovation

The average annual energy-related investments in renovation covers both the private and public investments (EC, 2023j).

Data shows an annual increase of EUR 13 billion between 2012 and 2016. Although there is no target on this indicator, the growing trend is in the right direction.

More information on the inflation of material and labour costs are needed to evaluate this indicator.

The Renovation Wave put forward by the EC in 2020 aims to at least double the annual energy renovation rate by 2030 as well as to foster deep energy renovation. If the EU wants to achieve its 2030 climate and energy efficiency targets, it must boost both the rate and the depth of renovation. Data on renovation and deep renovation rates are not continuous. The latest available data is for the period 2012-2016 (DG Energy et al., 2019). More recent data are needed to capture the potential effects of ongoing regulations at national level (renovation strategies) and upcoming regulations at EU level (Renovation Wave EU and the Energy Performance of Buildings Directive). Furthermore, a more uniform approach at EU level is needed to adopt a common definition of deep renovation to create a relevant renovation activity indicator.

Average renovation rate

The average renovation rate describes the annual reduction of primary energy consumption achieved through the sum of energy renovations of all depths. The Renovation Wave (EC, 2020b) outlines a target of achieving at least doubling the renovation rate by 2030.

There is not enough data to assess the recent trend of this indicator. The average renovation rate was estimated close to 1% in the EU27 for the period 2012-2016 (DG Energy et al., 2019) which is far from the 2030 target.

Deep renovation rate

The deep renovation rate comprises all renovations with primary energy savings above 60%.

There is not enough data to assess the recent trend. A single study (DG Energy et al., 2019) shows that the average annual rate of deep renovation for the period 2012-2016 was only around 0.2%. This means it is only about one fifth of all renovations and highlights that such 'one-off' deep renovations are not common practice.

Progress towards enabler 3: Accelerate the technology switch

The share of renewable energy in heating and cooling needs to increase 6.8 times faster than the current rate of progress to realise a full phase-out of fossil fuels by 2040 as proposed by the EC in the revision of the Energy Performance of Buildings Directive. This would contribute to reaching the target of at least 60% emission reductions by 2030 in the buildings sector in comparison to 2015 and achieve climate neutrality by 2050. This move by policy-makers acknowledges the key role buildings should play in achieving EU climate goals. The feasibility of this target depends on the rate and depth of renovation and the evolution of the demand for heating and cooling services. The current trend is far from trend required to reach (almost) 100% of renewable energies by 2040.

Share of renewables in heating and cooling

The share of renewable energy for heating and cooling includes solar, geothermal energy, ambient heat, biofuels, and the renewable part of waste (Eurostat, 2023m). The target is to achieve a phase-out of fossil-fuels by 2040 (EC, 2021j) requiring (almost) 100% renewables.

The renewable share in heating and cooling increased by 0.6%-points between 2016 and 2021. To meet the target, an average increase of 4%-points per year is required between 2021 and 2040 which is 6.8 times faster than the past rate of progress.

The recent (but not entered into force yet) third revision of the Renewable Energy Directive indicates an intermediate target of 49% of renewables in buildings in 2030. To reach this 2030 target, the main indicative objectives at European level are: (i) the EC's RePowerEU plan mention the deployment of 60 million heat pumps by 2030; (ii) the EC also proposed to end the sale of fossil fuels boilers by 2029 via the Ecodesign Directive; and (iii) the recent RED III suggests increasing the renewable share of district heating and cooling by 2%-points per year.

4.4.3 Conclusions and recommendations

The pace of deep renovation and technology shift must drastically increase in order to reach sufficient reductions in the emissions from buildings

The current pace of renovation and the related decrease in projected emissions are not sufficient to reach the decarbonisation targets in the buildings sector. The reduction trend needs to accelerate significantly to meet the overall 2030 GHG emissions target. The buildings sector would need to reduce its own emissions by 60% to achieve the EU's overall objective of a 55% reduction in emissions by 2030 compared to 1990, as stated in the EU Renovation Wave.

To achieve this, the current energy renovation rate of building stocks needs to increase significantly to at least 2 to 3%, in line with the ambition of the Renovation Wave aiming to at least double the current annual energy renovation rate, while ensuring these renovations reduce energy requirements at least beyond 50% (what is often described as the minimum for deep energy renovations). If renovations are not reaching sufficient depth, the yearly renovation rate will need to increase accordingly to renovate these buildings once again. Reaching these higher rates and depths will require mobilising both additional public and private investments towards renovation, as well as much more stringent obligations for renovation like the minimum energy performance standards (MEPS) for buildings.

The target for energy efficiency in buildings is too low and can make the decarbonisation target very dependent on the technology shift, which should be accelerated

The Renovation Wave EU's unambitious target of -18% reduction in space heating and cooling energy consumption between 2015 and 2030 could be achieved by following the trend of recent years. The target could even be exceeded if the renovation rate and renovation depth targets are met by 2030. However, the shift to low carbon energy will be hard to reach as heat pumps are

harder to implement in weakly renovated buildings, and the current pace is largely off track (the renewable share for heating and cooling in 2021 (23%) was only 2%-points above the level in 2017 (21%)).

For this indicator to reach 100% in 2040, an average increase of 4 percentage points per year is required. This objective is also harder to reach due to all other demand-side factors not going in the right direction: (i) the current limited pace of energy related buildings renovation, (ii) the low ambition of the energy savings target by 2030 (better insulated buildings make it easier to switch to heat pumps) and (iii) the absence of a reduction target for the buildings floor area (which will mean more buildings are required and some of the renewable heat production capacity will go for new buildings).

The demand for new buildings leads to a significant demand for highly emitting materials and should be limited

The demand for average space per person is a powerful lever for reducing emissions as it reduces (i) the floor space to be heated or cooled, (ii) the number of buildings to be insulated, as well as (iii) the demand for new buildings and the associated embodied emissions. New buildings are the main driver for the use for cement and steel in the buildings sector, and their production produces a lot of GHG emissions.

Policies encouraging the most efficient use of the available floor space and materials should be encouraged. That includes (i) considering the re-use and the renovation of existing buildings than building new ones, (ii) optimising the building size and thus the overall need for materials and (iii) considering the re-use of materials rather than using new ones.

Box 5: Highlights from the assessment of Buildings

The data on the buildings sector is spotty, which makes the tracking of the implementation very difficult

The amount of data collected on the indicator for buildings is sparse, and outdated. For example, there is just one mere data point concerning the rate and depth of renovation dating back to 2016. Data on average space per capita dates to 2015, and the average annual energy-related investments in renovation to 2016, with no clear view on the impact of inflation.

The limited target for energy efficiency puts a lot of pressure on the shift to renewable heat

The -18% reduction in energy consumption set for 2030 in EU's Renovation Wave seems unambitious compared to the 60% emissions reduction required. This means a lot of the ambition is set on decarbonising heat, where little progress has been shown in the past 5 years (+2%-points to 23% of the share of renewable heat). However, this indicator is slightly biased and should be corrected to better reflect the recent growth of heat pumps (Gibb et al., 2022).

Achieving the 60% reduction in emissions by 2030 requires more than doubling the pace of renovation, and increasing the renovation depth

Current projected emissions in the plans from the Member States (in the WEM and WAM projections) are far from sufficient, as also highlighted in the trend of historical reductions. To achieve the 60% reduction stated in the EU Renovation Wave, the current energy renovation rate of building stocks needs to increase significantly to 2 to 3%, at least doubling current annual energy renovation rate reaching significant energy consumption cuts.

4.5 Agrifood

The agrifood building block refers to all stages of the agricultural supply chain from food production to consumption, including food processing, retail, and associated waste. It also considers aspects of land use and the production of agricultural inputs.

Overview

The agrifood building block refers to all stages of the agricultural supply chain from agricultural production to food consumption, including food processing, retail, and associated waste (Jensen & Scalamandrè, 2023). It also considers land use and land use change elements associated with the agricultural sector, as well as emissions related to the production of agricultural inputs (e.g., fertilisers, pesticides). The term 'Agricultural emissions' refers to methane and nitrous oxide emissions from the agricultural sector as defined in EU/UNFCCC accounting methodologies.

Agriculture is one of the only sectors where emissions cannot be fully eliminated due to the biological processes involved and growing demand for agricultural products, but emissions from the sector must be minimised and reduced in absolute terms to decrease reliance on natural and technical carbon removals (EC, 2018b). The agrifood sector can minimise its emissions and become compatible with climate neutrality through measures including shifting towards low-carbon diets and alternative proteins, reducing synthetic fertiliser use, preserving soil carbon on agricultural lands, reducing the emissions intensity of livestock production and livestock numbers, reducing food waste volumes, and reducing downstream emissions from food production.

The agricultural sector is far too slow in its progress to meet the EU's overall climate neutrality objectives. Agricultural emissions must decrease by 33% relative to 2021 levels to reach the 2050 target. Current trends, however, show that emission reductions must occur 2.4 times faster to achieve the target. While agricultural emissions in the EU decreased by 15% between 1990 and 2000, emissions have only declined by 2% since 2005. Current national policies are only expected to reduce emissions by 1.5% by 2040 compared to 2019 levels, while planned measures would result in emission reductions of just 5% (German et al., 2021). The 2023-2027 EU Common Agricultural Policy (CAP) reform is not included in the estimate above; however, its impact on GHG emissions is expected to be minimal. The previous iteration of the CAP had nominally allocated a quarter of its budget (over EUR 100 billion) to climate mitigation and adaptation, but it had little impact on agricultural emissions during the same period (ECA,

2021a). An initial review of Member State-level CAP strategic plans under the new reform found a lack of ambition and general continuation of business as usual, despite the reform's increased focus on the environment and climate (Nemcová et al., 2022). Trends in synthetic fertiliser use, livestock emissions and numbers, and food waste volumes further impact whether the agricultural sector is on track to meet climate neutrality objectives.

4.5.1 Objectives and enablers

Objectives: Minimising agrifood emissions by 2050 while shifting to diets with a low carbon footprint

Selected indicator:

Agricultural emissions [Mt CO_2e]

Overall, the EU must minimise agrifood emissions and reduce animal product consumption to be compatible with climate neutrality. Since the agriculture sector is one of the only sectors where emissions cannot be fully eliminated, it is imperative that emissions from the sector are reduced as much as possible (EC, 2018b). Emissions from agricultural production and land use must be reduced to minimise reliance on natural and technological GHG removals to reach net zero. The indicator *'agricultural GHG emissions'* (excl. LULUCF and downstream impacts) shows whether the sector is on track towards minimising its emissions.[5] The 1.5LIFE and 1.5TECH scenarios described in the impact assessment for the EU LTS estimate that agricultural emissions must decrease to 230 and 277 Mt CO_2e, respectively, to reach climate neutrality by 2050 (EC, 2018c). The EU does not have a sectoral target for the AFOLU sector in its 2030 nationally determined contribution (NDC) under the Paris Agreement, but modelling suggests that the agricultural and LULUCF sectors must reduce their emissions by a combined 20% to be in line with 'Fit for 55' (German et al., 2021).

Animal products have a significantly higher GHG and environmental footprint per kilogram of protein than plant-based products (Searchinger et al., 2019). While there is still some scope to improve emissions from livestock production in the EU, most of the potential for livestock emission reductions stems from diverted agricultural production in response to demand-side measures, such as shifting to healthy, sustainable diets (Roe et al., 2021). There has already been

[5] Note: LULUCF emissions related to agricultural production, such as peatland oxidation, must also decrease for the EU to be compatible with climate neutrality. Further indicators on LULUCF-related emissions are found in section 4.6.

considerable growth in the EU plant-based food market, with sales growing by 49% from 2018 to 2020 (Smart Protein Project, 2021). Alternative proteins, such as insects, cultivated meat, or precision fermentation products, can also play a role in dietary shifts, but their development and commercialisation have been hindered in part by the EU's Novel Food Regulation (Lähteenmäki-Uutela et al., 2021). If clear incentives are in place, reduced meat and dairy consumption could additionally free up land to allow for increased afforestation, which would help to meet carbon removal targets (EC, 2018b).

To minimise agricultural emissions in 2050, European diets must shift to lower levels of meat consumption, especially from ruminants (e.g., cows, sheep). Thus, tracking *'bovine meat consumption per capita'* shows whether EU diets are undergoing the necessary shift.[6] Dietary shifts are outlined in the 1.5LIFE scenario of the EU's LTS, and most notably correspond to a 34% reduction in bovine meat consumption and 26% reduction in milk consumption. The Diet 5 scenario, the most stringent but in line with recommendations from other studies, also includes a 35% reduction in pig meat consumption, and a 27% reduction in poultry consumption by 2050 compared to 2013 levels (EC, 2018c).

Selected indicator:

Bovine meat consumption per capita [kg/capita]

Enabler 1: Reducing fertiliser use and cropland-related emissions

Feeding a growing population while also reducing GHG emissions means striving towards low emissions cropping systems. Most emissions from crop production result from synthetic fertiliser application, which makes up around a fourth of EU agricultural emissions (EU, 2023a). Due to the overuse of fertilisers, not all nutrients are effectively absorbed by plants, which results in GHG emissions and significant environmental pollution. The EU Farm to Fork Strategy, a key facet of the EU Green Deal, aims to reduce nutrient losses on agricultural lands by 50% in 2030 while maintaining soil fertility, corresponding to a potential 20% reduction in fertiliser use (EC, 2020a). The indicator *'nitrogen fertiliser consumption'* is used to determine whether the EU is on track to reach this target, and in turn reduce emissions from cropland.

Selected indicator:

Nitrogen fertiliser consumption [kg N/ha]

[6] Note: further indicators on food consumption and dietary shifts, as well as the willingness to adapt climate-conscious behaviour and discussion on sustainable public food procurement, are found in the section 4.7.

The share of agricultural area under organic farming in the EU has substantially increased in recent years. Between 2012 and 2020, the share of organic farming area relative to total agricultural area increased by 50% (EC, 2023s). Although organic farming yields may, depending on the system, be lower than conventional farming yields, organic farming practices are considered more environmentally-friendly due to avoided emissions from synthetic fertiliser production and reduced nitrogen application, increased adaptation and resilience to climate change impacts, and improvements to soil health and fertility that can subsequently result in higher soil carbon sequestration (Brook, 2022; Hülsbergen et al., 2023). Under the Farm to Fork Strategy, the EU aims for 25% of agricultural area to be classified as organic farming area by 2030 (EC, 2020a). The indicator *'organic farming as a share of total utilised agricultural area'* determines whether the EU is on track to reach this target.[7]

Selected indicator:

Organic farming as a share of total utilised agricultural area [%]

Enabler 2: Shifting livestock production towards a sustainable model

Livestock systems make up the majority of the EU's agricultural GHG emissions – this consists of emissions from enteric fermentation, manure management, and manure left on pasture or applied to soils. If also accounting for emissions associated with domestic livestock feed production, this equates to 81-86% of total agricultural emissions (Peyruad & MacLeod, 2020). The largest sources of livestock emissions in the EU are enteric fermentation from beef and dairy cattle, and manure management from cattle and swine (EEA, 2023b).

While there may be some potential to reduce emissions from enteric fermentation from measures such as improved animal health, livestock systems are already relatively efficient in the EU. For instance, cattle enteric fermentation emissions intensities are below average compared to other high-income economies (FAO, 2022). Since cows raised on pasture usually take longer to reach finishing weights and expend more energy to digest forage, efforts to further reduce enteric fermentation emissions risk greater shifts to high-intensity industrialised systems with high feed consumption, which are associated with higher indirect

Selected indicator:

Manure management emissions intensity of cattle [t CO_2e/cattle]

[7] Note: further indicators on soil carbon content and emissions from organic soils are found in section 4.6. A further indicator on the extent of land applying gentle tillage practices is found in section 4.12.

emissions from feed production. It can also result in increased reliance on technologies such as feed additives and anti-methanogenesis vaccines that currently face animal welfare, environmental, and efficacy concerns (Hegarty et al., 2021; Mulhollem, 2019). On the other hand, there is still considerable scope to reduce manure management emissions from livestock, where the largest source is cattle followed by swine, by improving manure collection, storage, and handling. Thus the *'manure management emissions intensity of cattle'* is used as an indicator to show whether the livestock sector is on track to minimise its GHG emissions.

Selected indicator:

Livestock numbers [million head]

To reach climate neutrality, the EU must achieve a sizable reduction in emissions rates per animal per annum (Buckwell & Nadeu, 2018). However, high rates of productivity improvements have not occurred for a long time, let alone sustained over decades, and efforts to improve efficiency have proved slow and difficult and are not conducive to animal welfare. While efficiency gains can play a role in reducing livestock emissions, a reduction in the number of livestock is equally necessary (Buckwell & Nadeu, 2018). Thus, *'livestock numbers'* is another indicator to show whether the livestock sector is on track to minimise its GHG emissions. However, it is important to consider livestock's role in agricultural production on marginal land, carbon sequestration in grassland, the production of organic inputs in the form of manure, as well as their socio-cultural and economic role in rural society (EC SAM, 2020). Livestock numbers must decrease, but these changes need to be implemented in a just manner given the above considerations.

Enabler 3: Reducing food waste and end-of-supply-chain emissions

The EU wastes a significant amount of food each year, primarily at the household level. Estimates highly vary, ranging from 57 Mt (EU estimate) to 154 Mt of wasted food per year (Eurostat, 2022c; Vera et al., 2022). The latter estimate accounts for significant volumes of on-farm waste that are not measured by the EU's current methodology. Not only does food waste lead to emissions from waste management, but upstream emissions from producing, processing, transporting, and distributing food that is eventually wasted can be considerable. Upstream emissions are most pronounced when food is wasted at the household level since it has already passed through all the supply chain stages (Scherhaufer et al., 2018). There is significant scope for emission reductions from the agricultural sector by reducing food waste and ensuring that food produced is also consumed. Since EU data on food waste volumes is only available for the year 2020, the '*total volume of waste from categories and*

Selected indicator:

Volume of waste containing food waste [Mt]

economic activities that generate food waste' is a suboptimal indicator to determine whether the EU is on track to achieve the necessary reductions. A legally binding food waste reduction target will be proposed by the EC by the end of 2023, but the EU has committed to Sustainable Development Goal (SDG) 12.3 of reducing food waste by 50% by 2030.

The agrifood sector further requires significant energy inputs in order to process, transport, and package food (Crippa et al., 2021). However, these energy emissions are generally not considered when discussing the EU agricultural sector. While these emissions can be reduced in line with the decarbonisation of the power, industry, and transport sectors, it is important to track the magnitude and trend of such downstream *'emissions from food processing, transport, and packaging'* since they are becoming an increasingly larger share of total emissions from food production, and emerging policies to address such emissions will have to be sector-specific (Crippa et al., 2021). It also highlights how wasted food, especially at the household level, also results in unnecessary emissions from other sectors.

Selected indicator:

Emissions from food processing, transport, and packaging [Mt CO_2e]

4.5.2 Progress towards climate neutrality

Progress towards the objectives

The trajectory of agricultural emissions has been heading in the right direction, but emissions must decrease 2.4 times faster than they have been in recent years to get on track towards the indicated benchmark in the impact assessment of the EU LTS. The majority of agricultural emission reductions occurred in the 1990s from the restructuring and modernisation of the sector in Eastern Europe, and emissions have more or less stagnated or minorly fluctuated since 2005 (EEA, 2022d, 2023b). A more concerted effort is needed to employ mitigation measures in the agricultural sector. Some of the indicators tracking the largest emissions sources in the sector – manure management and total livestock numbers – have continuously increased when

Agricultural emissions

This indicator shows past development in EU agricultural GHG emissions (EEA, 2023b) in comparison to the EU target of reaching 254 Mt CO_2e in 2050 (middle value of 1.5TECH and 1.5LIFE scenarios outlined in LTS) (EC, 2018c).

Data show an annual decrease of 1.8 Mt CO_2e between 2016 and 2021. To meet the benchmark, the required annual change between 2021 and 2050 needs to be 4.3 Mt CO_2e, which is 2.4 times faster than the current rate of progress.

the trend should be developing in the opposite direction, and action to reduce nitrogen fertiliser consumption must accelerate. There are also too few official benchmarks set by the EU for the agricultural sector to effectively drive the required changes, and those that currently exist do not comprehensively cover the main emissions drivers.

Bovine meat consumption has gradually decreased in the EU since 2000, however, the rate of change must be 1.3 times faster than the current rate of progress to be aligned with the dietary changes outlined in the EU LTS impact assessment. Recent data has positively changed this indicator's direction, with progress being far too slow before the addition of 2022 consumption rates. The decrease in beef consumption over time can likely be attributed to higher poultry consumption rates, but veganism and vegetarianism have also been on the rise (EEA, 2019b). On average, EU citizens eat double the meat that is recommended by health authorities. Phasing out meat for higher shares of fruits, vegetables, and legumes would also result in positive nutrition outcomes and decreased premature deaths (Buckwell & Nadeu, 2018).

Bovine meat consumption

This indicator shows past development in bovine meat consumption (DG-AGRI, 2023) in comparison to the EU benchmark of a 34% decrease in bovine meat consumption relative to 2013 levels (EC, 2018c).

Data show an annual decrease of 0.10kg/capita between 2017 and 2022. To meet the benchmark, the required annual change between 2022 and 2050 needs to be 0.12 kg/capita, which is 1.3 times faster than the current rate of progress.

Progress towards enabler 1: Reducing fertiliser use and cropland-related emissions

Synthetic fertiliser use has only marginally decreased in the EU, and more action is needed to meet the target outlined in the Farm to Fork Strategy. The CAP's organic farming support could play a role in reducing fertiliser use, but the increased organic farm area has resulted in little impact on fertiliser consumption, considering nitrogen fertiliser application per hectare of cropland is higher now than in the early 2010s (ECA, 2021a). In light of this pattern, it is likely that conventional farms that have recently transitioned to organic agriculture have had relatively low fertiliser use already, or that the decrease is counteracted by growth elsewhere. The CAP has minimally supported measures that are known to reduce fertiliser use, such as forage legumes on grassland or nitrification inhibitors (ECA, 2021a).

The Farm to Fork Strategy additionally aims to achieve a 25% share of organic farming area relative to total agricultural area. According to the latest data, organic farming made up around 9% of total utilised agricultural area. The trend is thus headed in the right direction, but organic farming uptake needs to be 3.2 times faster than the current rate of progress to meet the set target. While not reflected by current available data, the adoption of organic farming may further be hindered by high inflation rates influencing consumer spending, and even result in a shift back to conventional farming. In 2022, organic food sales reportedly decreased by 5% in the EU (Rehder, 2023). The uptake of organic farming has been moderately encouraged by current policies; almost two-thirds of organic farming area received specific organic support payments under the CAP and national co-financing (EC, 2023s). Based on this, the support under the CAP for climate mitigation and funding for specific mitigation measures should increase in magnitude and specificity to achieve similar development to organic farming.

Nitrogen fertiliser consumption

This indicator shows past development in nitrogen fertiliser consumption per hectare of cropland (Eurostat, 2022a) in comparison to the EU target of a 20% reduction in fertiliser consumption in 2030 (compared to a 2018 reference point) (EU, 2023a).

Data show an annual decrease of 0.8 kg N/ha between 2016 and 2021. To meet the target, the required annual decrease between 2021 and 2030 needs to be 1.5 kg N/ha, which is 1.8 times faster than the current rate of progress.

Organic farming as a share of total utilised agricultural area

This indicator shows past development in the uptake of organic farming (Eurostat, 2023j) in comparison to the EU target of reaching a 25% share of organic farming relative to total agricultural area in 2030 (EC, 2020a).

The data show an annual increase of 0.5%-points between 2015 and 2020. To meet the target, the required annual change between 2020 and 2030 needs to be 1.6%-points, which is 3.2 times faster than the current rate of progress.

Progress towards enabler 2: Shifting livestock production towards a sustainable model

The EU currently lacks targets for the livestock sector, despite emissions from livestock making up the majority of agricultural emissions. Manure management emissions per head of cattle have increased at an annual rate of 0.09% between 2016 and 2021, which is headed in the opposite direction than what is needed. Despite absolute manure management emissions

Manure management emissions intensity of cattle

This indicator shows past development in manure management emissions per head of cattle (EEA, 2023b; EU, 2023a). No benchmark is available from an official EU source.

Data show an annual increase of 0.09% between 2016 and 2021. This development was heading in the wrong direction, and a U-turn is needed.

decreasing over the years, the manure management emissions intensity per head of cattle in 2021 is higher than 1990 levels. This could, in part, be attributed to the rising intensification of animal agriculture in the EU – in 2018, a mere 4% of European farms generated 80% of total manure (Köninger et al., 2021). Although there are well-established measures for reducing manure management emissions on farm, including slurry acidification, the cooling of manure, impermeable covers, and producing biogas from manure, only a small number of farms received CAP support for these practices, meaning their implementation is rarely incentivised (ECA, 2021a). Thus, the consolidated generation of manure and the current lack of action also presents considerable opportunities for mitigating manure management emissions.

Livestock

This indicator shows past development in total livestock numbers (EU, 2023a). No benchmark is available from an official EU source.

The data show an annual increase of 0.19% between 2016 and 2021. This development was heading in the wrong direction.

Total livestock numbers have increased at an annual rate of 0.19% between 2016 and 2021, which is headed in the opposite direction than what is needed. While the number of cattle and sheep have decreased, the number of pigs and other livestock (primarily poultry) have increased. In addition to increasing animal numbers, the livestock sector has become increasingly consolidated over the years, which has resulted in significant changes to agricultural production and related emissions. Around 63% of EU cropland is used to produce feed for livestock, which is often intensively farmed with high synthetic fertiliser and pesticide application rates. It is also inefficient since livestock are only able to convert 10–30% of the feed they consume into food for people (Greenpeace, 2019). Purchasing feed from abroad has also resulted in high indirect emissions from land use change in Latin America. Recently, as much as 20% of EU soy imports from Brazil were linked to illegal deforestation, although the recent regulations on banning goods linked to deforestation is a positive development (Rajão et al., 2020). Overall, reducing livestock numbers would have positive implications for GHG emission reductions and freeing up land.

Progress towards enabler 3: Reducing food waste and end-of-supply-chain emissions

Volume of waste containing food waste

This indicator shows past development in the volume of waste containing food waste (Eurostat, 2023e). No benchmark is available from an official EU source.

The data show an annual increase of 0.5% between 2010 and 2020. This development was heading in the wrong direction.

The volume of waste containing food waste has increased at an annual rate of 0.5% between 2010 and 2020. This development is currently headed in the opposite direction than what is necessary. However, the volume of waste containing food waste is used as a proxy indicator, since EU data on food waste volumes is only available for the year 2020. Now that baseline measurements of food waste per Member State are available, it is imperative that legally binding food waste targets, which are set to be introduced by the EC sometime in 2023, cover all stages of the supply chain. Also, current volumes of primary production food waste are likely underreported by the EU since edible, unharvested crops on farm are not considered waste under current directives (Vera et al., 2022). Food waste volumes and their development will continue to be monitored.

Downstream emissions from the agrifood sector, in this case food processing, transport, and packaging, have decreased at an annual rate of 0.8% between 2016 and 2021. While this is a positive development, the rate in emissions decrease should accelerate in the future. This is underscored by need for rapid decarbonisation in the power, industry, and transport sectors, which make up the majority of downstream emissions in the agrifood sector (Crippa et al., 2021). The high magnitude of downstream emissions, which totalled 193 Mt CO_2e in 2020, illustrate another benefit of avoiding food waste, since it avoids emissions from the processing of subsequently wasted food.

Emissions from food processing, transport, and packaging

This indicator shows past development in downstream emissions from food processing, transport, and packaging (FAO, 2022a). No benchmark is available from an official EU source.

The data show an annual decrease of 0.8% between 2015 and 2020. This development was heading in the right direction but should accelerate in the future.

4.5.3 Conclusions and recommendations

The EU agricultural sector must accelerate emission reductions in order to be compatible with climate neutrality, and structural changes to demand are needed to achieve targets

Emissions from the agricultural sector must be minimised for the EU to be compatible with a net zero emissions trajectory without an overreliance on natural and technological removals. However, many of the indicators used to track progress are headed in the opposite direction than needed, or the rate of change is still too slow. More concerted action is needed in the agricultural sector. The current efforts to integrate climate mitigation into existing policy frameworks like the CAP have been unambitious and superficial and have not resulted in significant emission reductions in the agricultural sector. Despite the recent round of reforms in the CAP, most of the Member State's new strategic plans still lack ambition and a focus on climate mitigation (Nemcová et al., 2022).

Existing agricultural policy frameworks should be reformed to be more conducive towards climate change mitigation, and the EU must also introduce new policies to further catalyse change in the agrifood sector. Not only could producers be incentivised to implement climate-friendly agricultural practices, but new measures could influence the current food environment, meaning how consumers engage with the food system and make decisions on what to purchase and consume (EEA, 2022d). Policies that help shift consumption patterns or reduce food waste at all levels of the supply chain can result in significant avoided emissions from diverted agricultural production and the end of the supply chain. The potential of demand-side policies in the EU heavily outweighs the emission reduction potential of traditional agricultural mitigation measures (Roe et al., 2021).

In 2023, the EU is expected to introduce sustainability labelling system requirements under a new framework for sustainable food systems. However, information-based campaigns are insufficient to change consumer behaviour on their own. Supporting sustainable choices also requires changes to the availability, presentation, and cost of choices to make them the easiest option (EC SAM, 2020). The new framework is also expected to introduce requirements for sustainable public procurement, which would provide more organic and plant-based choices to consumers in everyday environments via changes in the food environment. The EU could also support the shift to low-carbon diets by supporting the research and development of alternative proteins and requiring food companies to offer plant-based alternatives, reviewing national health guidelines, and removing harmful subsidies such as those supporting meat and dairy

production (EEA, 2022d) (please note that further discussion on sustainable public food procurement is found in section 4.7).

Despite strides in the uptake of organic farming and reducing nitrogen fertiliser consumption, action must accelerate

Synthetic fertiliser use has only slightly decreased in the face of the Farm to Fork Strategy, which emphasises nutrient management and reducing fertiliser use to decrease nutrient losses. While nitrogen fertiliser application per hectare of cropland has declined in recent years, rates have remained relatively unchanged since the 1990s. Concrete measures to reduce fertiliser use must be introduced to meet outlined benchmarks. Optimised nutrient management or reduced fertiliser application can reduce emissions from managed soils while diverting emissions from fertiliser production. Another option is to switch to organic farming, which eliminates nitrogen fertiliser use and does not rely on chemical inputs, although the inadequate application of manure to soils can result in the same magnitude of managed soil emissions. Synthetic fertiliser production is dependent on natural gas imports, meaning fertiliser supply and prices are highly variable (WWF, 2022b). The recent energy crisis has caused sharp price hikes in fertiliser and will likely impact the extent of fertiliser use in the coming years (EEA, 2023b).

Despite the consistent increase in organic agricultural area in the EU, nitrogen fertiliser consumption per hectare of cropland is higher than a decade ago when there was less organic area, which is contrary to what is expected with changes in farm type. The conventional farms that are transitioning to organic farming likely already have low synthetic fertiliser use (ECA, 2021a). Given the current pattern, it is unclear whether achieving the organic farming target will result in a notable reduction in fertiliser use. Under the new CAP, organic farming is considered an ‘eco-scheme’, although it does not have a strong link to emission reductions. At the same time, many organic farming practices fall under the umbrella of regenerative agriculture, which has a broad range of benefits for biodiversity, climate adaptation and resilience, air and water pollution, and soil health, and these principles should be disseminated and supported through clear targets and policy measures (Hülsbergen et al., 2023). Further consideration should be given to what is and is not funded under current policies.

Little action has occurred in the livestock sector; CAP subsidies should fund concrete emission reductions measures rather than support intensive animal agriculture

The emissions intensity of manure management in cattle has increased and stagnated since the 1990s and overall livestock numbers have continuously increased; both indicators are heading in

the opposite direction than necessary to be compatible with climate neutrality. The lack of action in the livestock sector can, in part, be attributed to the support from the CAP. Around 69–79% of direct payments from CAP went to the livestock sector or to feed producers (Greenpeace, 2019). Since the extent of payments are based on acreage or total number of livestock, there is little incentive to shift the status quo. On the other hand, little of the CAP budget has gone towards actual emission reduction measures in the livestock sector, such as improved manure handling and storage (ECA, 2021a).

In addition to high direct emissions, the increasingly consolidated and industrialised livestock sector in the EU has been responsible for high indirect emissions from domestic and overseas feed production. In general, emissions from the livestock sector must decrease at a faster rate than productivity improvements can realistically occur. The total number of livestock and the land available to sustain them are currently out of balance, and livestock's contribution to GHG emissions and nitrogen pollution are incompatible with climate and environmental targets. Total livestock numbers must decrease to effectively minimise emissions from the agricultural sector (Buckwell & Nadeu, 2018). As observed in the Netherlands, however, government plans to reduce livestock numbers can be highly controversial. The EU agricultural system needs to be systematically changed to achieve emissions targets, but it is crucial to ensure that relevant policies are developed alongside farmers and promote a just transition for rural livelihoods.

Box 6: Highlights from the assessment of Agrifood

The EU's current agricultural policies are insufficient for climate neutrality

Current EU agricultural policies and payment structures have supported large farms and intensive animal agriculture instead of climate mitigation. This is evident in stagnating agricultural emissions and rising fertiliser consumption and livestock emissions. Previous iterations of the CAP have rarely encouraged measures on cropland or in livestock farming that result in emissions reductions, and the recent reform to the CAP is not expected to change much.

The EU lacks a detailed plan for the agricultural sector

Agricultural emissions need to be reduced by a third of current emissions to reach the emissions levels outlined in the LTS. However, there are only a few official EU benchmarks for tracking progress in the sector. Out of the major emissions sources in the agricultural sector, only fertiliser use has a corresponding target. Developing further targets, such as for livestock emissions, can improve mitigation efforts while understanding what is possible within the constraints of the sector.

Trends in consumption patterns are headed towards the right track, but must accelerate to be aligned with climate neutral emission scenarios

Bovine meat consumption has continuously decreased over the years; however, it must decrease 1.3 times its current rate to meet the dietary targets in the EU LTS impact assessment. There should be an increased emphasis on consuming plant-based food and limiting animal products in EU diets. This would result in positive health outcomes as well as environmental benefits from reduced livestock emissions, pollution mitigation, and freed up land for afforestation.

Box 7: National-level insights for Agrifood

Ireland and Denmark lead in per capita beef consumption, while beef consumption is low throughout Eastern Europe

The consumption of bovine meat highly differs throughout the EU. The per capita beef consumption rate in Bulgaria, Poland, Latvia, and Romania, among others, has decreased since the early 2000s and is already below the levels needed to be in line with the dietary changes outlined in the LTS. On the other hand, Ireland and Denmark still have extremely high rates of bovine meat consumption that are 4 to 5 times higher than the EU-wide benchmark, although levels have also decreased since the early 2000s.

Fertiliser use is notably high in some EU Member States

When measuring fertiliser use per hectare of agricultural area, the countries with the highest application rates in recent years mainly consist of major agricultural producers, such as the Netherlands, Belgium, France, Germany, and Ireland. On a positive note, fertiliser consumption is gradually decreasing in these countries. Efforts to decrease fertiliser consumption could focus on optimising fertiliser application and reducing nutrient losses in the above countries.

4.6 Carbon Dioxide Removal

Carbon dioxide removal (CDR) will be crucial to achieve climate neutrality by compensating for minimal residual emissions that cannot be avoided. Currently, CDR comprises only natural sinks but is anticipated to include technical solutions in the future.

Overview

Carbon dioxide removal (CDR) will be crucial to achieving climate neutrality by mid-century, and net negative GHG emissions thereafter, by compensating for the minimum residual emissions that cannot be avoided (EC, 2018c; IPCC, 2022b). Anthropogenic removals are defined as the 'withdrawal of GHGs from the atmosphere as a result of deliberate human activities' (IPCC, 2018a). CO_2 can be removed by enhancing natural sinks through land use, land use change, and forestry (LULUCF), e.g., through afforestation/reforestation, improved forest management, or enhanced soil carbon. It can also be removed, within the limits of the approaches' own sustainability, through carbon removal technologies (CRT), including bioenergy carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS). These two options, which combine the capture of CO_2 from either the air (DACCS) or from the exhaust gas stream of a bioenergy facility (BECCS) with a storage option, are currently at a demonstration level only. For the effective removal of CO_2, storage options must be *permanent*, for example, via the geological storage and storage in minerals (for a good overview, see IPCC, 2022b Cross-Chapter Box 8, Figure 1). It is further important to note that all CRT comes with substantial risks and trade-offs, such as impermanence, high energy needs and competition for land, water, and other resources, which can put energy security, biodiversity, livelihoods, and food security at risk (IPCC, 2022b). The development of these technologies must be secondary to exhausting all emission reduction options, and they must only be deployed within sustainable limits and with clear rules. To date, nearly all removals come from natural sinks, with technical CDR only responsible for a tiny fraction of gross removals (S. M. Smith et al., 2023).

Measured against the benchmarks set in current EU frameworks and regulations, the development of carbon dioxide removals in the EU was heading in the wrong direction over the period 2016-2021. This is primarily as LULUCF removals declined by an average of 13.9 Mt CO_2e per year. This trend must be reversed to an annual increase of 6.3 Mt CO_2e per year necessary to meet the EU's LULUCF net removals target of 310 Mt CO_2e in 2030 (LULUCF Regulation). The decline in LULUCF removals was caused by slower forest growth rates, as well as ongoing net emissions from soils (EEA, 2023b; EP, 2020). These changes were driven in turn by various factors including deforestation, land degradation, wildfires and climate change, as well as

increased demand for biomass (Ceccherini et al., 2020; EPRS, 2023). In 2023, the EU revised the LULUCF Regulation to address these issues, setting individual Member State removal targets for 2026-2030 and proposing additional policy support for LULUCF removals. These include a proposed carbon removal certification framework (EC, 2022c), which, however, raises questions with respect to long-term storage and permanence as well as on the eligible uses of the removal units (Meyer-Ohlendorf et al., 2023).

There are currently no technology-based removals within Europe, with the exception of one DACCS demonstration facility in Iceland and a BECCS facility in the UK. Noting that all scenarios in the impact assessment of the EU's LTS include at least some BECCS and DACCS, we have assessed progress against the EC's aspirational objective of reaching 5 Mt CO_2e technical removal in 2030 (EC, 2021f). This implies that 625 kt CO_2e per year of technological capture and storage would be needed. However, any scaling up of BECCS in particular must take into account the trade-offs that come with the technology, such as competition for land, biodiversity loss and the loss of water retention. To support the sustainable and rules-based build-up of technological removals in the EU, demonstration projects are thus a priority, to investigate and manage environmental and social risks, increase scale, reduce energy requirements, and bring down costs. Only own demonstration projects with scientific analysis of net effects may inform the policy discussions and can help to setup a high-quality removal certification scheme.

4.6.1 Objectives and enablers

Objectives: Enhancing natural sinks and delivering on technical removals

The EU aims to increase both natural and technical removals of GHG emissions. Nature-based removal options are the most sustainable option and in principle, ready for immediate upscaling: these removal options are mature, available at relatively affordable cost, and already widely implemented in Europe, though there are land availability limits (Bey et al., 2021). Accordingly, our first indicator monitors the upscaling of nature-based removals by assessing 'net removals from LULUCF (land-use, land use change and forestry)'. Net removals consider both the sequestration of CO_2 and release of CO_2 from existing carbon stores, i.e., fluxes. In the past, cropland, grassland, wetlands, settlements, and other land emitted more CO_2 than they absorbed, while forest land and harvested wood products absorbed more CO_2 than they emitted and more than offset the emissions from the other categories. The EU has set an EU-wide

Selected indicator:

Net removals from technical solutions [Mt CO_2e]

2030 target for net LULUCF removals of 310 Mt CO_2e, in addition to a requirement that each of the Member States individually remove at least more than they emit within the LULUCF sector over the period 2021 to 2030 (EC, 2021j).

Technology-based CO_2 removals are currently at demonstration level only. The EC (2021f) has established an aspirational objective for technology-based removals of at least 5 Mt CO_2e in 2030. In light of the estimated required global technical removals of around 75 Mt CO_2 by 2030 (Boehm et al., 2022), this aspiration seems to reflect the EU's responsibility to develop the technologies and their application within strict rules and in acknowledgement of their limitations. Progress is monitored with the indicator: 'net removals from technical solutions'. Here, we consider permanent storage, which prevents CO_2 from re-entering the atmosphere over a long timeframe, ideally permanently, only – e.g., by storing CO_2 in stable geological formations and excludes short-term and medium-term storage options, such as building materials or synthetic fuels. Furthermore, all GHG emissions that arise from the operation of the capture, transport, and storage facilities are included in the calculation (i.e., net removals); meaning for instance that net removals are higher when removal facilities are powered with clean energy (see e.g., IPCC, 2022b).

Selected indicator:

Net removals from LULUCF (land-use, land-use change and forestry) [Mt CO_2e]

Enabler 1: Store more carbon in trees

Storing more carbon in trees is considered the most important land-based biological carbon removal technique in the EU (EC, 2020e; EEA, 2023d; IPCC, 2022b). The total carbon stored in trees depends on several factors, including inter alia the extent of the EU's forests, their health, management, and age. The carbon stored in European trees has increased since 1990, however, annual forest expansion has slowed down and with it increases in net removals (Forest Europe, 2020).

Progress on Enabler 1 can be tracked using two indicators. The first indicator is 'growth in forest area'. This indicator captures whether forests are expanding or contracting across Europe, which is a key driver of carbon storage in forests (EC, 2018c; Forest Europe, 2020). The second indicator is 'growing tree stock'. Growing stock refers to the living component of standing trees (EEA, 2017). It is a basic forestry statistic that is a useful indicator of the size of forests and can be simply converted into carbon storage,

Selected indicator:

Growth in forest area [1000 ha per year]

Growing tree stock [Mm³ per year]

as well as being a proxy indicator for other societal objectives, such as enhancing biodiversity (EEA, 2017). Alongside the first indicator, this second indicator also communicates information on the health of forests and the density of tree planting, which provide additional insight into forestry carbon storage. Given data availability, future updates of ECNO will consider indicators of natural ecosystem restoration, which promises longer-lasting sequestration with greater co-benefits, especially for biodiversity.

Enabler 2: Store more carbon in soils

Storing more carbon in soils is a natural sink with high technology readiness, low-cost, and high mitigation potential (IPCC, 2022b). Soils are commonly differentiated according to their carbon content into two categories: mineral soils (low carbon content) and organic soils (high carbon content, including, e.g., peatlands). Mineral soils account for 92% of soil area in the EU, with organic soils accounting for 8% (EEA, 2022c). Soils either sequester or release carbon, depending on their management and local conditions. Accordingly, it is important to consider net soil carbon removals. Overall, the EU is currently losing soil carbon, driven mainly by net emissions from organic soils. However, there is considerable uncertainty due to poor data quality and significant data gaps (Bellassen et al., 2022).

Selected indicator:

Concentration of organic carbon in arable land [g/kg]

Selected indicator:

Net carbon dioxide emissions from croplands, grasslands, and wetlands [Mt CO2]

The main indicator is the 'concentration of organic carbon in arable land'. This indicator measures the development of the carbon content of European arable soils, though it poses difficulties due to complex monitoring, with accompanying high uncertainty (IPCC, 2022b). Given the driving role of organic soil emission in the net removals from soil, a second indicator would ideally focus specifically on organic soils; however, a lack of useful data sources meant this was not currently feasible. Instead, we draw on national inventory reporting to track a more general indicator of soil carbon storage: the net carbon dioxide emissions from croplands, grasslands, and peatlands. While this indicator also includes other carbon pools (e.g., biomass), these are of only small scale for these land use categories, which are driven by changes in soil carbon storage. This indicator should capture reversals in soil carbon storage, i.e., the re-release of carbon sequestered in soils. Please note that this Enabler and indicator should be read alongside section 4.5 on agrifood, particularly Enabler 1: Reducing fertiliser use and preserving carbon stocks in croplands.

Enabler 3: Demonstrating the sustainable application of technical CO_2 removals

The multiple technical carbon removal methods are all still in the pilot and demonstration phase. The long-term potential for technical removals is high especially direct air CO_2 capture and storage (DACCS) and for bioenergy coupled with carbon capture and storage (BECCS) (IPCC, 2022b). However, it is important to note that BECCS in particular requires large amounts of land for related biomass generation (IPCC, 2022a; Terlouw et al., 2021). This comes with high impacts on forests, water retention and biodiversity, and could bring competitive usage over land, by bringing difficult choices between food production, nature restoration and BECCS (see also section 0). DACCS is at present a very energy and water-intensive technology but is, however, flexible in its local position with limited land occupation (if it does not rely on biomass as energy source) (IEA, 2022a; IPCC, 2022a). Both technologies require the permanent storage space for CO_2 which can be found in geological formations or minerals. Global as well as EU geological storage sites seem sufficient through 2100 to limit global warming to 1.5°C; however regional availability is not a given (Anthonsen & Christensen, 2021; IPCC, 2022b).

As it is in the early stage of deployment, data availability on technical removal is scarce which makes the selection of useful indicators and related monitoring difficult. In particular, there is a lack of consistent data on public and private funding for businesses and projects in the EU. The indicators we selected for this analysis come with limited data but will become more meaningful in the future as carbon removal activities are further developed.

Selected indicator:

DACCS and BECCS capacities [Mt CO_2e per year]

The first indicator, 'DACCS and BECCS capacities', monitors the maximum amount of CO_2 that can be captured and permanently stored through those technical removals sites in operation in a given year. Due to maintenance hours and reduced load as well as CO_2 losses between capture and the storage site, the EC's (2021f) aspirational objective for technology-based removals of at least 5 Mt CO_2e in 2030 means that installed capacity must be at a minimum 20% higher in that year (e.g., full-load hours for biomass combustion plants is around 7.000h per year; Kost et al., 2021). The second indicator 'costs of BECCS and DACCS' measures how far the development of these technologies has matured, and how this impacts the affordability of their deployment. In the future, when the technologies are applied more substantially on the ground, other indicators should also cover the energy sources supplying the required energy needs for capture, transport, and storage, as well as (in)direct impacts on land use from BECCS and energy supplied to DACCS.

It is worth stressing (again) that the development of these technologies must be secondary to exhausting all emission reduction options, and they must only be deployed within sustainable limits and with clear rules. The EU foresees a role for them as highlighted in the impact assessment of its LTS (EC, 2018c), in the EC's communication on sustainable carbon cycles (2021f) and the proposed carbon removals certification framework (EC, 2022h), implying a need for demonstration and standard-setting to investigate and manage environmental and social risks.

Selected indicator:

Costs of BECCS and DACCS [EUR/t CO_2e]

4.6.2 Progress towards climate neutrality

Progress towards enhancing natural sinks and delivering on technical removals

The EU has regressed in the development of natural sinks and has not yet seen significant progress with technical removals. LULUCF net removals were 230 Mt CO_2e in 2021, however, nature-based removals declined by 13.9 Mt CO_2e/year from 2016 to 2021 (EEA, 2023b). Thus, a U-turn is needed, with an increase of 6.3 Mt CO_2e each year necessary to reach the EU 2030 target of 310 Mt CO_2e (LULUCF Regulation).

Net removals from LULUCF

This indicator shows past net removals from LULUCF (land-use, land-use change and forestry) (EEA, 2023b). The EU target for LULUCF removals is 310 Mt CO_2e per year in 2030 (LULUCF Regulation).

The data show an annual decrease of 13.9 Mt CO_2e per year between 2016 and 2021. To achieve the target, removals must, on the contrary, increase annually by 6.3 Mt CO_2e per year between 2021 and 2030. As such, the current trend is in the wrong direction and a U-turn is needed.

Cropland, grassland, wetlands, settlements and other land emitted more CO_2 than they absorbed, while forest land and harvested wood products absorbed more CO_2 than they emitted and offset the emissions from the other categories (EEA, 2023b). While the total stock of carbon in forests increased each year, the rate of increase – that is, annual removals –slowed. This was driven by slower expansion of forest area, and slower increases in forest growing stock (see enabler 1). Soils are a current source of net emissions, though research indicates they could become a net source of removals in the future (Frelih-Larsen et al., 2022). Net CO_2 emissions from agricultural soils fell overall, though this has yet to show up as an increase in soil carbon stocks in some indicators (see

enabler 2). Overall, there is concern that natural sinks decreased because the carbon sink capacity of the LULUCF ecosystems declined over the past decade due to various factors such as deforestation, land degradation, wildfires and climate change, and increased demand for biomass (Ceccherini et al., 2020; EPRS, 2023). Deforestation, the conversion of forest land to other land uses, e.g., into urban areas or agriculture is the main driver of emissions by land-use change (EP, 2020). Land degradation, e.g., through unsustainable agricultural management practices or drainage of wetlands for agricultural use emits sequestered carbon and reduces the carbon sink capacity of soils. Climate change will also affect LULUCF removals, as it affects the survival and growth of plants and its potential to sequester carbon through change of water availability, severe weather events link droughts, floods, storms, heat waves, wildfires, as well as shifts in range and activity of pest infestation and diseases (see also section 4.12).

These changes mean that, with no new policies, LULUCF removals are expected to drop to 225 Mt CO_2e per year by 2030 (EC, 2020e). To reverse this trend, the EU is revising the LULUCF Regulation, including setting an overall EU-level objective of 310 Mt CO_2e of net removals in the LULUCF sector in 2030 (LULUCF Regulation). To support the achievement of this target, every Member States has received a 2026-2030 net removals target, and the EC is exploring incentive mechanisms for individuals to deliver carbon removals (e.g., for 'carbon farming' under the proposed Carbon Removal Certification Mechanism) (EC, 2022c).

Net removals from technical solutions

The indicator shows past net removals from technical solutions (S. M. Smith et al., 2023). The aspirational objective of the EC (2021f) is to capture and store 5 Mt CO_2 from the atmosphere in 2030.

With no CO_2 removal facility currently running in the EU, progress towards the EC's aspiration for technical removals in 2030 was far too slow and increases in technical removals must raise to 625 kt CO_2e per year.

To reach the aspirational objective of the EC to remove 5 Mt CO_2 in 2030, the current level of development is far too slow with no demonstration plant yet in the EU. The yearly increase in removals would have to reach 625 kt CO_2e to reach the EC' objective, which is not out of sight considering that a planned BECCS facility in Sweden is expected to have an annual capture capacity of 783 kt CO_2e. Overall however, the deployment potential of BECCS is highly limited, given the limits to feedstock being sourced sustainably (see also section 0).

While the EU already provides funding for projects from the Innovation Fund, political attention too seems to be increasing in the EU and in Member States (Schenuit & Geden, 2022). The EC (2022c) published a proposal for a voluntary framework to certify high-quality carbon removals. Here, questions remain with respect to long-term storage and permanence as well as

on the eligible uses of the removal units (Meyer-Ohlendorf et al., 2023). While Sweden has taken a pioneering role in regulating and implementing CDR through incentive schemes for BECCS, Member States demonstrate considerable diversity in their policies (BECCS Stockholm, 2023; Schenuit et al., 2021). How fast projects will come online may also depend on developments happening outside of the EU, such as in the USA, UK, and China (S. M. Smith et al., 2023).

Progress towards enabler 1: Store more carbon in trees

Carbon stored in trees is a key driver of LULUCF removals. Our selected indicators show that more carbon is being stored in trees every year but that this rate is slowing; that is, we are seeing carbon removed and stored in trees each year, but the amount is falling each year. This is visible in our enabler indicator on forest area, which is increasing but at a decreasing rate. Between 2010 and 2020 the rate of growth decreased by 21,400 ha per year. This is comparable to longer historical trends in forest area growth. Similarly, data indicates that Europe's growing stock – that is, the volume of stem wood in living trees – is also increasing but its growth rate slowed by 11.8 Mm^3 per year over the same period of time. This indicator too shows that the growth rate of growing stock is slowing.

Growth in forest area

This indicator shows past development in EU forest area (Forest Europe, 2020). No benchmark is available from an official EU source.

The data show an increase in forest area but at decreasing rate, with the rate of forest area growth decreasing by 21,400 ha per year or 6.7% over the period 2010 to 2020. This development is heading in the wrong direction and the negative trend must be reversed.

Growing tree stock

This indicator shows past development in the growing stock of EU trees (Forest Europe, 2020). No benchmark is available from an official EU source.

The data show that wood stocks increased but the rate of growth decreased by 11.8 Mm^3 per year or 4.5% over the period 2010 to 2020. This development is heading in the wrong direction and the negative trend needs to be reversed.

There are additional reasons to be concerned about the slowing down of growth shown by our indicators: First, it is possible that the current data may not adequately capture decreases in forest carbon sequestration, and for example, that they do not yet reflect how the exceptional droughts in the EU since 2015 have negatively affected forest stands (Forest Europe, 2020). Ceccherini et al. (2020) express concern that satellite data showing increases in harvested area

due to wood market shifts may also negatively affect forest targets. The EC reflects these worries in its Forest Strategy for 2030, which proposes new protections for existing forests and financial incentives to increase forest cover, to ensure that forest carbon removals increase (EC, 2021e). There is, however, the potential that land availability may limit forest expansion; which could be allayed if agricultural land needs decrease (e.g., due to reduced livestock numbers; see section 4.5).

Progress towards enabler 2: Store more carbon in soils

Soil carbon is a significant store of carbon and offers potential for increased sequestration (Rodrigues et al., 2021). However, soils are currently a net source of emissions within the EU (EEA, 2022c). Soils are under significant pressures that lead to net emissions, including land cover change, high intensity land use, and erosion (EEA, 2020). While there has been progress in this policy area in recent years, a lack of a consistent, ambitious European policy is a potential cause of the failure to increase soil carbon. Recent and proposed policies that should help address this issue include the 2021 soil strategy, a revised LULUCF regulation (2023), a forthcoming Soil Law (2023), and a renewed focus on soil science through the EU Mission: A Soil Deal for Europe.

Concentration of organic carbon in arable land

This indicator shows past development of the mean concentration of organic carbon in arable land (EC, 2019a). No benchmark is available from an official EU source.

The data show a minor decrease of 0.1% per year between 2009 and 2015, with no more recent data available. As the concentration of organic carbon needs to increase to meet removals targets, the trend must be reversed.

The lack of significant progress towards the enabler 'store more carbon in soils' is visible in the underlying indicators. Arable land is currently a significant source of net emissions in the EU. Meeting carbon removal objectives will require that soil carbon storage on arable land increases. However, current soil carbon stocks in European arable land are not increasing, as illustrated by the indicator, *'concentration of organic carbon in arable land'*. This indicator shows that concentrations have marginally decreased between 2009 and 2015, though the ability to interpret this indicator is limited by lack of data. The second indicator shows a small annual

decrease in CO_2 emissions by wetlands, croplands, and grasslands of 0.79 Mt CO_2 between 2016 and 2021. This means that agricultural soils are becoming less of a source of CO_2 than before. The development is heading in the right direction, but the pace must significantly increase to support the revised LULUCF target of 310 Mt per year in 2030 and the EU's climate neutrality target. Soils have a great capacity to act as a natural sink, but they need to be managed differently to contribute positively to climate change mitigation (ECCP, 2016).

Net CO_2 emissions from croplands, grasslands, and wetlands

This indicator shows past net CO_2 emissions from wetlands, croplands, and grasslands (EEA, 2023b).

The data show an annual decrease of 0.8 Mt CO_2 or 1.4% between 2016 and 2021. This development is heading in the right direction but is far too slow; the pace must significantly increase.

Monitoring the trend of soil carbon storage is complicated by measurement challenges and consequently relatively limited data (P. Smith et al., 2020). Despite significant efforts, soil carbon data is incomplete and fragmented across Europe, with significant gaps in data and expertise (EC, 2021c). To improve our ability to monitor progress towards LULUCF targets and the climate neutrality target more generally, improved indicators and data on soil carbon storage must be a priority.

Progress towards enabler 3: Demonstrating the sustainable application of technical CO_2 removals

While the use of in particular BECCS is among the most contested aspects of pathways towards climate neutrality, the EU foresees a role for them, implying a need for demonstration and standard-setting.

So far, technical solutions are available only at a demonstration level and have played virtually no role in overall removals. Globally, approximately 2,000 Mt CO_2 are currently removed from the atmosphere and stored each year, of which only 1.8 Mt CO_2 or 0.09% is attributable to BECCS and less than 0.01 Mt CO_2 or 0.0005% to DACCS (S. M. Smith et al., 2023). Companies like Climeworks, which built the DACCS facility Orca in Iceland, have attracted more than USD 150 million in funding, including from Microsoft (Joppa et al., 2021). Elon Musk has also offered a USD 100 million prize for the development and prototyping of carbon removal technology (XPRIZE, 2023). Public support including research, development, demonstration, and deployment (RDD&D) subsidies are further required to develop technical CO_2 removals, as well as high integrity rules and standards for their application in light of the associated risks (Brandt, 2021; Edenhofer et al., 2023; Poralla et al., 2021) (see also above in the objective section).

In Europe, there is no BECCS facility with permanent geological storage to date. The EU Innovation Fund contributed EUR 180 million to the EUR 609 million needed for the BECCS @ STHLM facility that is currently under development in Stockholm, Sweden, with a planned annual capture capacity of 0.783 Mt CO_2 (BECCS Stockholm, 2023; EC, 2021h). The project description outlines that 'locally-sourced biomass waste [will be used] as a feedstock in the electricity and heat generating plant' (EC, 2021h). However, Swedish environment organisations highlight that currently under 60% of residues from the forest and forest industries comes from Swedish forests (Air Clim, 2022). A planned Drax BECCS facility in the UK is expected to have a capacity of up to 8 Mt CO_2 when completed (CATF, 2023); yet, existing bioenergy plants owned by Drax in the UK have been targeted as responsible for high levels of deforestation, notably in primary forests in Canada (BBC, 2022). This shows that any BECCS project must be hold accountable of its direct and indirect effects and should only get public support if feedstocks are sourced verifiable from sustainable sources.

DACCS and BECCS capacities

This indicator shows past capacities of technology-based CO_2 capture and permanent storage from direct air capture and bioenergy capture and storage facilities (CATF, 2023).

Data show that there are no technical removal capacities in the EU and that none started operation between 2017 and 2022. This means that change is far too slow if such capacities should deliver at least 5 Mt CO_2 in net removals by 2030 (EC, 2021f).

There is no DACCS facility yet in the EU and no larger project officially announced. However, in Iceland, the DACCS Orca plant has been in operation since September 2021 with a capture and storage capacity of 4,000 t CO_2 per year. Orca was built by the Swiss company Climeworks and the Icelandic company CarbFix which was funded with EUR 2.2 million for the development of DAC under the Horizon 2020 Programme (EC, 2017a). Another DACCS plant in Iceland, called Mammoth, is currently being constructed with an expected capacity of 36,000 t CO_2 per year (CATF, 2023). Iceland is a suitable place for testing due to its storage sites and available clean and cheap energy (Government of Iceland, 2023). This is crucial since DACCS currently needs significant energy inputs (4–10 GJ / t CO_2) with heat accounting for about 80% and electricity about 20% (IPCC, 2022b).

The fact that technical CO_2 removal is still in its infancy can also be seen in the (missing) data on the cost development of the two most prominent technologies, BECCS and DACCS. While there is no data available from demonstration projects, the IPCC provides cost estimates in its 2014 and 2022 reports (IPCC, 2014, 2022b). For BECCS, the expected costs changed from USD 60-250 per t CO_2 in 2014 to between USD 15-400 per t CO_2 in 2022. For DACCS, in 2014, cost estimates were between USD 40-300 per t CO_2 for storage in supported amines and USD 165-

600 per t CO_2 in sodium or calcium scrubbers and decreased to USD 100-300 per t CO_2 in 2022 (IPCC, 2014, 2022b). The costs depend on numerous factors such as the distance to storage sites, the technology used for CO_2 capture, energy and solvent prices, resource consumption and capital investment (Fuss et al., 2018). This also means that competition on suitable storage sites might arise in the near future due to rising usage of DACCS, BECCS, and also CCS (see section 4.3).

Costs of BECCS and DACCS

This indicator shows the cost development of capture, transport, and storage with BECCS and DACCS in the EU.

There is no data available over a longer period for the EU.

4.6.3 Conclusions and recommendations

Removals are no substitute for emission reductions but they can support swifter and deeper GHG mitigation

Carbon removals are no substitute for the swift and deep emission reductions that must remain Europe's first priority to meet climate neutrality by 2050. Targets and policies for emission reductions should thus remain separate from, those for removals – as was agreed for the 2030 target in the EU Climate Law. However, removal activities have the potential to already now reduce the CO_2 concentration in the atmosphere. Additionally, IPCC and EU scenarios indicate that in 2050 residual emissions will remain that cannot further be reduced (e.g. from agricultural activities). The deployment of removals, if applied within high integrity rules that minimise the associated risks and trade-offs, can usefully compensate these residual emissions and support the achievement of net negative emissions post-2050 (EC, 2018c; IPCC, 2022b). This implies that the deployment of LULUCF removals must be ramped up, and technical carbon removals - currently in their infancy – should be readied.

Past decline in LULUCF removals must be reversed

Currently, virtually 100% of carbon removals come from natural carbon sinks in the land use, land use change, and forestry (LULUCF) sector. The focus within the LULUCF sector must be on maintaining and increasing current stocks. The indicators we monitor, however, show a decline in LULUCF removals that must be reversed. Slowing growth in forestry cover and density is occurring, in part due to aging forestry stocks and increased demand for biomass. Currently, soils are a net emitter, largely driven by emissions from organic soils (EEA, 2022c). Indicators

show that there are slow improvements in carbon storage in croplands, grasslands, and wetlands, but these must be accelerated. As land availability is limited, agriculture and forestry land must be managed cohesively. It is also crucial that broader impacts are considered, including impacts on biodiversity, water availability and use, and on land users.

To meet the objectives of increased LULUCF removals, improved soil carbon data and stronger policy incentives are needed:

Improved soil carbon data: Current data and indicators of soil carbon storage are limited. Improved and more consistent methods and reporting are required to track emissions and removals by soils, especially organic soils, and to support identification and incentives for sequestration.

Stronger policy incentives: There are currently limited incentives or requirements for individuals to increase soil carbon or forestry removals. Forthcoming policies such as the Soil Carbon Law should increase requirements for soil carbon protection. The Common Agriculture Policy must also be implemented more ambitiously, with conditionality requirements and eco-scheme incentives that result in increased removals. This should be accompanied by increased public support for mitigation provided by forests; here the Nature Restoration Law offers a potential vehicle. The EC's proposed Framework for Carbon Removal Certification may create incentives for individual action but in its current form poses risks to broader EU climate objectives (McDonald et al., 2023; Meyer-Ohlendorf et al., 2023).

Scientifically accompanied deployment of sustainable carbon removal projects in the EU is crucial to learn about and manage associated risks

Technical solutions for CO_2 removal and storage, such as DACCS and BECCS, are at demonstration level only but will get more important especially in the second half of the century. The cost development of these technologies remains rather uncertain as factors such as the availability of feedstock, energy costs, access and type of storage sites the technology used for CO_2 capture, energy and solvent prices, resource consumption and the amount of capital investment can lead to large cost differences. While technical removals can help to achieve deeper emission cuts, their wide-spread use will depend on available resources and safe storage options, and their application must be well regulated and considered in the light of associated potential risks, such as high energy and water consumption and negative impacts on biodiversity and food security.

It is crucial for the EU to simultaneously make carbon removal technologies available, investigate their potential side-effects and set clear rules to make sure associated trade-offs and risks are kept in check. To achieve this, the EU should enhance its research, development and demonstration efforts in carbon removal technologies and storage options, including their negative impacts on land, water, and energy consumption to ensure sustainable implementation. Additionally, it is essential to monitor and verify upcoming projects to obtain reliable data on the actual net CO_2 removal. With regards to technology-based removals, the proposed carbon removal certification framework (EC, 2022c) goes in the right direction but questions remain with respect to long-term storage and permanence as well as in terms of the eligible uses of the removal units (Meyer-Ohlendorf et al., 2023). Own demonstration projects with scientific analysis of net effects may inform the policy discussions and can help to setup the envisioned high-quality removal certification scheme.

Box 8: Highlights from the assessment of Carbon Dioxide Removal

EU forests struggle to fulfil the required function as carbon sinks

The EU aims to increase carbon removal by land use, land use change and forestry (LULUCF), but faces challenges from limited land availability, land degradation, deforestation, wildfires, and climate change. The growth rate of wood stock decreased by 174 Mm^3 per year between 2015 and 2020 resulting in a drop in EU forest's rate of carbon sequestration to 230 Mt CO_2e in 2021.

Technical removal is still in its infancy requiring demonstration and standard-setting

There is currently no technical removal facility in the EU. The European Commission set an aspirational objective of achieving 5 Mt CO_2 stored in 2030. This implies a need for demonstration – and importantly, standard-setting as deployment must adhere to robust sustainability criteria to make technical removals environmentally and socially sound.

The EU aims to increase carbon removal by land use, land use change and forestry (LULUCF), but faces challenges from limited land availability, land degradation, deforestation, wildfires, and climate change. The growth rate of wood stock decreased by 174 Mm^3 per year between 2015 and 2020 resulting in a drop in EU forest's rate of carbon sequestration to 230 Mt CO_2e in 2021.

4.7 Lifestyles

The transition of collective and individual lifestyles towards more sustainable behaviour patterns and social practices is a meaningful driver of decarbonisation. These are dependent on policies to promote options that are accessible, affordable, and desirable.

Overview

Globally, lifestyle changes in end-use sectors have an emission reduction potential of 40-70% compared to the IPCC's 2050 emissions projection. Developed countries have the highest decarbonisation capacity due to their disproportional contribution to global emissions (IPCC, 2021). Altering specific household actions can reduce emissions in a cost-efficient manner and may even reduce household spending, especially in the energy and building sectors (Chan & Adabre, 2019; Pagliano & Erba, 2022). Sustainable consumption patterns are dependent on policies to promote options that are accessible, affordable, and desirable (Ademe, 2021). Demand-side solutions can bring various co-benefits, such as improvements in public health and social justice (EC, 2018c). In the EU, changing everyday behaviours can reduce the risks associated with emissions overshoot (EC, 2020e). Still, lifestyle changes are only part of a comprehensive transition and will only be effective if accompanied by deep structural transformation in a sector (Solnit, 2021).

The progress towards sustainable, sufficient lifestyles in the EU is heading in the right direction, but well below the required pace. Even still, the uptake of consumption choices and habits that are in line with climate neutrality is progressing against a backdrop of high public awareness of the climate crisis and its implications (see also section 4.11). The creation of daily environments that enable climate-positive lifestyles are a key to the transition to climate neutrality. While the per capita material and carbon footprints continue to decline among EU citizens, this positive trend is not happening fast enough for lifestyle changes to play a substantial role in the transition. Overall, assessing progress on lifestyle changes is challenging due to a lack of good, quantitative data. This lack of information reflects the fact that structural changes in collective and individual behaviours has not been a priority for EU and national climate policies. Data limitations constrain the scope of our assessment and point to the need for further investigation of the role of lifestyles in reaching net zero emissions by 2050.

4.7.1 Objectives and enablers

Objectives: Reaching sufficiency in lifestyles through reduced carbon footprints of households

The first objective under lifestyle changes aims at the guiding principle of reducing household material consumption. The amount of emitted GHGs goes hand in hand with material production and energy use. While technological advancement (see section 4.8) can improve efficiency or enable shifts to clean energy sources, sufficiency has the potential to speed up the climate neutral transition and will be crucial to transform the EU into a climate neutral economy (Pagliano & Erba, 2022). Sufficiency policies are defined by the IPCC as 'a set of measures and daily practices that avoid demand for energy, materials, land and water while delivering human well-being for all within planetary boundaries' (Clever, 2022; IPCC, 2022c). By definition, sufficiency differs from forms of rationing that can occur due to material constrains, or inflation, as especially low-income households are currently forced to cut down consumption (Charalampakis et al., 2022). ECNO will measure the objective of reducing consumption by observing the '*per-person material footprint*'. Thereby, we measure both sufficiency and efficiency gains that lead to an overall reduction in consumption. By measuring the end-use, possible rebound effects are considered. Additionally, in this way, the indicator also encompasses imported emissions (see section 4.13).

Selected indicator:

Per-person material footprint [tonnes per capita]

Lifestyles also play a role in climate mitigation when individuals consume less carbon-intensively. This includes shifting from conventional consumption modes to less GHG emission-intensive alternatives, whether in dietary preferences, mobility choices, or housing (see respective sections; Akenji et al., 2021). Research has shown that despite environmental concern, people still tend to choose the option they are accustomed to. To overcome this 'attitude-behaviour gap' and reduce overall emissions stemming from consumption choices, sustainable and climate neutral options need to become the desired path, gaining in popularity, cost-effectiveness, diffusion across all parts of society, and eventually becoming the new normal (Asquith et al., 2022; Wintschnig, 2021). In order to assess the extent to which Europeans consume more sustainably, we will look at the '*per-person carbon footprint from household expenditure*'.

Selected indicator:

Per-person carbon footprint from household expenditure [tonnes CO_2e per capita]

Enabler 1: Providing infrastructure that promotes climate-neutral behaviour

Everyday climate-friendly behaviour must become the *easy choice*. Our lifestyles vastly depend on the external material conditions or 'choice architecture' that surrounds us (Shove et al., 2023; Thaler & Sunstein, 2021). Public policy can influence and support climate-positive lifestyles through spatial planning and the provision of infrastructure that increases the availability of clean alternatives while inadequate infrastructure can limit or impede sustainable choices, 'locking-in' consumers to climate-damaging habits (Akenji et al., 2021; Dubois et al., 2019).

Urban planning must provide secure bike lanes and reliable public transport options if individuals are to give up the convenience of driving. Easy access to a wide network of charging stations will help encourage a consumer shift from cars powered by combustion engines to electric vehicles. The reliability of railroad networks, in addition to the expansion of high-speed rail and comfortable overnight connections, are crucial to make trains a serious alternative to short-distance flights (see section 4.2). Also, improvements to digital infrastructure enhances remote working, lowering commuting and overall mobility needs (see section 4.8). Finally, the creation of healthy and sustainable food environments such as the promotion of vegetarian and vegan options in public canteens support a shift in dietary habits (Carmichael, R., 2019; Garnett et al., 2019; Hook et al., 2020).

Selected indicators:

Investment in public transport [EUR per capita]

Share of EU population living in EU Member States, regions or local communities that promote sustainable food in canteens [%]

As a proxy for measuring the provision of infrastructure that encourages sustainable behaviour, we zoom in on two sectors: mobility and agrifood. The *'investment in public transport'* is a good signal for the availability of clean mobility alternatives (UNEP, 2022). Unusually high and spontaneous investments in bike infrastructure during the COVID-19 pandemic in Europe showed increases in bike transport of 11% up to 48% on average (Kraus & Koch, 2021). As a second indicator, *'share of the EU population living in EU Member States, regions or local communities that promote sustainable food in public canteens'* aims to monitor the degree to which people are nudged towards choosing the vegetarian option for their meals. The provision of more sustainable options, and presenting them as the default, has significant effects on the choice of consumers in canteens, while freedom of choice is preserved (Garnett et al., 2019; Reisch & Sunstein, 2021). Cities and local governments can support here with the public procurement of sustainable diets (UNEP, 2022).

Enabler 2: Enhancing economic incentives

One way to entrench sustainable lifestyle changes is to create conditions that make the sustainable choice the *cheap choice*. In the past, neither the negative impacts of climate change, nor peoples' awareness of their own contribution to the crisis, seem to drive sustainable practices like tangible, monetary motivations (Buenstorf & Cordes, 2008). Moreover, taxing carbon-intense products supports countries in reaching their climate goals while simultaneously generating revenues (EC, 2020e). Aside from increasing the price of carbon-intensive products and services, public authorities can further generate a steering effect with subsidies or support programmes. However, price mechanisms have distributional effects and can become regressive when not designed carefully (Ohlendorf et al., 2021). It is easier for consumers to live sustainably when prices reflect the true costs of a product or service in terms of emissions.

Selected indicators:

Price on carbon [EUR/t CO_2e]

Affordability of vegetarian options compared to meat options

We use '*carbon prices*', measured as net effective carbon rates, as a proxy indicator for the end-user's consumption of energy, building- and industry-related expenses, and mobility choices. As the agri-food sector is rarely covered by carbon prices, we employ the '*affordability of vegetarian or plant-based options with meat-intensive alternatives*' as a second indicator.

Enabler 3: Diffusion of climate-neutral habits in society

Aligning behaviours and habits with a climate neutral future must be perceived as either the *right choice or the normal choice*. European citizens are aware of the climate crisis and largely supportive of the transition to climate neutrality (see section 4.11). However, sustainable consumption patterns and climate-neutral options are still a long way from being the 'norm' across society. In addition to becoming more accessible and attractive, sustainable behaviour needs to be normalised such that it relies less on active choice by consumers but becomes the default. Moreover, behaviour is often learned through social observation and strongly connected to an individual's socialisation and cultural identity (Kahan et al., 2011; Stoknes, 2014). The establishment of new social norms promoting pro-environmental behaviour is most effective when exercised by trusted peer group members or admired role models. In short, if the sustainable choice is the socially acceptable choice, it will be more popular (Eurobarometer, 2021; Hulme, 2009; IPCC, 2022c; Lazaric et al., 2020; O'Rourke & Lollo, 2015).

Selected indicators:

Self-reported climate-conscious behaviour [% of surveyed population]

Climate-damaging advertisement [EUR]

Individuals have different reasons why they behave climate friendly (Šajn, 2020). But as awareness for the climate crisis rises and climate-neutral habits diffuse, it becomes more usual to choose the sustainable option. To monitor's people's change in behaviour due to their awareness of climate change, we monitor the development of '*self-reported climate-conscious behaviour*'. Still, the transition can only succeed if also individuals with a less environmentally conscious attitude choose the sustainable option, meaning that climate-friendly behaviour becomes the norm. To monitor progress in this realm, we want to monitor trends. Advertisement can be a critical driver for social norms and modifying consumption patterns, and, as such, the indicator *'decrease in climate-damaging advertisement'* has been chosen to can show how trends, norms, and the default choice shift consumers to less carbon-intensive products and services (Abokhoza et al., 2019; Brulle & Young, 2007).

4.7.2 Progress towards climate neutrality

Progress towards the objectives

The trendline, drawn from the years 2015 to 2020, shows marginal improvement in the average per capita material footprint in the EU (Eurostat, 2022f). Individual material footprint decreased on average 0.03% per year. A closer look at interannual changes across the observed timeframe shows that the trend was skewed by the COVID-19 pandemic. The indicator's development up to 2019 was moving in the wrong direction. A partial rebound is likely in 2021 and the coming years, still, the present cost of living crisis might keep consumption levels below pre-pandemic standards (Bounie et al., 2020). At the time of writing, data is only available up to 2020.

Per-person material footprint

This indicator shows past development in the per-person material footprint (Eurostat, 2022f). No benchmark is available from an official EU source.

The data show an annual decrease of 0.03% between 2015 and 2020. Up to 2019, the indicator's development was moving in the wrong direction. More recent positive trends are likely significantly skewed by disruptions to consumption patterns during the pandemic.

Progress towards the second objective for Europeans to consume better has evolved in a slightly more promising direction. The average carbon footprint from household expenditure decreased by 1.2% per year between 2014 and 2019 (Eurostat, 2022a). As the last data point in the series falls before the pandemic, these data may offer a more realistic indication of how consumers' choices have developed compared to the indicator on material footprint. Following this trend, households in the EU are likely to further decrease their carbon footprint in the future. However, the current rate of decrease is still far too slow and will need to accelerate significantly to be in line with climate neutrality by 2050. The current rate of inflation in Europe and elsewhere coupled with the energy crisis catalysed by Russia's war against Ukraine will further impact carbon footprint from household expenditure.

Per-person carbon footprint from household expenditure

This indicator shows past development in the per-person carbon footprint from household expenditure (Eurostat, 2022a). No benchmark is available from an official EU source.

The data show an annual decrease of 1.2% between 2014 and 2019. This development was heading in the right direction but was far too slow.

Progress towards enabler 1: Providing infrastructure that promotes climate-neutral behaviour

At present, there is no data available that allows for a comprehensive look at investment in public transport at a Member State level. The OECD tracks data on infrastructure investments in railways, one part of the picture, but only for 19 EU countries. Therefore, a trendline analysis is not possible for this indicator. Nevertheless, the EU has a range of funding programs for the development and improvement of public transport. For instance, the European Investment Bank (EIB) distributed around one quarter of their transport portfolio to urban public transport in 2019, and this number has increased over the years. Likewise, the European Regional Development Fund supports the expansion and connection of public transport in rural areas, focusing on southern and eastern EU Member States. EU-level funding suggests there is recognition of the need for better public transport systems throughout Europe, but the lack of national-level information makes it difficult to gauge the rate of progress.

Investment in public transport

For now, there is no EU-wide aggregated data on investments in public transport available.

Similarly, the creation of healthy and sustainable food environments such as the promotion of sustainable food in canteens by federal or local governments is currently not being tracked for the EU. Guidelines for sustainable public procurement, also in the food sector, exist (Procura+ Network, 2016), but no data exists on how many cities chose to implement these. To date, the Belgian city Ghent and the Finnish capital Helsinki are the only members of the Global Lead City Network on Sustainable Procurement that set targets on sustainable food procurement (GLCN, 2023). Interestingly, most cities that promote sustainable food in canteens focus on locally and/or organically produced food rather than on reducing the consumption of animal products. In France, it was decided in 2018 that by 2022 public canteens should source 20% of their food from organic production – a target that has not been met despite progress (Bon, 2022; MASA, 2018). Italy has a national goal that 50% of canteen food should be organic, and Latvia and Slovakia have similar targets in place, 30% and 15%, respectively (ICLEI & IFOAM Organics Europe, 2021). Yet, studies have shown that contrary to popular belief, a vegetarian diet is in any case lower in emissions than even locally and organically produced meat (Polleau & Biermann, 2021).

Share of EU population living in Member States, regions or local communities that promote sustainable food in canteens

At present, there is no EU-wide aggregated data on the promotion of sustainable food in canteens by EU Member States or local governments.

Progress towards enabler 2: Enhancing economic incentives

The OECD monitors the development of carbon prices with (net) effective carbon rates. Effective carbon rates consider fuel excise taxes, carbon taxes, and emissions trading systems. Twenty-two EU countries are members of the OECD, representing over 90% of the EU population. We therefore take the weighted average price of these plus the United Kingdom as a proxy for the development of a carbon price for the bloc as a whole. In 2018, the net effective carbon price was at EUR 58.9 per t CO_2e. By 2021, the price rose to EUR 74.7 per t CO_2e. With only two data points it was not possible to calculate a trend. All other things remaining equal, the increasing price signal for carbon-intensive products and

Price on carbon

This indicator shows past development in the net effective carbon rates of 22 EU Member States plus the United Kingdom (OECD, 2018, 2021). No benchmark is available from an official EU source.

There is insufficient data to calculate a trend. Still, data show an increase of 27% between 2018 and 2021.

services is a positive development for reaching carbon-neutrality although it may be still too slow when compared to Pietzcker et al. (2021) estimating that the carbon price might need to reach around EUR 190 by 2030 in the ETS and non-ETS sectors.

Affordability of vegetarian options compared to meat options

For now, there is no EU-wide aggregated data on the affordability of vegetarian options compared to meat options available.

There is no EU-wide aggregated data on the affordability of vegetarian options compared to meat options. However, recent studies comparing the costs of a diet that includes meat with a vegetarian or vegan diet in the Netherlands (ProVeg, 2022), Portugal (Pais et al., 2022), and globally (Springmann et al., 2021) provide evidence to suggest that a plant-based diet is the cheaper choice. This disparity is even more pronounced if the externalities of meat production are included in the calculation, such as the associated costs of climate change and the costs to society for healthcare for diseases associated with a meat-rich diet. Moreover, the costs of meat replacements have converged with the prices of meat in the Netherlands. Notably, meat is more vulnerable to the impact of inflation on commodity costs, leading to higher prices for the end-consumer while the prices of meat replacements remain stable (ProVeg, 2022). These developments coupled with adequate policy actions point towards fairer prices for animal products in the future that internalise the associated costs of climate change and healthcare.

Progress towards enabler 3: Diffusion of climate-neutral habits in society

Self-reported climate-conscious behaviour

This indicator shows past development in self-reported climate conscious behaviour (Eurobarometer, 2011, 2014, 2015, 2017, 2019, 2021). No benchmark is available from an official EU source.

The data show an annual increase of 7% between 2011 and 2021. This development was heading in the right direction.

It is difficult to quantitatively measure how and if European citizens are adopting sustainable habits. Especially where choices happen unconsciously, it is difficult to assess what circumstance led to the behaviour change. Yet, for now, it is often still a conscious choice if consumers are willing to choose the sustainable option. The Eurobarometer biennial climate change survey asks participants if they have 'personally taken any action to fight climate change over the past six months' (Eurobarometer, 2011, 2014, 2015, 2017, 2019, 2021). In addition to

consumption choices pertaining to travel habits, mobility, diets, etc., this also considers political activism and protests. In 2017, less than half of the respondents answered 'yes' (49%), but this share rose to 64% in 2021. The average annual increase of 7% between 2011 and 2021 suggests that individual sustainable behaviours are becoming increasingly widespread, despite the low threshold of the question. Still, it is important to consider the limitations that come with any self-reported survey answers. Questions on pro-social, or climate-friendly behaviours are not free from response biases. One of the common methodological limits to polling is the possibility that respondents do not answer truthfully, and instead attempt to comply with prevailing social norms – in essence giving a socially desirable answer. From this perspective, we could also interpret the Eurobarometer question as an indication of how climate neutral behaviours have become a mainstream social norm.

Social norms are a good indicator for collective consumption shifts in a society, and trends in advertising investments away from climate-damaging goods and services provide a suitable proxy measurement. However, to date, there exists no aggregated EU data on investment in advertisement campaigns for carbon-intensive products. Still, at least, in the agrifood sector it seems that the EU is actually supporting increased emissions through advertising. For instance, EU grants for promotion projects for European animal products have increased from 2016 to 2020, while the grants for fruits and vegetables have decreased (Eräjää, 2021). A better understanding on how marketing funds are spent throughout the EU, not just through EU grant programmes, and also for other carbon-intensive sectors, such as in aviation or the auto industry, is needed to investigate further.

Climate-damaging advertisement

For now, there is no EU-wide aggregated data on climate-damaging advertisement available.

4.7.3 Conclusions and recommendations

Demand-side action, the blind spot of EU climate policy

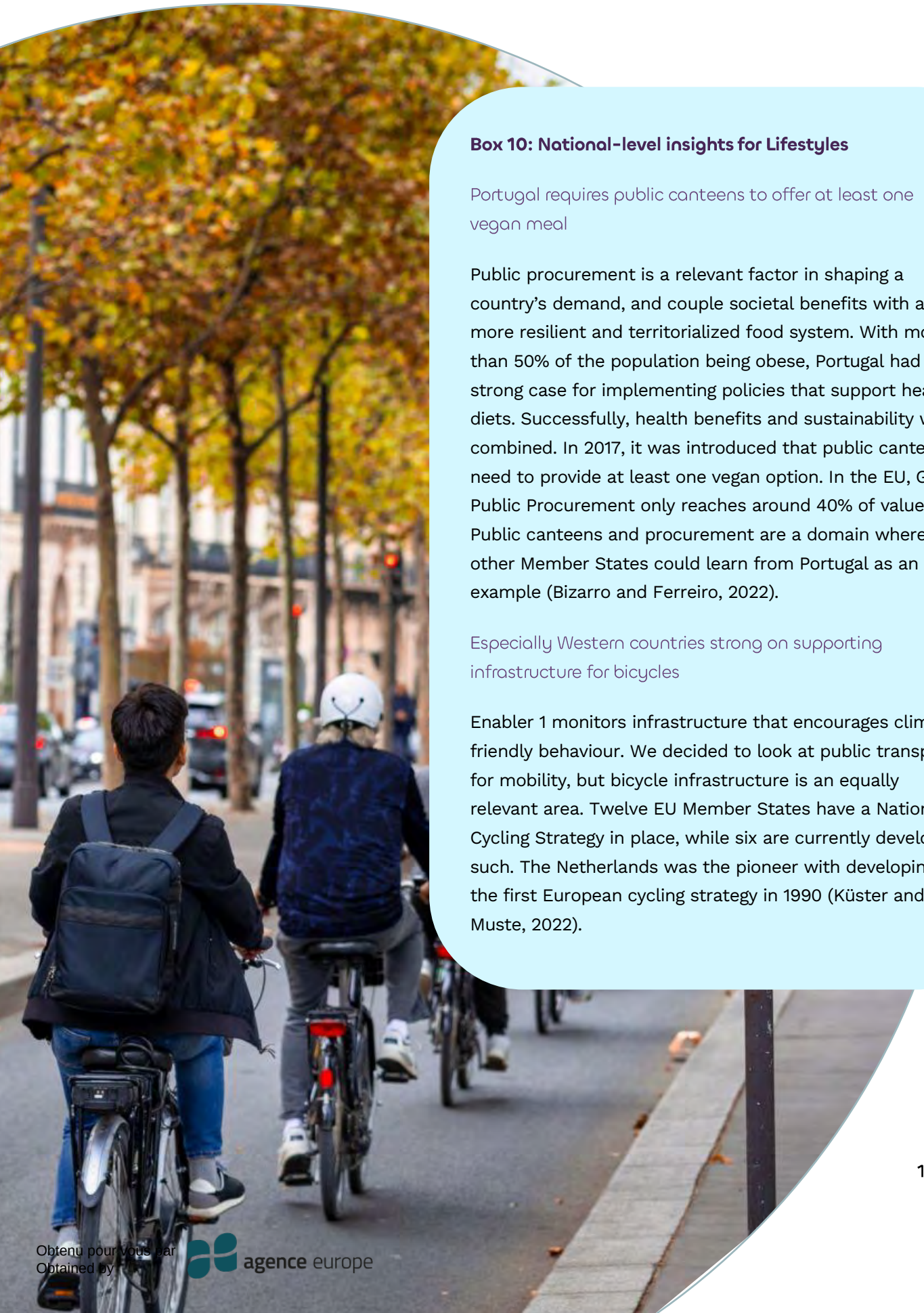
Reaching sufficient lifestyles is a crucial piece in the EU's climate neutrality puzzle. Still, the data availability for quantitatively measuring progress is minimal. There are little to no policies at the EU level that support sufficiency in lifestyles, which is underscored by the lack of official EU benchmarks for the indicators used in our analysis. Collectively, while the EU would do well to develop a comprehensive demand-side focused policy framework, scattered measures in the field already exist. For example, the Ecodesign Directive sets out minimum energy efficiency requirements for a range of products to reduce energy consumption and GHG emissions. The

EU's scheme of eco-labelling provides consumers with information about the environmental and social sustainability of products. The Circular Economy Action Plan, including the Food Waste Reduction Policy, aim to create a closed-loop system where resources are continuously reused, recycled, and repurposed, thereby reducing the pressure on the environment, and ensuring economic growth in a sustainable manner. It is foreseen that at the end of 2023, the EC will adapt the sustainable food system legislative framework, aiming at policy coherence and more sustainability in food-related policies. These existing initiatives show that a comprehensive demand-side focused policy on the European level is possible if Member States bring the political will.

Consumers need the agency to decide over their consumption without structural constraints

While EU citizens seem increasingly willing to act to mitigate climate change (see Enabler 3), overall reductions in both carbon and material footprints are still marginal. In other words, progress on the enablers has to date not translated to progress on the objectives. This insight paints a rather contradictory picture: empowered consumers, willingness to change, but stagnation regarding actual climate impact. It is a common critique that overemphasis of sufficiency transitions shifts responsibilities to citizens, and away from governments and business. In reality, consumer's hands are often tied. Structural conditions like the affordability (Enabler 2) or accessibility (Enabler 1) of climate-friendly alternatives act as barriers to more sustainable everyday habits. Moreover, consumption decisions are rarely purely rational, and are highly influenced by social norms (Enabler 3) and the environment in which people make choices. Sustainable consumption decisions must be promoted, and structural obstacles dismantled so that a climate neutral lifestyle is easy and accessible for all. To achieve this, an elaborate mix of both upstream and downstream measures is needed to ensure that cheaper and easier alternatives diffuse in society, generating new social habits.

Box 9: Highlights from the assessment of Lifestyles



Box 10: National-level insights for Lifestyles

Portugal requires public canteens to offer at least one vegan meal

Public procurement is a relevant factor in shaping a country's demand, and couple societal benefits with a more resilient and territorialized food system. With more than 50% of the population being obese, Portugal had a strong case for implementing policies that support healthy diets. Successfully, health benefits and sustainability were combined. In 2017, it was introduced that public canteens need to provide at least one vegan option. In the EU, Green Public Procurement only reaches around 40% of value. Public canteens and procurement are a domain where other Member States could learn from Portugal as an example (Bizarro and Ferreiro, 2022).

Especially Western countries strong on supporting infrastructure for bicycles

Enabler 1 monitors infrastructure that encourages climate-friendly behaviour. We decided to look at public transport for mobility, but bicycle infrastructure is an equally relevant area. Twelve EU Member States have a National Cycling Strategy in place, while six are currently developing such. The Netherlands was the pioneer with developing the first European cycling strategy in 1990 (Küster and Muste, 2022).

4.8 Clean Technologies

Developing new and improving existing technologies while ensuring manufacturing capacity to deploy them at scale is critical to enable the transition to climate neutrality across the economy.

Overview

'Clean' or 'green' technologies lie at the core of the transition to climate neutrality; they enable required changes across the economic sectors. This includes particularly strategic net zero technologies (EC, 2023b), which are established technologies, such as on- and offshore wind or solar photovoltaics and solar thermal technologies, heat pumps and bioenergy and geothermal technologies, as well as new technologies still in early adoption phase, such as hydrogen electrolyses, fuel cells, or carbon capture and storage (CCS) technologies. Further developing and deploying clean technologies is crucial, as their current level is 'insufficient to meet the global net-zero challenge' (Cervantes et al., 2022). This requires policies which support not only R&D activities, but also increases in manufacturing capacity for clean technologies. The latter faces both financial and non-financial barriers, such as excessive permitting procedures, lack of access to cost-competitive energy, shortage of qualified labour force, and insufficient access to public funding, as highlighted by the Green Deal Industrial Plan (EC, 2023b). Furthermore, the transition to climate neutrality will be enabled by general supporting technologies, such as robotics, AI, chemical and biotech innovations, as well as circular economy solutions, which are not strictly strategic net zero technologies but contribute to development of an innovative industrial ecosystem.

The progress in the area of clean technologies was found to be too slow, both in terms of the pace of developing new technological solutions and the increase of cleantech manufacturing capacity. The scale of economic activity (value added) in relevant environmental goods and services categories increased at an annual rate of 4.6%, which is too slow given the starting point and required increase in deployment of clean solutions. The index of eco-innovation related patents per million inhabitants declined on average by 1.2% per year, despite satisfactory progress in research excellence (a critical enabler), where a steady increase of related academic publications was accompanied by implicit growth in the number of researchers. This might be the result of insufficient progress in terms of the second enabler, resources for bringing ideas to market and innovation development, as financial resources allocated to energy and environmental R&D by governments were sluggish (especially if an outlier observation influenced

by the COVID-19 pandemic is not considered). The rapid increase of private investment in clean technologies is an important and hopeful sign for a potential acceleration of cleantech manufacturing, but this development is very recent and its longevity cannot be taken for granted without continuing efforts to provide enabling policy framework at the EU and national levels.

4.8.1 Objectives and enablers

Objectives: Increasing the capacity of the clean industrial base and pushing the frontier for clean technologies

A key objective in clean technologies is to ensure sufficient supply of environmental goods, including solar panels, equipment for onshore and offshore wind farms, batteries, heat pumps, electrolysers and fuel cells, sustainable biogas/biomethane technologies, carbon capture and storage technologies, as well as grid technologies. Building enough manufacturing capacity for clean technologies deployment in the EU will be a crucial enabling factor for a successful transformation, and for maintaining the EU's international competitiveness in the global market, which is expected to experience rapid growth in the coming years and be worth around USD 650 billion per year by 2030 (more than three times today's level) (IEA, 2023a). Therefore, the EU's strategic documents and policy initiatives, such as the Net Zero Industry Act (EC, 2023r), REPowerEU (EC, 2022j), and the Green Deal Industrial Plan (EC, 2023b) put emphasis on support for clean industrial value chains through increased funding and the reduction of administrative barriers. The indicator '*value added in management of energy resources and protection of ambient air and climate*' (Eurostat, 2023i), deflated to take into account price effects, helps to monitor progress in terms of increasing the capacity of the clean industrial base. This indicator might be replaced in future versions of this report, as the proposed Net Zero Industry Act includes a target for the manufacturing capacity of the strategic net zero technologies, according to which at least 40% of the EU's annual deployment needs should be manufactured domestically by 2030.

Selected indicator:

Value added in management of energy resources and protection of ambient air and climate [bnEUR]

The second objective for clean technologies is focused on technological advancement. The development of new decarbonisation technologies, as well as the improvement of existing ones, are essential for building a climate neutral economy in a cost-efficient way, while simultaneously helping to boost growth opportunities and strengthen productivity (Amoroso et al., 2021), and driving the economy's overall competitiveness (Ciocanel & Pavelescu, 2015). Innovation is often monitored using patent data (e.g., in EU's Eco-innovation Scoreboard and Innovation Scoreboard (EC, 2023e, 2023j)), which offers a good representation of activity in this respect. A meaningful indicator for measuring changes within this objective would therefore be *'climate mitigation and adaptation related patents'*. However, as this data is not currently available, the '*index of eco-innovation related patents*' can serve as a proxy, although it covers a broader scope of patents. The base year of the index is 2013, and data are sourced from the Eco-innovation Scoreboard, which concerns patent applications filed under the Patent Cooperation Treaty in the field of environment-related technologies, climate change adaptation technologies, and sustainable ocean economy inventions (Eco-innovation Scoreboard, 2022).

Selected indicator:

Index of eco-innovation related patents [% change]

Another highly relevant indicator to track would be: *'cleantech ready for market entry as a share of total cleantech'*, using the IEA's database of Technology Readiness Level (TRL) of individual technology designs and components across the energy system that contribute to achieving the goal of net zero emissions. However, to compute this indicator's dynamics it is necessary to gather annual datapoints registering changes in the flow of the database's content. It is ECNO's intention to collect these data and replace the indicator concerning patents with one tracking the dynamics of TRL in the future.

Enabler 1: Research excellence

The development of new clean technologies and the improvement of existing ones is conditional on creating new science-based knowledge. Funding for environmental R&D is an important catalyst of this process, as is the availability of skilled professionals who are capable of providing new scientific discoveries in the fields of energy and environment. One of the means for monitoring changes in research excellence is '*R&D researchers and personnel working in environmental sciences*' (Eurostat, 2022j). For

Selected indicator:

R&D researchers and personnel working in environmental sciences [full-time employment equivalents]

Selected indicator:

Index of eco-innovation related publications [% change]

now, this indicator is only flagged in Eurostat and data is not available for analysis. In future editions of ECNO, this indicator might be substituted or complemented by a number of learners in Net-Zero Academies, which should be set up in the coming years according to the Net Zero Industry Act, and which should aim at training at least 100,000 learners each within three years of establishment. Tracking '*the index of eco-innovation related publications*' (Eco-innovation Scoreboard, 2022) takes into account activity in relevant research areas. Here, the focus is on publications with the following keywords in title or abstract: eco-innovation, energy efficient/efficiency, material efficient/efficiency, resource efficient/efficiency, energy productivity, material productivity, and resource productivity. The base year is 2013.

Measures of academic activity are limited and not optimal for assessing the trends relevant for climate neutrality, as the functions of engineers and practitioners working with and adapting these technologies in practice also play a key role. To allow for a more robust analysis of the drivers behind pushing the frontiers of clean technology, the EU should consider widening its data collection activities in this area in the future.

Enabler 2: Resources for bringing ideas to market and innovation development

Selected indicator:

Funds allocated to environmental and energy R&D by governmental sector [% of GDP]

The delivery of clean solutions to the market is preceded by a research and development (R&D) phase, which requires financial support. As pointed out by OECD (Cervantes et al., 2022) science, technology, innovation, and industrial (STI&I) policies, which aim at R&D stimulation, are crucial to achieving climate neutrality. It is worth to note that the strength of the relationship between the number of patents and the amount of R&D spending is not consistent in the literature and can be influenced by many factors. Nevertheless, research generally shows a significant and positive link between the amount spent on R&D and the number of patents (Danguy et al., 2018). The measures of progress for this enabler encompass both public and private funding. The first indicator is *'funds allocated to environmental and energy R&D by governmental sector'* (IEA, 2022b), while the second focusses on '*private energy R&I spending'* (JRC, 2020). Here, both are given as a share of GDP (Danguy et al., 2018). The measures of progress for this enabler encompass both public and private funding. The first indicator is *'funds allocated to environmental and energy R&D by*

Selected indicator:

Private energy R&I spending [% of GDP]

governmental sector' (IEA, 2022b), while the second focusses on '*Private energy R&I spending'* (JRC, 2020). Here, both are given as a share of GDP.

Enabler 3: Clean technology uptake

Governments can play a key role in incentivising the green goods market's growth by influencing demand and supply. One of the most powerful tools to stimulate demand for environmental goods is green public procurement (GPP): governments act as a major consumer of goods and services (spending approx. 14% of the whole EU's GDP), and in some of the markets public purchasers constitute a particularly large share of the whole value (e.g., construction, health services, or transport) (EC, 2016), so they can positively influence green goods demand. An ideal indicator for monitoring progress on green technology uptake is thus the use '*green public procurement as a share of total public procurement'*, but it is important to note that this information is available only from single studies.

Selected indicator:

Green public procurement as a share of total public procurement [%]

Selected indicator:

Private investment in clean technologies [bnEUR]

Public funding, such as feed-in tariffs or support programmes that drive the uptake of clean technologies must be accompanied by significant private investment across the different sectors (see also section 4.9) (ECA, 2021b). The indicator '*private investment in clean technologies'* shows the financial assets invested in the sector by private investors in the EU and is based on data provided by cleantech for Europe (2023).

4.8.2 Progress towards climate neutrality

Progress towards the objectives: Increasing the capacity of clean industrial base and pushing the frontier for clean technologies

The change in the capacity of the cleantech industrial base developed in the right direction based on the value-added dynamics in the management of energy resources (CReMA 13) and the

protection of ambient air and climate (CEPA 1). It showed an average annual increase of 4.6% between 2015 and 2020. The sector's performance improved rather steadily, with energy management resources component observing a higher rate of increase over period of analysis (36.4% between 2014 and 2020) than the protection of ambient air and climate component (22.5%). The latter component is rather small compared to the former, as it constitutes only 5% of the whole aggregate, and is strongly dominated by Germany, which contributed 65% to it. This might be a result of a strong position of this country in the market of electric vehicles, which are included in this category (Eurostat, 2020b). Overall, given the scale of the necessary increase in local manufacturing of cleantech goods, announced in the Net Zero Industry Act (EC, 2023r), the dynamic of this indicator is too slow to meet the needs of a climate neutral economy. The target for the manufacturing capacity of the strategic net zero technologies indicates that at least 40% of the EU's annual deployment needs to be manufactured domestically by 2030.

Value added in management of energy resources and protection of ambient air and climate

This indicator shows past development in the value added in management of energy resources (CReMA 13) and protection of ambient air and climate (CEPA 1) (Eurostat, 2023i). No benchmark is available from an official EU source.

The data show an annual increase of 4.6% between 2015 and 2020. This development was heading in the right direction but should accelerate in the future.

Index of eco-innovation related patents

This indicator shows past development in the eco-innovation related patents compared to 2013 (Eco-innovation Scoreboard, 2022). No benchmark is available from an official EU source.

The data show an annual decrease of 1.2% between 2017 and 2022. This development was heading in the wrong direction.

The developments relevant for the second cleantech objective were found to be less favourable. Between 2013 and 2022, the indicator measuring eco-innovation related patents (per million population) decreased by 12%, with average annual drop amounting to 1.2% over the last five years of the period. The fastest decrease can be attributed to the years 2017–2019, but even given subsequent temporary improvement, the overall trend remains negative. Population changes also influenced this dynamic (as the denominator grew by 1.2% in total over this period); however, most of the contribution to the decrease came from the dropping number of patents.

Progress towards enabler 1: Research excellence

Currently available data sources do not allow us to track the number of R&D researchers and personnel working in environmental sciences. While there is a Eurostat dataset that includes statistics on the number of people employed in the R&D sector, with categories concerning their area of expertise and form of employment (full-time or not, researchers or other position), for now, there is no information available for some of the categories, which could be relevant for cleantech development. Moreover, it is not clear which categories would be applicable, as scientists working on cleantech could be assigned to several different categories under the existing classification. However, the total number of researchers involved in R&D activity for the EU in full-time employment equivalent shows steady progress, having more than doubled in the period 2000-2021. Thus, if the structure of researchers with regard to their field of study has not changed drastically in that period, it is reasonable to assume that the number of professionals working on research and development of climate neutral technologies has not decreased over the last two decades.

Number of R&D researchers working in environmental sciences

For now, there is no EU-wide aggregated data on the number of R&D researchers working in relevant areas of environmental sciences; however, data about the total number of R&D researchers shows steady improvement (Eurostat, 2022j).

Similarly, the progress in terms of the second indicator for this enabler – the index of eco-innovation related publications per million inhabitants – can also be assessed as on track. The value of the indicator in 2022 was almost twice as high as in 2013, when the data started to be collected. However, the changes have not been steady, as one third of the increase over the decade can be attributed to a single year (2022), and in four years prior to that, growth moderated from the prior fast pace. Therefore, the average annual growth rate of the trendline over the period 2017–2022 was equal to only 4.0%. Nevertheless, the overall outlook indicates that the index of eco-innovation related publications

Index of eco-innovation related publications

This indicator shows past development in index of eco-innovation related publications per million inhabitants (Eco-innovation Scoreboard, 2022). No benchmark is available from an official EU source.

The data show an average annual increase of 4.0% between 2017 and 2022. This development is on track, as the indicator's value nearly doubled over the whole 2013-2022 period and the annual average growth line for the last five years of data is only narrowly below the threshold 5% value.

contributes positively to reaching the goals of climate neutrality, and the indicator is on track, as it grew fast over the whole 2013-2022 period.

Progress towards enabler 2: Resources for bringing ideas to market and innovation development

Funds allocated to environmental and energy R&D by governmental sector

This indicator shows past development in funds allocated to environmental and energy R&D by governmental sector, relative to GDP (IEA, 2022b). No benchmark is available from an official EU source.

The data show an average annual increase of 4.6% between 2015 and 2020. This indicator developed too slow.

Data regarding the financial assets dedicated to clean energy R&D by governments are available only for the period of 2014 to 2020 (IEA, 2022b). Over the last five years, the value of the indicator grew significantly by 44.7%-points, which is equivalent to a 4.6% rate of annual increase. Nevertheless, it is worth to note that most of the increase can be attributed to the year 2020, when the denominator of the indicator fell sharply, as the COVID-19 pandemic reduced the EU's GDP and government expenditure increased due to anti-crisis measures. Thus, the indicator's value for this year is likely skewed to a large extent. Before that year, the indicator did not form an unequivocal trend, moving up and down by a small margin, which amounted to an average annual increase of 1.5%. Therefore, there is no definite sign of long-term progress, and the rate of progress on this indicator was too slow.

Private energy R&I spending, relative to GDP

This indicator shows past development in private energy R&I spending, relative to GDP (JRC, 2020). No benchmark is available from an official EU source.

The data show an average annual increase of 1.9% between 2014 and 2019. This indicator developed far too slow.

There are no data suitable for the IEA's monitoring framework for the private sector. Therefore, ECNO chose to assess progress in this area using estimates of energy R&I spending by private sector created by the JRC (JRC, 2020), which are based on patent information. Unfortunately, the most recent datapoint comes from 2019, and thus the analysis may not be the most up to date. In the inspected period 2012–2019 the amount spent by the private sector on energy R&I relative to GDP did not follow any definite trend. It fell gradually until 2016 and subsequently reversed direction, reaching a peak in 2018. In 2019, the value of the indicator dropped again to a level lower than the first observation from

2012. Over the whole period, sustainable transport technologies were the leading expense category (ca. 45% of the aggregate), followed by renewables, smart systems, and energy efficiency innovation with similar shares of 15–18%. The average annual growth rate of the aggregate between 2014 and 2019 was equal to 1.9%, and thus the indicator's value increased at a far too slow pace to contribute positively to reaching the goal of climate neutrality.

Progress towards enabler 3: Clean technology uptake

Green public procurement as a share of total public procurement

For now, there is no EU-wide aggregated data on green public procurement as a share of total public procurement.

Green public procurement (GPP) as a policy tool has a high potential for influencing markets, as it can incentivise industry to develop green technologies and products as well as stimulate their uptake (Delre et al., 2022). However, to date, there are neither aggregated EU data nor a harmonised methodology of measuring the extent to which public procurement procedures are optimised in terms of their influence on climate and environment. Two available data points come from separate studies and concern the years 2009 and 2010 and the period of 2006–2017. The 2009–2010 survey looked at public contracts from 10 product and service groups (CEPS & CoE, 2012). It revealed that 55% of public procurement contracts included at least one EU core green criterion, while 26% included all EU core green criteria existing at that time. A second study by (Sapir et al., 2022) relies on the Tenders Electronic Daily (TED) database, which registers all tenders above certain thresholds, but due to many missing values information from the TED inspection it can still only be treated as an estimate. The results of the study show that the average proportion of GPP relative to all public procurement in years 2006–2017 ranged from less than 0.5% in Malta to more than 15% in Denmark and France, but most countries only applied green criteria to procure less than 5% of their contracts. Due to significant methodological differences, the available sources cannot serve as a base for inference about the direction of changes in this area or the current prevalence of GPP; however, especially results of the second study show that the value of the indicator seems too low to drive clean technology uptake.

Private investment in clean technologies

This indicator shows past development in private investment in clean technologies (ECA, 2021b). No benchmark is available from an official EU source.

The data show an average annual increase of 101% between 2017 and 2022. This development is on track.

Progress in private investment in clean technologies showed fast improvement as it more than doubled each year on average between 2017 and 2022. The pace of growth is

uneven, though, with huge annual jumps followed by a much slower rate of improvement in the next year (or even stagnation in the last of the analysed years, which reflects a small venture capital market globally, and in all sectors). Nevertheless, overall past evolution of this indicator is favourable. Given the expected boost to private cleantech investment in the coming years following also the Net Zero Industry Act (EC, 2023r), this indicator's development is likely to remain on track.

4.8.3 Conclusions and recommendations

Progress in the area of clean technologies was too slow, both in terms of the pace of developing new technological solutions and in the increase of cleantech manufacturing capacity. Nevertheless, there is a good chance that positive developments will occur in the coming years as signalled by an acceleration of private investment in cleantech and a strong increase in the academic base. Moreover, recent communication from the EC (e.g., Net Zero Industry Act (2023r)) shows that incentivising innovation and the stimulation of cleantech manufacturing could become a policy priority in the future.

Securing future cleantech progress needs more robust investment in energy and environment R&D

More consistent policies stimulating both governmental and private investment in energy and environment R&D activity, as well as in cleantech manufacturing, could facilitate reaching objectives in cleantech. Such policies have already been announced in the Green Deal Industrial Plan for the Net-Zero Age (EC, 2023b) and a proposal for a Net Zero Industry Act (EC, 2023r). Their fast implementation should be a priority for the EU to be able to meet its net zero pledge.

Green public procurement remains an underutilised tool

Another area where urgent policy action on the EU level is necessary is increase in ambition of the GPP policies across the Member States. An important first step should be harmonisation of GPP definitions and the tracking of GPP share on the aggregate and sectoral levels, which in turn should enable establishing actionable national and/or sectoral targets. Available datapoints suggest that utilisation of this tool was below its potential, with no more than 15% of tenders signed in the EU fully compliant with EU guidelines in the period of 2006 to 2017. Given the strong position of governments in some markets (e.g., construction, transport), and their high share in total consumption on the macroeconomic level, GPP should play an important role in incentivising growth in cleantech manufacturing capacity, which could also be supportive for decarbonisation of industry.

Consistent statistics for the cleantech ecosystem

The anticipated establishment of a cleantech manufacturing target in the Net Zero Industry Act (EC, 2023r), which states that domestic manufacturing capacity should approach or reach at least 40% of the Union's annual deployment needs by 2030, should attract more attention to tracking progress in this area. It also presents a good opportunity to extend the current monitoring framework of trends in cleantech activity so that it includes also publicly available and regularly updated statistical information concerning the whole cleantech ecosystem.

Box 11: Highlights from the assessment of Clean technologies

Securing future cleantech progress needs a more robust investment in energy and environment R&D

More consistent policies stimulating both governmental and private investment in energy and environment R&D activity, as well as in cleantech manufacturing, could facilitate reaching objectives in cleantech. Such policies have already been announced in the Green Deal Industrial Plan for the Net-Zero Age (EC, 2023a) and the Net Zero Industry Act (EC, 2023u). Their fast implementation should be a priority for the EU to be able to meet its net zero pledge.

Green public procurement remains an underutilised tool

Green public procurement (GPP) remains an important area for improvement. Available datapoints suggest that utilisation of this tool was below its potential. Given the strong position of governments in some green goods markets, and their high share in total consumption on the macroeconomic level, GPP should play an important role in incentivising growth in cleantech manufacturing capacity, which could also be supportive for the decarbonisation of industry. Setting ambitious targets in terms of GPP and the establishment of a sound monitoring framework are among the necessary policy actions that would be supportive for higher uptake of GPP.

Both the capacity of clean industrial base and cleantech innovation are developing too slowly

The value added in management of energy resources and protection of ambient air and climate improved rather steadily between 2015 and 2020, and the sector's growth amounted to an average annual increase of 4.6%. However, given the scale of the necessary increase in local manufacturing of cleantech goods announced in the Net Zero Industry Act (EC, 2023u), the dynamic of this indicator is too slow to meet the needs of a climate neutral economy. Simultaneously, the indicator measuring eco-innovation related patents was heading in the wrong direction, and thus progress in terms of both cleantech objectives was unsatisfactory.

4.9 Finance

Redirecting financial flows towards clean products and services is essential to put the EU on track to achieve climate neutrality by 2050. It includes both public and private investment flows.

Overview

Redirecting financial flows towards clean technologies and services is essential to put the EU on track to achieve climate neutrality by 2050 (IPCC, 2022b). With many past and current investments indeed locking-in future GHG emissions, the transition to a climate-neutral economy will require both increasing climate-friendly investments and decreasing climate-hostile investments. These investments involve both public financial investments, i.e., the flows from and to public authorities (e.g. fossil fuel subsidies, environmental taxation) as well as private financial investments (e.g. bank loans, household purchases, business capital expenditure). Further, in the below, climate finance flows, include all financial flows that contribute to climate change mitigation while those for climate adaptation are excluded at this stage.

Today, the scientific literature underlines that global financial flows are not on track to limit global warming to 2°C or less (IPCC, 2022b). The European Union economy is no exception. The climate investment gap that needs to be filled to enable the EU to reach its climate objective by 2030 is still significant. According to the EIB, the EU needs from now on to increase its annual climate investments by EUR 360 billion. This means that it must multiply its climate investments by at least 1.5 compared to those made today. Public intervention is essential to both support cleantech investments and to increase the purchase costs of products and services that have a negative impact on the climate. However, the EU is clearly going in the wrong direction when it comes to fossil-fuel subsidies granted by EU Member States. Environmental taxation furthermore remains well below what is expected by the EU. Finally, it is difficult to assess the progress of the financial system towards climate neutrality financing as no relevant indicators are currently available, suggesting that this may lead to an implementation gap in the EU sustainable finance aspirations. Overall, the EU is heading in the wrong direction when it comes to climate finance issues.

4.9.1 Objectives and enablers

Objectives: Financing climate change mitigation while phasing out funding for fossil fuels

The transition to climate neutrality requires significant changes across the different building blocks of the EU Green Deal. These changes all depend on investments that will have to be made now and every year until at least 2049, so that the EU is able to meet its climate targets (EC, 2019b).

The first objective under climate finance is therefore to close the '*climate investment gap*', which is the gap between the level of climate-friendly investments happening in the EU in a given year, and the investment needs required to achieve a specific EU climate target (e.g. reducing EU territorial net GHG emissions by 55% by 2030, compared to a 1990 baseline). No consistent and yearly analysis of this climate investment gap exists at this stage. As a proxy, we will use data published by the EIB (EIB, 2023).

Selected indicator:

Climate investment gap [bnEUR/year]

The second objective is to phase out climate-hostile finance in the EU. Climate-hostile investment flows refer to investments that are incompatible with the goals of the Paris Agreement to limit global warming to well below 2°C above pre-industrial levels. These investment flows may concern investments in fossil-fuel assets, but also investments in combustion cars, or in sectors with high GHG emissions, such as aviation or coal-powered blast furnaces. However, no information on global climate hostile financial flows are disclosed for the moment at the EU level.

Selected indicator:

Climate hostile financial flows [bnEUR/year]

Enabler 1: Channelling public funds away from fossil fuels and towards climate neutrality

In the EU, public investments account for a significant share of the economy. Public procurement alone represents 14% of the EU gross domestic product (EC, 2017b). Public

Selected indicator:

Public climate subsidies [mEUR/year]

subsidies furthermore crowd-in private finance, by incentivising specific private sector spending choices.

Selected indicator:

Fossil fuel subsidies [mEUR/year]

The enabling role of public funding in the transition to climate neutrality can be described by the yearly amount of '*public climate subsidies*' *vs* '*fossil-fuel subsidies*'. Public climate subsidies enable climate-friendly investments but the data is not available. Public environmental subsidies are disclosed at the EU level but cannot be considered as a good proxy for public climate subsidies as they also focus on other environmental areas such as waste and water and do not include all climate mitigation subsidies. Consequently, no information will be disclosed for this indicator for now.

Enabler 2: Modifying market prices through public intervention

In the EU, different forms of taxation and carbon pricing tools play a significant role in the policy mix. The overall tax-to-GDP ratio in the EU is or around 40% of the EU GDP (Eurostat, 2020c). By choosing where and how those taxes are levied, European public authorities, including the EU, Member States and local authorities, do affect the market price paid by businesses and households. This can be used to increase or decrease the purchase costs of products and services that have a negative impact on the climate.

Selected indicator:

Share of GHG emissions covered by a carbon market price or tax [%]

EU and Member States revenues from environmental taxation [% / total tax revenues]

To assess the extent to which public authorities use this tool to steer the EU economy towards climate neutrality, '*the share of EU GHG emissions covered by an official carbon pricing scheme*' provides insights into how much of the emissions already have a price-tag such as from the EU ETS and national carbon taxes. The '*revenues from environmental taxation*' provides information on energy, transport and pollution and resource taxes in comparison to the total of revenues from taxation. These indicators make it possible to assess the evolution of the regulatory framework in promoting the transition to carbon neutrality.

Enabler 3: Climate alignment of the financial system: Shifting private finance towards climate-friendly financing

In 2015, the Paris Climate Agreement established the objective of making global financial flows consistent with a pathway towards climate-friendly and resilient development (UNFCCC, 2015). In this context, the concept of aligning finance with the Paris Agreement emerged, highlighting the fundamental role of the financial system in meeting climate objectives (Pauthier, 2019). Financial institutions can give more access to cheaper finance for clean investments and transition projects, and progressively give no access to climate-harmful investments.

To assess the level of alignment of the financial system, it is important not only to look at what project or asset the financial institutions are currently financing but rather what strategy they put in place to concretely finance the transition.

Significant efforts have been made to develop the EU taxonomy, a classification system establishing a list of environmentally sustainable economic activities, helping the EU to scale up sustainable investments. However, the EU taxonomy gives no indication of the decarbonisation trajectories required for climate hostile activities and how financial institutions can help them to achieve this. As the EU taxonomy only classify activities that are already 'sustainable", most of EU economy is currently not aligned with it. It seems likely that it won't be for several years, if not decades. In the meantime, financial institutions financing this economy won't be either. This does not mean that the economy is not on a decarbonisation pathway that is compatible with the Paris Agreement. Companies can be aligned with the Paris Agreement, just like the financial institutions that finance them, without necessarily being aligned with the EU taxonomy. Relying only on the EU taxonomy does not enable to differentiate financial institutions that are financing a decarbonisation pathway compatible with the Paris Agreement from those that do not (Institut Louis Bachelier et al., 2020).

Transition plans, however, are ideal tools for this purpose as they are based on a strategic vision of the financial institutions' client transition, sector by sector (I4CE, 2022b). Transition plans for banks and large companies will become progressively mandatory in the EU with the implementation of the Corporate Sustainability Reporting Directive (CSRD) from 2025 (they will have to either publish a sound transition plan or indicate the deadline by which they will be able to do so). The global level of ambition of the standards of such transition plans has been considered relevant by several think tanks (EU Survey, 2022; Europe Jacques Delors, 2022) and NGOs (Finance Watch, 2022; Reclaim Finance, 2022; WWF, 2022a). The Corporate Sustainability Due Diligence Directive (CSDDD), which is still currently under negotiation, will also make transition plans mandatory for companies and regulated institutions, but their perimeter of application for financial institutions remains unclear as it is not certain that it will include

emissions and negative environmental impacts from the final use of the products and services (E3G, 2023).

Selected indicator:

Share of banks weighted by balance sheet that have a sound transition plan [% of banks weighted by their balance sheet]

As banking institutions are prime financers of the European economy – they for instance represent more than 30% of the financing of the euro zone (ECB, 2022) –'*the share of banks with a sound transition plan'* is relevant for assessing the progress of financial system alignment. As it is the largest banks that are most likely to support GHG emitting clients in the transition, this share should be weighted by the size of their balance sheet.

The second indicator used to assess the alignment of the financial system is '*the share of new loans that are aligned to the Paris Climate Agreement*', as it allows to follow the progress of the implementation of these banking transition plans.

Selected indicator:

Share of new banking loans that are aligned with the Paris Climate Agreement [% of loans / year]

4.9.2 Progress towards climate neutrality

Progress towards the objectives: financing climate change mitigation while phasing out fossil fuel fuels

The objective of financing climate change mitigation is currently not on track in the EU. According to the EIB and based on EC calculations, EUR 1 trillion is needed if the EU wants to reduce its net GHG emissions by 55% by 2030. Climate investments have increased in recent years but are still far below what is required. The climate investment gap stands at around EUR 360 billion a year compared to the climate investments made between 2011 and 2020 (EIB, 2023). The EU cannot be serious in its willingness to achieve its climate objectives if the necessary investments for the transition are not undertaken. Consequently, as

Climate investment gap

The EIB estimates a climate investment gap of EUR 360 billion per year. The climate investment gap must be closed immediately. To fill the gap, climate investments must be multiplied by at least 1.5 by 2030. It is then possible to affirm that the progress of this indicator is too slow.

long as the climate investment gap is not completely filled, the EU will not be considered on track in the financing of climate change mitigation. The current state of the data makes it difficult to establish a robust trend assessment, but the size of the climate investment gap (climate investments must be multiplied by at least 1.5 by 2030) makes it possible to affirm that the progress of this indicator is too slow.

Financing climate investments is not enough. The EU must also stop financing climate-hostile investments. For now, there is no EU-wide aggregated data available on EU financial flows that contribute to significant GHG emissions. However, it seems likely that the EU is not on track in the phasing out of climate-hostile investments. In 2022, the IEA estimated that USD 90 billion had been invested in fossil-fuels in the European continent (IEA, 2022e). It is 6% higher than in 2021. Fossil-fuel investments flows have increased overall by 1.3% per year over the last 5 years in this area. However, the data includes the EU as well as the UK, Iceland, Switzerland, Norway, the Balkan countries, Ukraine, Belarus, Turkey and Israel so that it can only provide a very rough estimate for the EU. To assess the EU's evolution of all climate-hostile investment flows, it would be necessary to be able to have data only for the EU and to complement fossil-fuel investments with other investment flows, such as investments in combustion cars, or in sectors with high GHG emissions, such as aviation or coal-powered blast furnaces.

Climate-hostile financial flows

For now, there is no EU-wide aggregated data available on EU financial flows that contribute to significant GHG emissions.

Progress towards enabler 1: Channelling public funds away from fossil fuels and towards climate neutrality

There is currently no official aggregated data at EU level on all climate subsidies. However, some partial data exists, for example on subsidies granted to renewable energies. They have increased overall by 3.0% per year since 2015 with an 8.1% leap in 2020, to reach a total amount of EUR 80 billion granted (Enerdata, 2022). As renewable energies are mainly supported through market-based instruments (feed-in premium, feed-in tariff, etc), the rise of subsidies is mainly influenced by the market environment, such as wholesale price movements, supply interruptions or shifts in demand. Thus, the average subsidy growth rate of 3% per year for the period 2015 to 2020 is lower than the average growth rate for the period 2008 to 2015 which was 7% per year. Various reasons may explain this lower growth rate, such as lower

Public climate subsidies

For now, there is no EU-wide aggregated data on public climate subsidies.

production costs, higher capacity factors for newly installed plants or higher prices on the wholesale market, thus leading to less public financial support (Enerdata, 2022). However, these data are not sufficient to estimate the progress of all subsidies granted by Member States to climate friendly projects, as these are not limited to renewable energies.

The rise of the EU ETS carbon price since 2020 may lead to an increase in climate subsidies as Member States are supposed to spend at least 50% of their auctioning revenues for climate and energy purposes. In 2021, 72% of these revenues would have been spent for these purposes (EEA, 2023e). However, some NGOs and think tanks pointed out that the use of these revenues might in fact be insufficiently tracked (WWF, 2022c) and that some of these revenues might even have been used for support programmes that include fossil-fuel subsidies (Ecologic Institute, 2022). The rise of EU ETS price and the introduction of the EU ETS2 could lead to a rise in climate subsidies but only if these revenues are effectively directed to climate purposes. If not, it would be counterproductive and could lead this indicator in the wrong direction. The EU committed to spend 30% of its 2021-2027 long-term budget and at least 37% of its Recovery and Resilience Facility to fight climate change. As this rate was 20% in its previous long-term budget, this new objective could also lead to a rise in climate subsidies granted by the EU.

No official benchmark exists for public climate subsidies. The European Union, in its Governance Regulation, however support subsidies and support mechanisms for renewable energies to help the development of these energy sources.

In 2020, EUR 46.2 billion were spent on fossil fuel subsidies by EU Member States. This represents approximately 0.42% of total EU GDP. Despite a slight decrease in 2019 and 2020, fossil fuel subsidies granted by EU Member States have increased overall over the last 5 years (+3.5% per year between 2015 and 2020). In 2020, 57% of the EU fossil-fuel subsidies were granted to industries (including the energy and mining industries), 21% to the transport sector, 12% to the agriculture sector, and only 6% directly to households (EC, 2022a). They have further more skyrocketed since the summer of 2021 (Bruegel, 2023a), even if official consolidated data is unavailable at this stage. This increase is mainly driven by subsidies granted to natural gas. Yet, as mentioned in the 8th Environmental Action Programme

Fossil-fuel subsidies

This indicator shows past development in EU Member State fossil-fuel subsidies (EC, 2022a) in comparison to the EU target of phasing-out these type of subsidies by 2025 (8th EAP).

The data show an annual increase of roughly EUR 1.5 billion between 2015 and 2020. To meet the target, fossil fuel subsidies need to decrease by approximatively EUR 9 billion every year between 2021 and 2025. The indicator is therefore going in the wrong direction.

of the EU , all Member States, as well as the EC, are supposed to implement concrete measures, policies and timelines to phase out all direct and indirect fossil fuels subsidies as soon as possible, and by 2025 at the very latest (EP, 2022). To achieve this goal, EU Member States would have to reduce their subsidy levels at a significant annual rate. The EU is therefore going in the wrong direction as it is increasing public fossil fuel spending.

Progress towards enabler 2: Modifying market prices through public intervention

Environmental taxation and carbon pricing can be powerful tools for the EU to reduce its GHG emissions. The share of GHG emissions covered by a carbon price scheme in the EU has gradually declined between 2017 and 2020 before rising again in 2021 to 54% of the EU total emissions (I4CE, 2022a). This increase is mainly due to the launch in 2021 by Germany of its National Emissions Trading System for heating and transport fuels, covering about 38% of Germany's emissions (BMUV, 2020; ICAP, 2022). The EU has no official target for covering its emissions through a carbon price. However, the revision of the EU ETS Directive and the creation of a new ETS2, including road transport and buildings and adopted by the EP and EUCO in April 2023, could significantly increase the EU GHG emissions coverage, up to around 80% (Marcu et al., 2022). As, there is no expert consensus that currently exists on the optimal coverage of EU emissions by a carbon price scheme, it is difficult to conclude on the progress of this indicator. Overall, historical data indicates that the carbon price coverage increased by 2% per year which will further increase with the introduction of a second ETS putting the EU on track in that regard.

Share of GHG emissions covered by a carbon market price or tax

This indicator shows past development in the share of EU GHG emissions that are covered by a carbon price scheme (I4CE, 2022a). No benchmark is available from an official EU source.

The data show a decrease from 47.7% of EU GHG emissions coverage to 43.5% between 2017 and 2020, followed by an increase to a coverage of 53.8% in 2021. No expert consensus currently exists on the optimal coverage of EU emissions by a carbon price scheme but increasing the share puts the EU on track to incentivise emission reductions.

The amount of revenues from environmental taxes represented on average in the EU 5.4% of the total revenues from taxes and social contributions in 2021 (Eurostat, 2023d). This average share hides significant differences between the different Member States, since this share reaches for example 9.5% for Greece and goes down to 4.2% for Germany. In 2015, the share of environmental taxes revenues represented on average 6.0% of the total in the EU. This declined is explained by the fact that environmental tax revenues have grown much more slowly than total Member State revenues in recent years, often because environmental tax levels are not adjusted for inflation. Yet, this share is supposed to increase. The EC, in its 2011 Analysis associated with the Roadmap to a Resource Efficient Europe (EC, 2011), set the objective that each Member States should shift their average share of environmental taxation in public revenues to more than 10% (in line with the best performing Member States in 2011) by 2020. This target has then not been met, not only on average at the EU level, but not for any Member States either. Member States that had reached this target in 2011, such as Bulgaria or the Netherlands, have seen this share fall below 10% over the last decade. This target is still considered relevant, and it is imperative that Member States meet it as soon as possible. For now, this indicator is therefore going in the wrong direction.

EU and Member States revenues from environmental taxation

This indicator shows past development in the revenues from environmental taxation. The share of environment taxes revenues in total taxes revenues stands at 5.4% (Eurostat, 2023d) in comparison to the EU target of reaching 10% share in total taxes revenues in 2020 (EC, 2011).

The data show an annual decrease of 2.3% between 2016 and 2021, while it should almost doble as soon as possible. The indicator is therefore going in the wrong direction.

Progress towards enabler 3: Climate alignment of the financial system: Shifting private finance towards climate-friendly financing

There are currently no available indicators at the EU level that assess the alignment of the financial system in a relevant way. Analysing only what exists in the banks' portfolios does not allow for an assessment of the banks' potential to align with the Paris Agreement. What matters is how they plan to finance the decarbonisation of an economy that is still very carbon intensive. There is then an urgent need for more transparency on how financial institutions are planning to better finance the transition. Sound transition plans are good instruments to do that. They should become mandatory from 2025 for banking institutions and significant companies with the implementation of the CSRD and the CSDDD. There are still major uncertainties about the content of these plans for banking institutions and about the sanctions applied in the event of

non-publication or non-compliance with these plans. The percentage of new banking loans aligned with the Paris Climate Agreement is an indicator that enables to follow the concrete implementation of these plans. Until these plans are disclosed, it will be difficult to assess the EU's progress in aligning its financial system.

Share of banks with a sound transition plan

For now, there is no EU-wide aggregated data on the share of banks that have a sound transition plan. The publication of banking transition plan should become mandatory from 2025 with the implementation of the CSRD and CSDDD at the EU level.

Share of new banking loans aligned with the Paris Agreement

For now, there is no EU-wide aggregated data on the percentage of new banking loans that are aligned with the Paris Climate Agreement.

4.9.3 Conclusions and recommendations

Overall, when it comes to climate finance the EU is moving in the wrong direction. Of the eight climate finance indicators studied in this report, only one has data that suggest that the EU is on track (sectorial carbon pricing coverage, with the creation of an ETS in Germany and the forthcoming extension of the EU ETS coverage), four of them of inconclusive data, two have data that tells us that this indicator is going in the wrong direction (a decrease in environmental taxation, and an increase in fossil fuel subsidies) and one is going too slowly (the climate investment gap).

Closing the climate investment gap through the introduction of an EU-wide climate investment plan and phasing-out climate hostile investments

Although climate investments have increased these last few years, the climate investment gap that needs to be filled is significant. According to the EIB, the EU needs from now on to increase its annual climate investments by EUR 360 billion, which means it has to multiply its current annual climate investments by at least 1.5 to reach its climate objectives by 2030. To meet this

challenge, it is essential that the EU puts in place a sound investment plan as soon as possible. There is no way to bridge such a gap without additional EU investments at scale. Mobilising significant public funds will also help to crowd-in private investments towards climate neutral financing. To better measure climate investment needs to ensure a more efficiency public investment, the EU must immediately start measuring annually the EU climate investment gap, building on existing methodologies such as the one developed by the Institute for Climate Economics (I4CE, 2023).

Financing climate investment needs is not sufficient. It is essential to the EU stops financing climate-hostile investments as well. While there is currently little data on the estimated total amount of climate-unfriendly investments in the EU, there is some evidence that they remain significant and increasing (Bruegel, 2023a).

Strengthening public intervention through taxation and subsidies to redirect financial flows towards a greener economy

Both challenges, closing the climate investment gap and phasing-out fossil fuel investments will require effective and efficient public intervention. To enable the redirection of financial flows from fossil assets to climate neutral ones, the EU and its Member States must strengthen their public policy instruments, including through taxation and subsidies, in this direction. It seems first essential that fossil fuel subsidies are replaced by climate subsidies as soon as possible. If subsidies for renewable energy have increased in recent years for instance, so have fossil-fuel subsidies, and at similar rate. This tendency was aggravated in 2021 and 2022 as most Member States increased fossil fuel subsidies (Bruegel, 2023b) and decreased the rate of taxation on fossil fuel – including VAT in some countries – in the context of the still ongoing energy price crisis and its impact on costs of living (Jacques Delors Institute, 2022). For the EU is to be on track to meet its climate targets, efforts must therefore be made by Member States, particularly in terms of phasing out fossil fuel subsidies. Revenues from environmental taxation are still too low within the different Member States compared to what is expected by the EU. This could change in the future with current price level in the EU ETS, the revision of the EU ETS Directive and the creation of the ETS2, including in particular road transport and buildings even if ETS prices remain volatile in the absence of carbon price floors.

More transparency is urgently needed to evaluate the alignment of the financial system with the Paris agreement

Private financial institutions play a crucial role in helping the financing of EU climate neutrality. However, there are currently no available indicators at the EU level to assess the alignment of

the financial system with the Paris agreement in a relevant way. At EU level, the CSRD and the incoming CSDDD plan to compel financial institutions to publish a transition plan, but uncertainties remain on the content of these plans, their timing of publication, and the sanctions that may prove necessary to ensure a proper implementation of EU law. Until these plans are disclosed, and until their soundness is assured, it will be difficult to assess the EU's progress in aligning its financial system. Numerous efforts have been made to develop the green taxonomy at EU level but in the absence of the development of a taxonomy of climate-harmful activities or activities in transition, it is difficult for financial institutions to accurately monitor their financing of fossil fuel assets.

More transparency is also needed for the public sector as many indicators, that would allow for a meaningful assessment of public sector involvement in financing the transition, miss consistent data. The ongoing national energy and climate plans (NECP) update would thus be an excellent opportunity to improve tracking of public instruments and the EC should have a close eye on such information when checking the draft plans.

Box 12: Highlights from the assessment of Finance

A need to close the climate investment gap

To meet its climate objectives by 2030, the EU economy needs to multiply its annual public and private climate investments by 1.5 compared to those made today. To meet this challenge, it is essential that the EU puts in place a sound and wide investment plan as soon as possible. Mobilising significant public funds will also help to crowd-in private investments towards climate neutral financing. To better measure climate investment needs to ensure a more effective public investment, the EU must immediately start measuring annually the EU climate investment gap, building on existing methodologies such as the one developed by the Institute for Climate Economics.

A need to an effective public intervention towards climate neutrality

To redirect financial flows towards a climate neutral economy, the EU needs effective and efficient public intervention. This requires greater subsidies given to climate-friendly assets, but also, a phasing-out of fossil-fuel subsidies as soon as possible. The EU also needs to strengthen its environmental taxation to disincentivise climate-unfriendly investments.

A need to increase the transparency on the alignment of the financial system with the Paris agreement

Private financial institutions play a crucial role in helping the financing of EU climate neutrality. However, there are currently no available indicators at the EU level that assess the alignment of the financial system with the Paris agreement in a relevant way. At EU level, the CSRD and the incoming CSDDD plan to compel financial institutions to publish a transition plan, but uncertainties remain on the content of these plans, their timing of publication, and the sanctions that may prove necessary to ensure a proper implementation of EU law. Until these plans are disclosed, and until their soundness is assured, it will be difficult to assess the EU's progress in aligning its financial system.

4.10 Just and Inclusive Transition

A Just and Inclusive Transition means that the timely shift towards climate neutral economy will not come at the cost of vulnerable regions and social groups.

Overview

Ensuring social, climate, and energy justice in the transition toward climate neutral economy is an important component of the climate policy of the European Union. We understand Just Transition as a transition toward an environmentally sustainable economy that is well managed and contributes to the goals of decent work for all, social inclusion, and the eradication of poverty (see also ILO, 2013). The current European climate policy framework covers two dimensions of the transition. The first one focuses on local and regional economies and is implemented via the Just Transition Mechanism, specifically in fossil-dependent regions. The second one addresses distributional impacts across society, with a focus on vulnerable citizens. The most prominent element of the EU-wide policy framework in this area is the newly introduced Social Climate Fund, which intends to mitigate energy and mobility poverty. Our analysis in this chapter covers both of these two dimensions, i.e. we consider the situation of regional economies as well as individual European households. It is important to note that this approach omits some of the meanings associated with the concept of Just Transition, such as public perception or framework for justice (Wang & Lo, 2021). It focuses on monitoring the impacts of key types of interventions introduced by the EU policy framework in this area.

We are now at a crucial point in the energy transition. With the submission of the Territorial Just Transition Plans (TJTPs) by the carbon-intensive regions and the start of the implementation process of the Just Transition Fund, the EU is yet too slow to deliver a Just and Inclusive Transition. These measures are only a basis for the sustainable development of carbon-intensive regions in the coming years. Our analysis shows that 2020 has seen a pause in the downward trend for poverty and social exclusion rates for regions in transition and Europe. A return to a decreasing trajectory would require European policies and Member States to respond more effectively to the challenges of the aftermath of the pandemic and the energy crisis. In the past, a substantial part of that support has been delivered as subsidies for households and for energy efficiency purposes. In the years to come, especially the portion of support distributed to households must increase significantly to tackle energy poverty in Europe more structurally. Additionally, the EU must strengthen the enabling framework to accelerate the green jobs

creation, which will help to compensate for the ones lost in the fossil-fuel industry and enable opportunities and growth.

4.10.1 Objectives and enablers

Objectives: No region and no person left behind

The European Just Transition policy works in two complementary ways. First, as a part of the EU Cohesion Policy, just transition has a strong regional and territorial component. Our analysis addresses this component in the first objective: 'No region left behind'. While transitioning away from emission-intensive activities has a significant impact on the European economy as a whole, regions and local communities that currently depend on fossil fuel-based activities, such as coal mining are especially vulnerable. The place-based support for these regions and communities is operationalised via the Just Transition Mechanism, with Just Transition Fund being its core element (EC, 2020g).

A basic set of population-related indicators can be used to monitor the situation in carbon-intensive regions in comparison to other territorial units, which allows a longer-term comparison between regions in transition (e.g., mining regions) and other regions. A suitable indicator is '*regional poverty rate*' (share of the people at risk of poverty and social exclusion in the total population), as it focuses on an important socio-economic outcome (poverty reduction). To account for the impact of broader macroeconomic situation (e.g. all regions typically see increases in poverty during downturns), in addition to the absolute changes of the poverty rate in carbon-intensive regions we also consider its shift relative to European average.

Selected indicator:

Regional poverty rate [% of population; relation to European average]

The second objective is 'No one left behind' which focuses on reducing the risk of poverty and social exclusion. This objective aligns with UN recommendations on enabling SDGs through inclusive and just energy transition (UN, 2021). Multifarious indicators can be applied to measuring poverty and social exclusion risk reduction. This assessment uses the set of indicators used to calculate the material deprivation rate including the ones which are transition related. The indicator '*material deprivation rate*' is thus the average of four sub-

Selected indicator:

Material deprivation rate [% of population]

indicators related to the ability to afford heating, food, bills and mobility.

The benchmark for both indicators is defined based on the European Pillar of Social Rights Action Plan, which establishes the goal of reducing the number of people at risk of poverty and social exclusion by 15 million by 2030, compared to the 2019 level (EC, 2019c). This translates in the annual rate of reduction of 1.6%, which we apply to both indicators included in the objective.

Enabler 1: Creating green jobs

The policies enabling the creation of new, good-quality jobs are an important complement to the process of the reduction and transformation of unsustainable fossil fuel-based industries (ILO, 2018; UNFCCC, 2020). Support for job seekers and people affected by the transition in reorientation and reskilling is an important part of the EU policy on Just Transition (EC, 2020g). Green jobs are decent jobs in traditional or emerging sectors, that contribute to the preservation or restoration of the environment (ILO, 2016). Green Jobs contribute to more environmentally friendly processes in the production or services, but they also produce goods and provide services that benefit the environment. Green jobs are often technology or management-oriented (OECD, 2023). With the support of the Just Transition Fund and further economic diversification, green jobs may not only replace jobs lost in the fossil-fuel industry, but they can also generate long-term growth, especially in the coal mining regions (JRC, 2021). The Social Climate Fund will further contribute to the creation of green jobs via support for labour-intensive activities such as building renovations.

Selected indicator:

Employment in renewable energy supply-chains [full-time jobs equivalent]

For the complementary analysis on this enabler, an ideal set of indicators would show the jobs created by the transition to climate neutrality in all sectors (while leaving out green employment not related to climate action) and the replacement or reskilling rate for jobs in the fossil fuel industry. Since the way of measuring green jobs created by climate action is not unified at this point, and there is no robust EU-level data on reskilling in the fossil fuel industry, we have combined two proxy indicators: '*Employment in all Renewable Energy Sources*', that covers direct and indirect employment in one of the key sectors associated with transition, and a broader indicator '*employment in environmental goods and services*', which shows progress within two groups related to the transition and defined in Eurostat data: CEPA 1 - Protection of ambient air and climate and CReMA 13 -

Selected indicator:

Employment in environmental goods and services [full-time jobs equivalent]

Management of energy resources. Although the scope of these indicators is not ideal, this is the most granular and comprehensive data available in public sources. Measuring employment in environmental goods and services allows for a broader analysis of the changes and opportunities created by the EU Green Deal, the impact of which goes beyond direct climate action.

Enabler 2: Regional Just Transition policies

The Just Transition Fund was established in particular to help regions vulnerable to the negative economic impacts of transition (EC, 2020g). Regional Just Transition policies, such as Territorial Just Transition Plans, were designed to shape and program the energy and climate transition in carbon-intensive regions. TJTPs, submitted by the Member States to the EC are meant to outline the impacts, and establish monitoring indicators, for regions in which the transition implies particularly deep changes (CEE Bankwatch, 2022). Therefore, this second enabler links to the place-based Just Transition policies, which are crucial in the transition process.

There are two stages of implementation of regional transition policies. First, we examine the '*share of accepted*' *Territorial Just Transition Plans* by the EC as it is a prerequisite for receiving funding under the Just Transition Mechanism (EC, 2020g). With the second indicator, '*JTF implementation progress*', we focus on the JTF project pipeline and the pace of financial resources disbursement. Although not available at the present time, data on the disbursement of JTF funds will be available once the Fund moves to the implementation stage this year. For this second enabler, we use as a benchmark the target of allocating 100% of its funds by the end of current JTF operating cycle in 2027. While the selected indicators will not provide information on the quality of the plans and investments beyond the fact that they meet the minimum criteria for the disbursement of funds, they will serve as a useful proxy for the effectiveness of the Just Transition Mechanism governance and capacity of the regions to utilise the available funding. This information may be later complemented by insights from separate, in-depth evaluation of JTF planning and spending.

Selected indicator

Share of accepted Territorial Just Transition Plans [% of submitted plans]

JTF implementation progress [funds allocated as a % of total available funds]

Enabler 3: Targeted support to vulnerable groups

The reduction of energy poverty and transport-related exclusion is crucial for the accomplishing of a Just Transition toward climate neutrality (CoM, 2022; EC, 2021k; Gouveia et al., 2022; Schwanen, 2021). With the establishment of the 'Fit for 55' legislative package and the revision

of the EU ETS, the EC proposed the Social Climate Fund, which aims to support the most vulnerable groups that will be affected by the transition in the buildings and transport sector. The Social Climate Fund will be launched in 2026, with each Member State required to present by mid-2025 a Social Climate Plan describing the initial state of play and measures to be financed through the Social Climate Fund by mid-2025.The future submission of Social Climate Plans by the Member States and updates of the methodology of the Energy Subsidies Reports may allow to track the '*Social Climate Fund's targeted support distributed to low-income households*'.

Selected indicator:

Share of support for households [%]

Share of support for energy efficiency [%]

At the present stage, the used proxy indicator is '*share of support for households*' and '*share of support for energy efficiency*', which is presented in the annual Subsidies Reports prepared by the EC. These proxy indicators most closely reflect the type of support that will be later provided by the SCF: the first indicator shows the share of public support that directly benefits EU citizens, while the second shows what part of subsidies is distributed to provide energy efficiency.

4.10.2 Progress towards climate neutrality

Progress towards the objectives

For the first objective, our findings might be influenced by the data gaps on poverty and social exclusion on regional level. Out of 39 EU carbon-intensive regions selected based on the OECD report (OECD, 2023), the data were available only for 25 of them (Eurostat, 2023j). Between 2017 and 2022, the carbon-intensive regions covered by the analysis had around 20% lower 'People at risk of poverty and social exclusion' rate compared to the EU average.

Regional poverty rate

This indicator shows past development in the 'At risk of poverty and social exclusion' rate in 25 carbon-intensive regions (Eurostat, 2023j, 2023k; OECD, 2023). The benchmark for this objective is set by European Pillar of Social Rights Action Plan (EC, 2019c).

The data show that the share of Europeans living in carbon-intensive regions who are at risk of poverty and social exclusion saw an annual decrease of 0.24%-points between 2017 and 2022. Past change was slightly too slow requiring at least 0.29%-points per year to deliver required reduction of poverty and social exclusion by 2030.

Material deprivation rate

This indicator shows past development in the four selected sub-indicators in the 'Material deprivation' rate (Eurostat, 2023f, 2023h, 2023a, 2023g). The benchmark for this objective is set by European Pillar of Social Rights Action Plan (EC, 2019c).

The data show an average annual decrease of 0.5%-points between 2016 and 2021 which can slightly slow down to 0.25%-points still meeting the target. This means that the indicator is on track to deliver on poverty and social exclusion reduction.

For the selected types of material deprivation which may be affected by the climate transition we found that the number of Europeans who are unable to afford sufficient heating, nutritious food, mobility and to pay their utility bills on time declined gradually for the last decade in the EU as a whole (Eurostat, 2023f, 2023h, 2023a, 2023g), with the exception of 2020. This coincided with the period of economic growth picking up after the years of turbulence following the Great Recession of 2007-2009 and European debt crisis. Between 2016 and 2021, the average rate for the assessed indicators of material deprivation decreased on average by 0.5%-points which is on track towards the target set by European Pillar of Social Rights Action Plan. Importantly, the data included in the analysis may not yet fully represent the impact of recent economic shocks (COVID-19 pandemics, fossil fuel supply crisis). As the transition to climate neutrality will need to accelerate in the next few years and the impact of current shocks subsides, the dynamics of both headline indicators will be increasingly affected by the ability of public policies to support most vulnerable regions and households in adjusting to the climate neutral economy and implementing required investments.

Progress towards enabler 1: Creating green jobs

For the groups of economic activities covered by our assessment (protection of ambient air and climate, management of energy resources), we see a steady 3.7% increase in the employment for the period 2015 and 2020. However, the dynamics of change are different in the two subgroups. For the jobs related to the protection of ambient air and climate, since a sudden decline in 2016, followed by another one in 2017 there is a persistent increase in employment that goes until 2020. Reaching back to pre-2015 data shows that the decline was preceded by a slowdown in production and a decline in employment in the sector. A much more numerous group of jobs related to the management of energy has seen a steady growth over the same time period, driving the overall performance of the indicator (Eurostat, 2023c, 2023l).

Employment in environmental goods and services

This indicator shows past development in the employment in environmental goods and services in two subcategories – CEPA 1 and CreMA 13 (Eurostat, 2023c). No benchmark is available from an official EU source.

The data show an annual increase of 3.7% between 2015 and 2020. This development was heading in the right direction but was too slow.

Employment in renewable energy supply-chains

This indicator shows past development in the direct and indirect employment in all Renewable Energy Sources sector (EurObserv'ER, 2020, 2022a). No benchmark is available from an official EU source.

The data show an annual increase of 1.3% between 2016 and 2021. This development was heading in the right direction, but far too slow.

Direct and indirect employment in the renewable energy sector also increased gradually after a drop in 2019 reaching an average annual increase of 1.3% between 2016 and 2021. As presented by the EurObserv'ER indicator for equivalent replaced fossil employment (EurObserv'ER, 2022), this increase will play an important part in reducing negative transition effects, as the new opportunities and employment possibilities will be complementary to those lost in the fossil fuel industry – especially in countries such as Germany, Romania and Poland. In terms of job deployment, in 2021 the industry that employed the most workforce was heat pumps (26% of all EU RES employment), which also remained the top industry in terms of the turnover, followed by solid biomass (24% of all EU RES employment) and PV (16% of all EU RES employment). In 2021, increase in RES employment was accompanied by a 13% increase in economic activity in RES sector (EurObserv'ER, 2022).

Progress towards enabler 2: Regional Just Transition policies

We are in the initial stage of implementing Just Transition policies in the European Union. For the past two years, regional and national governments have worked on developing TJTPs (Enabler 2., '*share of Territorial Just Transition Plans accepted*') which will guide the implementation of the Just Transition Fund, the key EU instrument for financing the economic restructuring of carbon-intensive regions in 2020s. The next few years will be crucial, as the financial resources will need to be efficiently allocated to the projects on the ground until 2027 (Enabler 2., '*JTF implementation progress*').

So far, 67 TJTPs covering 93 regions have been accepted by the EC, with only three regions in Bulgaria still waiting for their policy-makers to review their proposed Plans and submit the final version to the EC. These regions' failure to deliver revised plans earlier resulted in their lack of access to funding in 2022 (CEE Bankwatch, 2023). Nevertheless, with almost all regions having finalised their plans, the preparatory phase of the JTF implementation is almost over. The first events launching the fund have already started in member states (EC, 2023k). In its final shape, the JTF focuses mainly on supporting SMEs (EUR 5.4bn EUR), reskilling and employment (EUR 3.1bn), clean energy (EUR 2.9bn), innovation and research (EUR 1.9bn), land regeneration (EUR 1.6bn), circular economy (EUR 0.7 bn) and investing in large enterprises (EUR 576.1mln) (EC, 2023m, 2023n). These priorities are in line with the goal of diversifying the economy and making it less dependent on fossil industry. To enable rapid deployment of the financial resources by the Member States, 70% of resources will be allocated within first two annual tranches of the operational programs (EC, 2023n). We will closely monitor the implementation process of

Share of accepted Territorial Just Transition Plans

This indicator shows how many TJTPs were accepted by the EC, framing the Just Transition financing in regions (EC, 2023m).

The data show in 2023, ~96% TJTPs were accepted by May 2023, with only three Bulgarian regions waiting for the final submission of their plans. Although the process should already be completed, it is now rated as on track with TJTPs delivery with the assumption that it will be finished this year at the latest.

JTF progress implementation

This indicator shows the pipeline of the JTF (EC, 2023m). The benchmark for this indicator will be 100% funds allocated by 2027 (end of the 2021-2027 multiannual financial framework).

We expect JTF implementation data to be available in the future (as it is with the previous multi-year financial framework data) and provided by the European Cohesion Open Data platform.

the Fund in the following years, when the European funding should be progressively disbursed to the regions in transition.

Progress towards enabler 3: Targeted support to vulnerable groups

The smooth JTF implementation and successful launch of the SCF in 2026 could prevent the increase of poverty, social exclusion and material deprivation among vulnerable households and regions. Since the direct support through the fund can be measured only after its implementation (Enabler 3. '*Social Climate Fund's targeted support distributed to low-income households*'), for now, we analysed the extent to which in the past years energy subsidies benefited households, especially in terms of support for energy efficiency purposes. We found that since 2015 (previous EC reports show, that this trend dates back to 2008) energy subsidies for households and energy efficiency purposes increased, which is advisable in terms of energy poverty reduction. However, this occurred at varying pace: while the support for energy efficiency purposes across the economy increased noticeably (over 3% per year on average), the growth of the support distributed directly to households (including for energy efficiency improvements) grew two times slower.

Share of support for households

This indicator shows past development in the share of EU energy subsidies distributed to households and serves as a proxy indicator, which will be replaced by SCF distribution reporting once available (EC, 2022a). No benchmark is available from an official EU source.

The data show an annual increase of 1.2% between 2016 and 2021. This development was heading in the right direction but far too slow and insufficient to deliver on energy poverty reduction.

Share of support for energy efficiency purposes

This indicator shows past development in the share of EU energy subsidies distributed for energy efficiency purposes and serves as a proxy indicator, which will be replaced by SCF distribution reporting once available (EC, 2022a). No benchmark is available from an official EU source.

The data show an annual increase of 3.5% between 2016 and 2021, making this change too slow.

4.10.3 Conclusions and recommendations

Uneven progress during less turbulent times provides a warning for the coming years: more should be done to ensure just and inclusive outcomes in the period of multi-crisis and accelerating transition

While both headline indicators measuring Just and Inclusive Transition have improved in the recent years, the progress was too slow for the 'no region left behind" objective. What is more concerning is that the indicator assessment covers mostly period of the relatively supportive macroeconomic conditions (including the period of relatively high economic growth coming after prolonged slowdown in the first half of 2010s), with full impacts of COVID-19 crisis and fossil fuel price shock not fully visible in the data yet. Furthermore, as transition accelerates, it will put more pressure on the carbon-intensive regions and vulnerable households to adapt. Therefore, past performance should not result in policy-makers' complacency, with next few years providing a true test for the effectiveness of just transition policies in Europe.

From plans to implementation: ongoing capacity building and coordination with the EU-wide policies needed to ensure that carbon-intensive regions will utilise resources available from JTF

With nearly all the regions covered by the JTF having their Just Transition Territorial Plans approved, the EU is moving towards implementation stage. Given much more dynamic economic and regulatory environment than only a few years ago, it is crucial to ensure that the projects supported via JTF are well-prepared and consistent with the new climate and energy targets. The EU institutions and Member States should ensure that the regional authorities and stakeholders are provided with appropriate technical support to develop, assess and implement new projects, taking into account recent developments such as plans to accelerate the exit from imported fossil fuels and strengthen the EU green industrial capacity.

No time to waste: preparing robust Social Climate Plans and adjusting existing support schemes to provide affordable energy and mobility options for vulnerable households

Increase in the share of energy subsidies going towards households and energy efficiency investment in the recent years signals a gradual shift which is in line with the type of interventions require to mitigate potential negative distributive impacts of the transition. With the recently approved Social Climate Fund providing additional source of financing investments

in sustainable energy and mobility solutions for vulnerable households starting from 2026, the responsibility now lies on the Member States to prepare ambitious Social Climate Plans which will guide the use of the Fund. Furthermore, as the fossil fuel crisis continues, until the SCF becomes available, the Member States should strengthen existing measures protecting the vulnerable households by directing more funds to permanent solutions (e.g. deep renovations).

Capturing the full potential of green jobs: more focus needed on providing stable growth in demand for green solutions and skills investment to improve matching between workers and job opportunities

While the number of jobs related to protection of climate and energy transition has gradually increased in the recent years, more can be done to ensure that this trend will accelerate in the future and deliver stable employment. Uneven dynamics of the employment in the RES supply chain illustrates the point: boom-and-bust cycles of green investments may not only put a strain on the supply chains, but also result in the unpredictable waves of jobs creation and loss. This, in turn, discourages long-term investments in skills, contributing to the problem of mismatch between the green job requirements and workers' experiences. Policy framework which put an emphasis on predictable scale-up of clean technologies paired with support for investment in the workers' skills should help Europe realise the full potential of the transition for its labour market.

Box 13: Highlights from the assessment of Just and Inclusive Transition

Green jobs on the rise again

After stagnation in the middle of the last decade, green jobs are slowly picking up on the EU27 level. The potential for replacing fossil fuel industry jobs by green jobs is high especially in countries such as Germany, Poland and Romania. This process is strongly affected by the regulatory framework in particular Member States, as well as market driven industry development.

Just Transition Fund is moving to the implementation phase

With almost all TJTPs accepted, the programming of JTF is almost over. In the next four years funds for carbon intensive region will be distributed to support specific projects. Together with the SCF launch in 2026, these resources are key to enable sustainable development of regions and help social groups affected by the transition. Moving forward an efficient and timely distribution is of essence to avoid adverse impact.

The impacts of COVID19 pandemic and energy crisis have not yet fully materialised in available data

Although measured indicators on poverty and social exclusion decreased again in 2021, with the inflow of the 2022 data it will become clear if the trend prevailed. This will set the scene for managing the impacts of the accelerated transition to climate neutrality in the coming years.

Box 14: National-level insights for Just and Inclusive Transition

Bulgaria still delayed on TJTPs

Bulgaria remains the only Member State that has not submitted the revised version of TJTPs. This delay cost the country a EUR 100 million loss of resources from JTF allocated in 2022 (CEE Bankwatch, 2023).

Germany, Romania and Poland with largest capacity to replace fossil fuel jobs

According to EurObserv'ER estimations, Germany, Romania and Poland has currently the biggest capacity to replace fossil fuel jobs by employment in renewable energy sources sector (EurObserv'ER, 2022).

Latvia pioneering energy efficiency subsidies

Latvia is pioneering the subsidization of energy efficiency, allocating as much as 2% of its GDP for this purpose in 2020. This amount accounts for two-thirds of the total subsidies distributed in Latvia that year (EC, 2022a).

4.11 Governance

Governance refers to the tools used by governments to align short-term actions with a climate neutral future, ensure a sound evidence-base for decisions, coordinate across sectors, enhance transparency and accountability, and foster public and political buy-in.

Overview

Achieving climate neutrality by 2050 at the latest is an unprecedented project for EU policy-makers in both its scope and depth. Immense foresight is required to make far-reaching and complex decisions for the future in an increasingly tight timeframe. Moreover, the transformation will impact all corners of European society and economy and can only be successful with buy-in from a broad coalition of stakeholders, politicians, and citizens (Jordan et al., 2022). Therefore, a dedicated building block on governing the transition is essential for any assessment of EU progress towards climate neutrality.

Governance pertains to the 'institutional machinery' and tools put in place by governments to manage these challenges (Bali et al., 2021; Dubash et al., 2021). An effective EU system must deliver several key functions (Duwe et al., 2017; Rüdinger et al., 2018). First among these is a credible signal for where the EU is headed. This should be complemented by procedures to ensure the alignment of short-term actions with long-term goals through regular policy learning cycles. The system must also coordinate key responsibilities across sectoral competencies within the EU and among its Member States and provide a sound evidence base for policy decisions. Finally, to enhance transparency and the legitimacy of public action, EU governments must provide meaningful channels for stakeholder and public participation in all stages of policy-making.

EU governments have made significant progress establishing governance systems that are designed to tackle climate neutrality. The Governance Regulation adopted in 2018 provides common 'minimum governance standards' for Member States, and the EU Climate Law from 2021 enshrines a framework for target-setting and monitoring progress at EU level (Evans & Duwe, 2021). The following analysis shows that the governance building block is largely on track. Still, there is substantial room for improvement.

The proliferation of overarching frameworks for climate policy-making (a key objective) is trending in the right direction at national level, but a closer look at the underlying components uncovers critical deficiencies in 2050 planning and monitoring processes. Innovative institutions

like independent climate councils and citizens' climate assemblies provide avenues for expert and citizen input, respectively, but these are not always positioned to fulfil their potential for policy impact. Awareness of the climate crisis and citizen support for an ambitious governmental response is high, but public confidence in the adequacy of national climate actions is lacking. And the adequacy of public involvement could not be measured properly: data on the quality of consultations on EU policy impact assessments does not provide sufficient information on their quality for climate policy relevant legislation. Moving forward these consultations will be relevant across all policy areas, as the EU Climate Law emphasises consistency with the climate neutrality goal as a requirement for all new policies. Transparency on the effectiveness of existing participatory processes at EU level is important to be able to fully measure progress on this building block. A negative indicator result could change the overall positive picture.

4.11.1 Objectives and enablers

Objectives: Putting in place a comprehensive operational framework and fostering stable political and societal buy-in

Foundational to an EU governance system fit for climate neutrality is a comprehensive framework that enshrines a credible signal for the direction and destination of change and establishes structures (or re-organises existing ones) to get there. The existing EU climate governance architecture is based on a series of laws and policies directed at both EU and national actors, but gaps remain. At European level, the quality or added-value of new institutions and processes under the EU Climate Law remains to be seen (Duwe, 2022; Duwe & Spasova, 2021). At national level, EU law requires Member States to adopt minimum planning and monitoring tools as well as multi-level climate and energy dialogues (as outlined in the 2018 Governance Regulation). However, the national landscape is uneven, with some countries displaying more robust institutions and embedded processes than others, not to mention differences in implementation (Evans & Duwe, 2021).

Selected indicator:

Share of EU GHG emissions that falls under a comprehensive climate framework law at the national level [%]

Note: 'Comprehensive' is operationalised as: law must include a long-term (i.e., post-2030 time horizon), quantitative, economy-wide reduction target and a short- and/or long-term national policy planning cycle (Averchenkova and Bassi, 2016; World Bank, 2020)

Selected indicator:

Share of EU citizens that supports and has confidence in the transition to climate neutrality [%];

Sub-indicator: Share of public that ranks climate change as a 'very serious problem' facing the world [%];

Sub-indicator (pre-2019): Share of public that 'agrees' or 'totally agrees' that fighting climate change is good for EU economy [%];

Sub-indicator (post-2019): Share of public that 'agrees' or 'totally agrees' with EU climate neutrality target [%]

Note: composite indicator is an average across the three survey questions

With the mammoth share of policy effort falling to Member States, robust national frameworks are essential to achieving climate neutrality (CAN Europe, 2022). Increasingly, national governments have pursued dedicated legislation, in the form of *climate framework laws*. Although these vary significantly in their substance and thus their ability to provide an operational framework and mainstream climate across policy fields, such laws are impactful because they consolidate and align political priorities, have staying power beyond election cycles, and can provide a strong credible message to actors in both the public and private spheres (Averchenkova et al., 2020; Duwe & Evans, 2020; Nash & Steurer, 2019; Iacobuta et al., 2018; Lockwood, 2021). A strong overarching national framework can also serve to align local and municipal planning and implementation. Therefore, the *'share of EU emissions covered by comprehensive national climate laws'* is a strong measure of national ownership and preparedness for a transition to climate neutrality in the EU.

The transition to a climate neutral future depends on broad political and societal support and ownership. Actions to reduce emissions must be retained and revamped across electoral cycles to provide certainty and predictability to businesses and citizens. Recent history underlines the importance of confidence and buy-in from European citizens. Germany's energy transition saw early successes in large part due to citizen-led, small-scale renewable energy deployment in the 2000s, but recent political debate over the government's ambitious plans to phase out fossil fuels in home heating systems has revealed limits to public acceptance, especially when the cost to consumers is high (Hockenos, 2023; Morris & Jungjohann, 2016). The latest developments in Germany echo the 2018 'yellow vest' protests in France, which were motivated by energy price concerns, underscored the need for equitable climate solutions (see also section 4.10) and led to policy changes and a rethink on national participatory processes (IDDRI, 2018). In contrast, the Fridays For Future youth movement is widely credited for placing climate front and centre in European political discourse in the lead up to the 2019 EP elections (Deutsche Welle, 2019; Marquardt, 2020).

The biennial Eurobarometer survey on climate change provides reliable and representative data from a sample of European society. Among other things, it asks EU citizens to state their opinion on (1) the perceived seriousness of the climate crisis and (2) EU climate policy and, since 2019, the 2050 climate neutrality goal. A composite indicator derived from responses to these questions can provide a sense of *'public support for and confidence in the transition to climate neutrality'* in any given year.

Enabler 1: Integrated learning cycle for planning, policy-making, and progress monitoring

An integrated policy learning cycle helps to ensure that actions are consistent with long-term climate targets. A learning cycle forms around policy planning and agenda setting, policy implementation in the form of programmes and packages of measures, and policy review/revision based on information from monitoring (Howlett et al., 2020).

Planning tools, especially with a long-term time horizon, serve as informative back casting exercises to elaborate pathways to reach climate neutrality (Duwe et al., 2017). Under the Paris Agreement all parties are invited to communicate 'long-term low GHG emission development strategies', and the EU Governance Regulation obliges Member States to draw up aligned short-term plans (NECPs) and national strategies with a 30-year time horizon (LTS) every five and ten years, respectively. Actionable strategies incorporate inter alia milestones and decision points, sectoral pathways, and policy impact modelling and thus provide a blueprint for guiding near-term government actions (Ross et al., 2021). The *'share of EU Member States (plus EU) with an up-to-date and compliant long-term strategy (LTS)'* is therefore a good indication of the strength of 2050 planning processes across the EU.

Selected indicator:

Share of EU Member States (plus EU) with an up-to-date and compliant long-term strategy (LTS) [%]

Note: 'Up to date and compliant' is operationalised as a strategy that is no older than five years (i.e., based on date of submission), fulfils at least the minimum content requirements of the Governance Regulation, and mentions climate neutrality or net zero GHG emissions in a national context.

Selected indicator:

Share of GHG emissions covered by a governance system with national progress monitoring that can trigger additional governmental action [%]

Regular progress monitoring is critical to ensure that actions provide the necessary GHG emission reductions. Ideally, the methods used track progress in the real world, with adequate

detail and scope. Accountability can be further strengthened when monitoring is coupled with an 'action trigger' mechanism that requires the refinement of existing policies or additional measures in the case of insufficient progress. This effectively 'closes' the loop of the policy learning cycle and is investigated here with the *'share of GHG emissions covered by a governance system with national progress monitoring that can trigger additional governmental action'*. Importantly, a national mechanism for progress monitoring is *in addition* to EU reporting obligations and the review and revision of planning tools to account for new evidence and economic developments.

Enabler 2: Robust institutional arrangements to ensure a coherent approach to the climate neutrality transition

Robust governance institutions are associated with higher climate policy ambition and positive policy outcomes (Guy et al., 2023). Institutional arrangements encompass a wide range of governance mechanisms, including inter-ministerial coordinating bodies, expert advisory councils, as well as framework laws and organising principles. Because of the technical, far-reaching, and complex nature of the climate crisis and its solutions, scientific climate councils, in particular, have become a critical ingredient strong governance (Averchenkova et al., 2018; Weaver et al., 2019). Established 'by government, for government', climate councils are often independent and serve several roles, such as expert advisors for policy formulation and watchdogs to monitor and point out weaknesses in governmental action (Evans & Duwe, 2021). The first indicator *'share of EU Member States (plus EU) with a permanent independent scientific advisory body for climate policy'* tracks the uptake of expert councils across EU governments, with the important qualifier of a *legal requirement* for government to consult at some point in policy formulation or review.

Selected indicator:

Share of EU Member States (plus EU) with a permanent independent scientific advisory body for climate

Note: there must be a legal requirement for government to consult and/or respond at some point in policy formulation or review.

Selected indicator:

Share of EU Member States (plus EU) that shows evidence for a coherent all-of-government approach [%]

Climate policy-making is a complex organisational challenge, spread across ministries and agencies, each responsible for a different sector of the economy, and often with competing priorities. Climate policy integration across policy areas is thus needed to ensure a cohesive, all-of-economy approach to tackle the scope of the crisis (Tosun & Lang, 2017). Such

mainstreaming of climate concerns can be furthered in many ways, including dedicated coordinating bodies, processes that link climate decisions to government spending legislation, or setting sectoral emission budgets and targets. It is monitored here with the *'share of EU Member States (plus EU) that shows evidence for a coherent all-of-government approach.'*

Note: A further indicator related to the integration of climate into EU foreign policy and institutions is included in section 4.13.

Enabler 3: Frequent, early, and effective participation processes to improve policy decisions

Selected indicator:

Share of EU Member States (plus EU) governments that has commissioned a country-wide citizens' assembly on climate [%]

Note: Climate assemblies are weighted along two criteria: (1) budget provided and (2) governmental response to operationalise 'governmental attention and investment'.

Inclusive processes that allow for early, frequent, deliberative, and effective participation can strengthen policy-making and promote buy-in to the climate neutrality objective (Finnegan, 2022). These can range from one-off public consultations to more institutionalised formats, such as dedicated citizens' or stakeholder engagement platforms, including citizens assemblies. Since 2018, Member States are required to pursue 'multilevel climate and energy dialogues' and must set reasonable timeframes to facilitate 'early and effective' opportunities for public consultation in the preparation of climate plans and strategies (Governance Regulation, Art. 10 and 11). However, as information is scarce on the frequency, inclusivity, and effectiveness of existing processes, we have applied the *'share of EU Member States (plus EU) governments that have convened a country-wide (or EU-wide) citizens' assembly on climate'* as a proxy indicator. Climate assemblies are becoming more and more common with approximately 150 documented cases across Europe, albeit many of these are sub-national. Given their high public visibility and involvement of ordinary citizens, climate assemblies can be a particularly impactful approach to implementing the Governance Regulation requirement for Member States to pursue multi-level climate and energy dialogues. They allow a range of voices and interests to be heard and are a sign that European governments realise the central importance of participation to engender buy-in to policies for climate neutrality. However, to date, assemblies tend to be single occurrences and vary in their participation, length, and degree of governmental response (KNOCA, 2023).

Selected indicator:

Quality of public and stakeholder consultations on EU climate policy impact assessments [Index 1-4]

The effectiveness of public consultation on policy-making at EU level is evaluated annually by the Regulatory Scrutiny Board within the context of its reporting on the implementation of EU Better Regulation. One specific component of the report looks at *'quality of public and stakeholder consultations on EU policy impact assessments'*. Insights from this exercise could in theory serve as a suitable indicator for the effectiveness of existing participatory processes at EU level. However, the form in which information is presented makes external analysis challenging. For one, the information is qualitative and secondly there is often no breakout for climate policy specifically. The underlying data is not accessible to the public. While the Regulatory Scrutiny Board also issues opinions on individual impact statements from the EC, there is no quantitative measure for the consultation evaluations or summary of the opinions for climate policy.

4.11.2 Progress towards climate neutrality

Progress towards the objectives

A strong governance system for climate neutrality must establish an operational framework for policy-making and foster public and stakeholder buy-in to the transition. Between 2017 and 2022, EU Member State governments made substantial progress in establishing comprehensive frameworks for long-term climate policy-making. In this period, the share of EU GHG emissions[8] that fell under a comprehensive climate framework law at the national level rose by 37% annually, from 14% to 59%. In 2022, ten EU countries had a qualifying law in place. Another five countries had a law, but these were missing either a post-2030 time horizon or adequate details on planning to qualify under our assessment. This landscape is dynamic as new laws are adopted and existing laws revised to account for international, EU, and national developments. At the time of writing, an additional five EU laws were currently being drafted or considered in Estonia, Italy, Latvia, Slovakia, and Slovenia, and at least three laws were undergoing revision – in Austria, Bulgaria, and Liechtenstein. Importantly, the sharp increase in the share of emissions covered by a law in 2019 can be explained by adoption of the German law. Germany alone

[8] To isolate year-to-year variation associated with the adoption of climate framework laws, emissions shares are calculated from 2015 data and remain static over the period.

accounts for approximately a quarter of EU emissions. More recently, the trend has plateaued as lower-emitting countries like Portugal and Ireland have adopted (or in latter case of revised) laws.

The speed at which climate framework laws have taken hold in the EU is a promising development and, while there is room for improvement on existing laws, EU governments are currently on track to ensure an operational and comprehensive overarching framework for climate policy-making. The EU Climate Law from 2021 and its upcoming review in 2024 is further support for this assessment. However, aside from voluntary sectoral roadmaps, the EU law does not include planning cycles for the Union as a whole and thus would fail to qualify as comprehensive under this assessment (Duwe et al., 2022).

Climate framework laws often incorporate many of the features of climate governance systems investigated by the indicators in this section, including long-term planning, national progress monitoring, scientific advice, and participation (Duwe & Evans, 2020). However, while these governance mechanisms can exist outside of a law, framework laws often serve to consolidate and organise national climate action across decades and thus political cycles, lending credibility to governmental action (Lockwood, 2021). As legislative instruments, the process of adopting and revising laws often frames the national public discourse and can serve as a powerful means to furthering the second key objective of EU climate governance: fostering stable support and confidence in the transition to climate neutrality.

The other objective chosen for this building block is support by citizens. Climate change has long been a key issue of concern for Europeans. Between the years 2011 and 2021, the share of citizens that support the EU climate action rose from 73% to 84%, a 2% annual growth rate. The steady but slow growth rate is due in large part to a ceiling effect – i.e., public support cannot be much higher – and is therefore on track. In 2021, 78% of Eurobarometer survey participants ranked as a 'very serious problem' for the world, and an overwhelming majority, 90%, supported the climate neutrality target. Although left out of the indicator analysis due to the lack of historical data, the latest survey in 2021 further includes a question on confidence in national climate action. Across the EU, only 19% of responders thought that their government was 'doing enough on climate'. However, among those participants who also viewed climate change as a 'very serious problem', this figure was only 13%. These data paint a less promising picture of EU citizens' confidence in national responses to the climate crisis. Thus, while there is evidence for stable public *support* for the EU's climate neutrality project, *confidence* in governmental action is lacking.

Taking a closer look at development of the first sub-indicator question over time – between 2011 and 2015, 68 to 69% of Europeans considered climate change a 'very serious problem'. This was

followed by 10%-point increase from 2015 to 2019. It is somewhat surprising that concern was not higher in the lead up to the highly anticipated adoption of the Paris Agreement in December 2015. Still, these data may point to a delayed 'Paris effect' (see, e.g., Tingley and Tomz, 2020) on public opinion that is also reflected in the increasing number of multi-lateral discussions, reports, and negotiations framed around the 1.5 degree target. The trend also coincides with the international spread of the Fridays For Future youth movement originating in Europe.

Notably, the largest jump in the composite indicator occurred between the 2017 and 2019 surveys, raising 9%-points from 77% to 86%. This is caused by changes to how the underlying survey questions are formulated. For surveys 2011–2017, we assess responses to a question on whether climate policy was good for the European economy. The share of public that 'agreed' or 'totally agreed' that fighting climate change was good for EU economy peaked at 90% in 2013 but dropped to 79% in 2017. However, since 2019 this question has been replaced with a set of related questions, including general support for the climate neutrality target in 2019. Support for the climate neutrality target has remained stable starting at 92% in 2019. Although further investigation is needed, the variation in responses suggests that some Europeans support the ends but not always the means of EU climate action.

Share of EU GHG emissions that falls under a comprehensive climate framework law at the national level

This indicator shows past development in the share of EU GHG emissions that are covered by a comprehensive national climate framework law (own research; Ecologic Institute, 2023; EEA, 2023b; Grantham Research Institute, 2023). No benchmark is available from an official EU source.

The data show an annual increase of 37% between 2017 and 2022. This development, while recent, puts the EU on track to ensuring an operational and comprehensive framework for tackling challenges and making the right decisions *en route* to climate neutrality.

Share of EU citizens that supports and has confidence in the transition to climate neutrality

This indicator shows past development in the share of EU citizens that supports and has confidence in the transition to climate neutrality (Eurobarometer, 2011, 2014, 2015, 2017, 2019, 2021). No benchmark is available from an official EU source.

The data show an annual increase of 2% between 2011 and 2021. This development, while seeming slow, reflects stable public support for the climate neutrality transition (84% in 2021) and is thus on track. However, 2021 data omitted from the analysis show a lack of public confidence in governmental response, which lessens the otherwise positive outlook.

Progress towards Enabler 1: Integrated learning cycle for planning, policy-making, and progress monitoring

Despite the positive trend towards operational climate policy frameworks, the data show that long-term strategic planning – a crucial component thereof – may not be given sufficient attention. In 2021, half (50%) of EU Member States (plus the EU itself) had in place an up-to-date and compliant LTS that accounted for climate neutrality in a national context. This is up from 2019 when only four such strategies existed. Keeping in mind that EU law required Member States to submit their strategies by January 2020, such rapid development (67% annually over the period 2017–2022) in long-term planning should not come as a surprise.

However, non-compliance and delayed submissions underscore governance weaknesses. Eleven strategies were discounted in the analysis for failing to comply fully with the content requirements set by EU law, and of these, the Czech and German strategies 'lapsed' in 2021 and 2020, respectively. Three countries have yet to produce a strategy at all (Ireland, Poland, and Romania). The EU LTS dating from 2018 only barely qualifies as 'up-to-date' under the five-year cut-off – albeit much of the underlying modelling has been updated since (e.g., in the impact assessment of the Climate Target Plan). These findings are especially concerning because the current Governance Regulation mandatory content guidelines for LTSs are already weak (Duwe, 2022; Oberthür et al., 2023). For instance, there is no provision that requires quantitative post-2030 figures for reductions or removals – two crucial components of an actionable vision for a net zero future.

The upshot? While progress at a national level is commendable, EU governments are nonetheless too slow on meaningful long-term planning for climate neutrality. It is important to point out that many LTS submissions pre-date the 2021 EU Climate Law provision that ensures national strategies are 'consistent with the Union's climate neutrality objective'. Moving forward it is unclear how Member States will operationalise 'consistency' to remain compliant short of setting a net zero date. Overall, although a long-term planning cycle has been set in motion by minimum governance standards imposed by regulation, it seems to be under-utilised and under-emphasised in the EU (see also Velten et al., 2022).

If long-term strategies should draw a path towards climate neutrality, progress monitoring ensures that governments do not stray too far from it. EU law requires Member States to report annual emission inventories and every two years on progress towards their NECPs, detailing specific policies and measures (PaMs). Yet, some countries have adopted mechanisms that go beyond these basic reporting commitments. In the period, 2016 to 2021 the share of EU GHG emissions covered by a national monitoring system with an 'action trigger' rose from 2% to 44%, an annual growth rate of 64% (as above, emissions shares are calculated from 2015 data and

remain static over the period). However, the increase is explained almost entirely by France and Germany, which together accounted for 37% of EU emissions in 2015, and both passed climate laws in 2019 that appreciably enhanced national climate policy monitoring. Prior to 2019, only Austria had a qualifying system in place, but this is now pending revisions to its 2017 Climate Protection Act. All in all, in 2021, only four countries had national progress monitoring with an action trigger – Netherlands, Germany, France, and Denmark.

Other systems for national progress monitoring exist in at least ten other EU countries, but these are not designed to oblige the government to pursue additional measures. However, in some cases, this is not clear due to vague wording in the language of the implementing regulation, e.g., Greece, Sweden, Latvia. Additionally, an annual progress report, especially if submitted to parliament and subject to public debate, can trigger new policy-making *in practice*. Overall, given that the trend can be explained by developments in two countries only, the proliferation of better practice national progress monitoring for climate neutrality is headed in the right direction but considered as too slow.

Share of EU Member States (plus EU) with an up-to-date and compliant long-term strategy (LTS)

This indicator shows past development in the share of EU Member States (plus EU) with an up-to-date and compliant long-term strategy (LTS) considering the EU Governance Regulation provision for Member States to update these by 2025 (own research; EC, 2023p; Velten et al., 2022b).

The data show an annual increase of 67% between 2017 and 2022. This rapid development is due largely to the impulse created by the Governance Regulation. However, progress is nevertheless too slow; only 50% of EU governments had a legally compliant strategy in 2022, well after the original deadline of January 2020 and robust long-term plans are needed *now* to steer decisions in the short-term.

Share of GHG emissions covered by a governance system with national progress monitoring that can trigger additional governmental action

This indicator shows past development in the share of GHG emissions covered by a governance system with national progress monitoring that can trigger additional governmental action (Ecologic Institute, 2023; EEA, 2023b; Evans & Duwe, 2021). No benchmark is available from an official EU source.

The data show an annual increase of 64% between 2016 and 2021. This development is too slow as the trend is explained largely by the governance systems in only two countries. Only four national governance systems have a qualifying monitoring mechanism in place. This underscores a lack of robust national monitoring that can trigger the necessary policy revisions.

Progress towards Enabler 2: Robust institutional arrangements to ensure a coherent approach to the climate neutrality transition

The transition to a climate neutral economy must be based on decisions that are grounded in the best available scientific evidence. In this spirit, the EU Climate Law encourages all Member States to establish independent scientific advisory councils for climate policy, but it stops short of prescribing this to national policy-makers. The rate of adoption of these institutions has picked up in the last half decade – between 2016 and 2021 the share of EU Member States plus the EU with a climate council increased from 7% to 29%. This signifies a promising average annual growth of 34%. More concretely, in 2021, there were eight councils with a strong anchor and function to play *vis-à-vis* governmental climate action. The oldest among these is the Danish Climate Policy Council, operational since 2015 and the newest addition is the EU Scientific Advisory Board on Climate Change, which was adopted with the EU Climate Law in 2021.

Share of EU Member States (plus EU) with a permanent independent scientific advisory body for climate policy

This indicator shows past development in the share of EU Member States (plus EU) with a permanent independent scientific advisory body for climate policy (Ecologic Institute, 2023; Evans & Duwe, 2021). No benchmark is available from an official EU source.

The data show an annual increase of 34% between 2016 and 2021. Given that four councils have been established in the last couple years alone, the potential impact of the EU Advisory Board, and the number of councils pending, this development is on track to ensure the EU has a sound evidence basis for policy-making on the path to climate neutrality in 2050.

For our analysis, we consider only those climate councils that are 'scientific', i.e., do not include stakeholder or other interest groups, and have a concrete role in their national governance context. This means the government must consult or respond to the council's input at some point in the policy cycle – planning, policy formulation, or monitoring. While integration into national governance processes has been argued to be an important prerequisite for having an impact on policy formulation, in addition to ample resources and a supporting secretariat (see e.g. Averchenkova et al., 2018; EEA, 2021b; Evans & Duwe, 2021), we are aware of individual cases in which a national council has changed policy direction without such a clear mandate. This is often due to the academic reputations of its members and weight in public discourse; climate councils are naturally seen as legitimate voices on national matters. For instance, the Finnish Climate Panel has taken upon itself to provide regular monitoring of governmental actions and its proposal for an earlier 2035 climate

neutrality date was incorporated into the 2022 revision of the Finnish climate law (Finnish Climate Panel, 2021). The Climate Policy Observatory in Luxembourg is obliged to produce an annual progress report but there is no requirement for the government to consider this or other outputs. Prior to a revision to the Greek climate law in 2022, the Scientific Committee on Climate Change had no dedicated role, but in the future, it will offer comment on each national carbon budget and adaptation plan.

The integration of institutionalised expert advice in climate policy making is occurring at a positive pace and we *cautiously* assess this to be on track to provide valuable and much-needed input to the transition to climate neutrality. Despite this optimistic outlook, it is important to note the regional variation here. To date, most of the development has been limited to northern Europe. In 2021, only three of the eight national climate councils with a concrete role in their respective national governance systems were from southern European countries and none were found in Central and Eastern (CEE) EU Member States. Still, there is reason to believe this dynamic is changing. At the time of writing, brand new institutions in Lithuania and Slovenia were omitted from analysis for lack of information on their role and operation. Moreover, the EU Advisory Board included in its 2023 Work Programme specific plans to engage with national experts, especially in Southern and Eastern European countries, which could serve to further promote the spread of climate councils in those countries without dedicated institutions. In place of a permanent institution, countries may also utilise other avenues for scientific input (e.g., targeted consultations, working groups, etc.).

New institutions, like climate councils, as well as other institutional arrangements can support a cohesive approach to climate policy-making, one that brings diverse governmental offices together and aligns actions. Environmental and more recently climate policy integration (or 'mainstreaming') has a long history in EU policy-making (EC, 2023i) and serves as a central component of the EU Better Regulation Agenda via the 'do no significant harm' principle and more recently the inclusion of climate neutrality consistency as a guiding question for impact assessments of Union measures (EC, 2021n; see indicator on Regulatory Scrutiny Board assessments below). Past research also reveals signs of climate policy integration at national level, especially pertaining the marriage of climate and energy policies (Kettner & Kletzan-Slamanig, 2020; Matti et al., 2021; Schmidt & Fleig, 2018). Still, compiling evidence of an all-of-government approach is challenging and limited by a lack of data on how mainstreaming has developed over time. As such, a reliable assessment of the share of EU Member States (plus EU) that shows evidence for a coherent all-of-government approach to climate neutrality is beyond the scope of this year's report due to insufficient data.

Nevertheless, specific anecdotal developments are worth mentioning in this context. One method of furthering climate policy integration often used by governments are provisions that

align budgetary spending with climate objectives. The EU has dedicated approximately EUR 670 billion in 2022 prices to the climate neutral transition by requiring that at least 30% of funding from the 'Multiannual Financial Framework' (MFF) for 2021–2027 and NextGenerationEU flow into climate spending (EC, 2022i). The OECD Green Budgeting Database surveyed budget officials in EU countries in 2020 for similar provisions at national level finding that nine EU countries practice some form of green budgeting – i.e., have a budgeting system that include 'special processes or tools that are used to encourage environmentally responsive policy making and help achieve green goals' (OECD, 2020). Some countries, such as Sweden, also intentionally align climate planning or reporting cycles with the budget cycle to prioritise climate actions in spending debates (see Art. 4 of the Swedish Climate Act).

Another approach to integrating climate policy-making across governmental ministries and competencies is the creation of coordinating commissions and inter-ministerial working groups. According to a 2021 survey of European national climate governance, over half of EU Member States had some form of internal coordination mechanism for climate policy in place, often in the form of a roundtable or executive committee tasked with overseeing policy formulation (Evans & Duwe, 2021). Recent high-profile examples include the Frans Timmermans' office as Commissioner for the Green Deal, leading the EU's work to implement the EU Green Deal and EU Climate Law; the German climate cabinet of ministers; and the new French prime ministerial post for ecological planning. However, a recent empirical study suggests that success of these cross-government institutions depends on the policy-making culture and general acceptance of climate actions (Guy et al., 2023).

Share of EU Member States (plus EU) that shows evidence for a coherent all-of-government approach

This indicator shows the share of Member States and the EU that has a governance framework that ensures a high degree of coherent climate policy integration and mainstreaming.

There is a lack of comprehensive data.

Future research could explore the possibility of a composite indicator based off these and other common approaches for promoting climate policy integration and an all-of-government approach to the climate neutrality transition, but data and information challenges remain.

Progress towards Enabler 3: Frequent, early, and effective participation processes to improve policy decisions

Frequent, early, and effective public participation is crucial for the success of climate policies at both EU and national levels. In our analysis we consider the spread of citizens' climate assemblies as well as the quality of stakeholder consultations within the context of the EU Better Regulation Agenda.

Citizens' climate assemblies are a promising method of engaging with the interested public on the direction and approach to climate action in the EU. This new policy innovation has spread to many European countries and in at least one case (i.e., Spain) is dictated by a climate framework law (Carrick, 2022; Elstub et al., 2021; KNOCA, 2023). Currently, there is no EU-level law or policy that mandates the establishment of dedicated climate assemblies for EU Member States. While the Conference on the Future of Europe – which included a session on sustainability – was an EU-wide citizens' assembly, it has not yet been turned into a permanent platform. Nevertheless, between 2018 and 2022, the share of EU countries that convened a national climate assembly grew steadily. Ireland was the first country to organise an assembly and in the following years was followed by Austria, Denmark, Finland, France, Luxembourg, and Spain. This represents an annual growth rate of 52% – a positive, on track trend, especially considering the novelty of this policy innovation. We expect additional countries to follow suit in the coming years, but, as with the state of play for independent scientific climate councils, the regional disparity on citizens' climate assemblies (especially in CEE countries) is cause for concern.

Share of EU Member States (plus EU) governments that has commissioned a country-wide citizens' assembly on climate

This indicator shows past development in the share of EU Member States (plus EU) governments that has commissioned a country-wide (or EU-wide) citizens' assembly on climate (KNOCA, 2023). No benchmark is available from an official EU source.

The data show an annual increase of 52% between 2018 and 2022. Given the novelty of climate assemblies in the EU as a channel for public engagement, this represents a positive on track trend. Regardless of this steady increase, the degree to which EU Member States will continue to pursue climate assemblies is unclear, as it is affected by a range of factors. The degree to which these become integrated into national governance systems with any regularity also remains to be seen.

Naturally, not all climate assemblies are on the same footing when it comes to their substance and impact. To get at the different realities we qualify the existence of an assembly with the

level of attention given by government. This is operationalised along two criteria: (1) the operating budget and (2) official public response (or written commitment to respond) by the ministry or other governmental authority. Operating budgets range from EUR 20,000 to over EUR 4 million, suggesting a significant variation in resources, possible reach, and size. Apart from Austria, Denmark, Finland, and Spain, all climate assemblies have received an official response by government, albeit these differed in substance and format. In France, President Macron committed to supporting 146 of the 149 proposed measures that arose from the assembly, and in Luxembourg a parliamentary debate was called on the assembly conclusions. The Irish case presents the most promising evidence of impact as its deliberations led to the declaration of a climate emergency and influenced the governments Climate Action Plan published in 2019.

Despite the steady increase of climate assemblies in the EU, the rate of adoption of remains unpredictable as it is affected by a range of factors, including changes in government, societal attitudes towards climate action, and the success of existing climate assemblies in achieving their objectives. Most importantly, the degree to which climate assemblies will become a regularly recurring and integrated component of national climate governance remains to be seen.

Quality of public and stakeholder consultations on EU climate policy impact assessments

This indicator shows past development in the quality of public and stakeholder consultations on EU climate policy impact assessments (RSB, 2016, 2017, 2018, 2019, 2020, 2021). No benchmark is available from an official EU source.

Despite some indication that the trend is headed in the wrong direction, the analysis is limited by insufficient data and challenges to interpretation.

In addition to dedicated forums for participation, EU governance can improve the quality and effectiveness of climate policies, increase their legitimacy, and build public trust in decision-making, by involving the public and stakeholders in policy impact assessments under the Better Regulation Agenda. This initiative, in combination with several related EU provisions, translate the UN Aarhus Convention and the public's right to participate in environmental decision-making into EU law making. The EC lists 67 climate action-related consultations on the 'Have Your Say' web portal for the years 2019 through 2023 (EC, 2023l). The quality of the information base and open public consultations is reported annually by the Regulatory Scrutiny Board. Although the methodology has changed year-to-year, the general approach grades the information base on an index of 1–4, with 1 = 'unsatisfactory' and 4 = 'good'. While the underlying assessment data are not available, it is possible to derive these scores from the report themselves.

Over the period 2016–2021, the index decreased by 3% per year pointing to a general weakening in quality of the consultations, which ranged from 3.1 in 2017 to 2.7 in 2021. At face value, this trend is headed in the wrong direction. Qualitative descriptions in the reports paint an equally negative picture. For instance, the 2021 report states that, 'stakeholders' views were obtained, but insufficiently reflected in, for example, the problem definition or the discussion of the impacts. Too often, the consultation outcomes were wrongly used as if they were the result of a representative survey.'

Indeed, the 2021 report highlights consultations as a weakness of the impact assessments overall (RSB, 2021). However, our trend analysis comes with significant limitations due to insufficient data and challenges to interpreting the data that does exist. First, information is missing for the years 2016 and 2019 and the reports do not include explicit values for the quality of public consultations as these are combined with a broader assessment of the information base and methodology. Finally, the reports do not distinguish between policy fields and therefore it is not possible to determine if the trend holds for climate action impact assessments alone. Since the adoption of the EU Climate Law, the EU climate neutrality target must be considered when assessing the impact of all new Union measures, and therefore, arguably all EU policy is covered by this additional assessment criterion. This new requirement underscores the complexity of the net zero transition and its relevance to all policy formulation and associated public consultations. Moreover, recent shocks, such as the pandemic as well as the Russian war against Ukraine and the ensuing energy crisis, underline the importance of a resilient and reflexive governance system.

This difficulty in obtaining a precise picture of the effectiveness of EU public consultation processes under the Better Regulation Agenda points to a lack of transparency in the system and the need for additional accountability improvements. The Regulatory Scrutiny Board fulfils an important function in this regard but could do a better job framing its assessment in a way more accessible to outside observers. The public consultation component deserves more attention and detailed evaluation, and further reporting could push EU institutions to improve existing participatory mechanisms.

4.11.3 Conclusions and recommendations

The analysis paints a cautiously optimistic picture of EU progress on governing the transition to climate neutrality. Progress has been made on many fronts, but several problems remain, which must be solved soon to avoid derailing or undermining those governance mechanisms, which are working well. Below we outline three main insights that arise from the analysis of the EU governance objectives, enablers, and their underlying indicators.

A solid foundation to build from: The rate of adoption of national climate framework laws is evidence that many EU countries are serious about climate neutrality

Climate framework laws are spreading quickly across Europe with new legislative drafts and revisions to existing laws appearing every few months in recent years. This trend suggests that EU governments are improving their ability to manage decision-making on climate action for the ling-term transition. But climate framework laws come in many forms, and some are more comprehensive than others. At the time of writing, six of sixteen existing national laws in the EU were missing either clarity on post-2030 emission reductions or an integrated climate planning and policy-making cycle to ensure continuous action. Naturally, the short- and long-term planning cycles required by the Governance Regulation and the distribution of non-ETS emission reductions shares via the EU Climate Law step in to fill in some of these gaps.

Still, despite an overall positive trend, the political situation in many countries has delayed or entirely frozen discussions, and developments – such as the expiration of the Austrian law or the early 2023 decision in Germany to do away with sector-specific emission budgets (an otherwise unique strength of the 2021 German Climate Protection Act) – prove that the door can swing both ways. Moreover, while there is momentum there is a risk that the trend will plateau off because of the political difficulties to enacting climate legislation in a handful of EU countries, such as Italy, Poland, and potentially Czechia. The indicator for this objective considers the share of GHG emissions to add weight to laws in countries that account for a greater share of EU emissions. These two countries accounted for over 20% of EU GHG emissions in 2015 and thus are important holdouts in the adoption of operational frameworks.

The good news is that things are changing fast, and most revisions in the past for the most part served to *improve* not dismantle legal frameworks. National governments (and the EU) should see **climate framework laws as 'working foundations'** and be willing to review and revise these to improve upon procedures and institutions over time. All EU countries should adopt climate framework legislation that at the least enshrines a national vision for 2050 and their existing obligations under EU law, i.e., short- and long-term planning cycles.

Implementation gaps: Long-term planning and national progress monitoring have been largely neglected and must be improved

A framework is only as strong as the components it is built from. The analysis finds that **many national systems lack good practice specifically on long-term planning and national monitoring processes**. The trend in the development of said processes, while headed in the right direction, is moving too slowly considering that Member States are already behind in submitting

compliant LTSs and governance systems with a built-in accountability mechanism in the form of an action trigger are a rarity. This finding points to a current lack of ownership in implementation of the EU climate neutrality project at national level.

If EU Member States continue to revise and develop their LTSs at the same rate as over the last five years, the trend suggests that only around the start of 2025 we will have 28 fully compliant strategies (27 Member States plus one for the EU). Of course, this is impossible to project with any degree of certainty, but as a thought experiment, this means EU governments will essentially 'get it right the second time' – LTSs were due January 2020 but are scheduled for an *optional* update in 2025. However, even a fully compliant strategy is not necessarily of adequate detail. The EU Climate Law requires national LTSs to be consistent with the EU climate neutrality goal but does not offer any explanation of what this means in practice. The original guidance and mandatory content requirements found in the Governance Regulation are likewise vague and may be one reason for the range of quality in the first batch of submissions (Velten et al., 2022).

On monitoring, only four countries have an action trigger. Given the size of these countries, this still accounts for a sizable share of EU emissions: 44%. The remaining countries, especially those in the process of devising or revising a climate framework law should strive for the highest level of accountability when it comes to designing a monitoring mechanism. In addition to a trigger that realigns national actions with their intended aims, this could include specific legal provisions that require a progress report be sent to parliament (e.g., as in France, and Germany), that all reporting is made public (e.g., Finland), or a feedback loop between government and an expert council, in which all consultation and official response is published (e.g., Denmark).

More voices at the table: Independent scientific climate councils and citizens' climate assemblies are promising new policy innovations

Independent scientific climate councils and citizens' climate assemblies have the potential to enhance the transparency, credibility, and robustness of EU and national climate policy decisions – but only If given the attention (and resources) they deserve. While these are relatively new additions to the climate governance toolbox, there is strong evidence of their impact, and the rate of adoption at national level over the last five years is likewise telling (for reviews see Thorman & Capstick, 2022; Weaver et al., 2019).

Nevertheless, **national (and EU) policy-makers should provide new institutions with sufficient resources and the attention they need to ensure actual policy impact**. If governments do a lacklustre job in setting up an expert body or convening a citizens' assembly, they risk undermining their purpose, and essentially set these new institutions up for failure. Moving

forward, citizens' climate assemblies should become a regularly recurring process, possibly on a biennial or three-year basis (given the longevity of impact) – and include a large-scale focus group or sounding board for policy-makers to gauge public sentiment. Governments should then provide good faith responses and follow up on citizens' demands, at least with justification if another direction is taken.

Independent scientific climate councils must be provided with a secretariat that has communications and research staff to support and disseminate the experts' conclusions. Notably, as mentioned above and evidenced in past research these are sufficient but not necessary conditions for successful impact on policy formulation (Evans & Duwe, 2021). Councils must be embedded in existing decision-making processes by design with a clear mandate to interject in at least on stage of the policy cycle. Although it was only established in 2021 and fully operational in 2022, the EU Advisory Board has few concrete anchors in EU policy-making but has already begun to establish itself as a clear monitor of progress, despite its vague mandate.

Box 15: Highlights from the assessment of Governance

Comprehensive legal frameworks and new institutions for governing the transition are being adopted at national level at a promising rate.

Climate framework laws and independent climate councils are of central importance in effectively managing the climate neutrality transition and ensuring that policy solutions are based on the best available science. The adoption of both at EU level in 2021 marked a significant milestone in EU climate governance. The spread of these two policy innovations at national level is a positive development and points to increased cohesion in the face of long-standing national disparities in good governance for climate.

Sufficiently detailed planning and proactive national monitoring for the climate neutrality transition were missing most EU Member States.

Most EU Member States have neglected good practice on long-term planning and progress monitoring, underscoring the need to bolster the learning cycle for climate neutral policy-making. It remains to be seen whether new monitoring under the EU Climate Law will serve this purpose at EU level, but the EU LTS also needs updating.

Citizens' climate assemblies support effective public consultation, but more transparency is needed on the quality of existing participation processes at EU level.

Climate assemblies are a positive development on citizen engagement for EU climate policy-making. However, given the novelty of these new institutions, it is hard to predict whether they will spread beyond a handful of countries or whether they will be repeated with any regularity. Survey results, although limited, point to a lack of public confidence in national governmental actions for climate neutrality, and data on the quality of public consultations at EU level are difficult to interpret. Both these lines of evidence suggest there is a need for enhancing participatory processes and transparency in their effectiveness.

National-level insights

France represents good practice on both long-term planning and monitoring.

The assessment reveals that France is the *only* EU Member State that has both a sufficiently detailed, up-to-date, and compliant long-term strategy and a national monitoring system that can trigger additional governmental action if progress towards national targets is found to be lacking.

Climate framework laws have started to spread in southern Member States, including Spain and Portugal (and Greece).

In 2021 and 2022, climate framework laws were adopted across Southern Europe. Both Spain and Portugal passed laws at the end of 2021 and, even though it is lacking a concrete policy planning cycle, the Greek law was adopted in 2022.

Despite being the second oldest independent climate council in the EU, the Finnish Climate Panel is missing a clear anchor in the governance system.

Due to this relative weakness compared to its peers, especially in other Scandinavian countries, it was omitted from the analysis. However, the researchers are aware that it has had a clear impact on national policy and climate target setting. Perhaps because of its tenure as an actor in national policy-making it serves as an important reminder that national circumstances differ and the challenges that come with assessing governance frameworks for their quality *in implementation*.

4.12 Adaptation

Adapting to climate impacts requires a wide range of responses across sectors. In order to track progress, the element assesses the implementation of adaptation measures and actions, specifically nature-based solutions in the urban context, land use sectors, and the aquatic environment.

Overview

Despite ongoing mitigation efforts the rising concentration of GHGs in the atmosphere will continue to push global temperatures upwards. No matter which path towards climate neutrality is taken, a certain degree of temperature increase is now locked in, and with this come certain 'locked in" climate impacts. This includes increased risks and vulnerabilities to a range of impacts including heatwaves, droughts, and floods, as well as rising sea levels and decreased biodiversity, amongst others. Adapting to climate impacts will thus require a wide range of adaptation responses across sectors, both at the European level, but also from individual Member States (EC, 2021b). Additionally, significant adaptation will be required internationally, especially in the developing world, and this aspect of adaptation must be strongly supported. For the purposes of the ECNO analysis of the European transition, this section focuses on assessing the state of adaptation within the continent.

A key element in progressing adaptation is acting on the ground through the implementation of adaptation measures and actions. In our case, we examine those adaptation measures that are considered nature-based solutions. The EU Adaptation Strategy sees these as important elements of adaptation strategies, often offering cost-effective, flexible, and low/no regret measures to respond to climate impacts and vulnerabilities. We have split them into three key categories to cover an important – though not comprehensive – portion of adaptation efforts. Firstly, 'green" measures in the urban context, especially related to urban green infrastructure; second, 'green" measures in the land use sector, specifically looking at agriculture and forestry practices; and finally, 'blue" measures related to water management of rivers and wetlands. We have deliberately not explored 'grey" infrastructural adaptation measures, and decided to focus on more progressive or 'transformational' adaptation approaches such as nature-based solutions. These are types of adaptation measures often have more robust long-term effects and a number of co-benefits, while 'grey" measures are often high-cost and create 'lock-in" scenarios that cannot be reversed.

The choice of enablers and indicators is challenging for climate adaptation, not least because there has been little work done on indicators in this area to date. Also, the cross-sectoral nature of adaptation makes it especially difficult to track or measure progress, as indicators would be needed in every sector. In this report, we focus solely on 'outcome indicators' but we aim at including 'process indicators', e.g., adaptation financing or governance, to gain a more holistic view in future iterations of this progress check. And finally, making concrete statements or judgements on progress on the indicators in this space is difficult: the indicators for the main objective of 'becoming a climate resilient society" either showed significant year-to-year variability (e.g. economic losses from climate-related extremes), or are not yet tracked at the EU-level – such as the kilometres of river restoration or the area of green roofs.

Despite not being able to provide a comprehensive picture on the state of adaptation in the EU, some insight can be gained. The indicators for the objective of becoming a climate resilient society either show significant year-to-year variability or are not yet tracked at the EU level. Some insight can be gained through the enablers which show, for example, that there has been a slight increase in the share of wetland area in the EU. This is a positive development, giving insight into the state of aquatic and marine conservation and restoration. Conversely, we observe that the share of gentle tillage practices being used on arable land has been on a decreasing trend, which must be reversed as one of many approaches to effectively adapting the agricultural sector.

4.12.1 Objectives and enablers

Objectives: Becoming a climate resilient society

The EU aims to build a climate resilient society by improving knowledge of climate impacts and adaptation solutions; by stepping up adaptation planning and climate risk assessments; by accelerating adaptation action; and by helping to strengthen climate resilience globally (EC, 2021d).

To monitor progress of countries in reducing vulnerability and increasing readiness to improve resilience, a suitable indicator is the Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index which 'summarises a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience" (University of Notre Dame, 2023). This indicator was chosen as it was the only identified measure of both vulnerability and resilience with data available for every EU

Selected indicator:

ND-GAIN country index [score out of 100]

Member State (allowing for the calculation of an average for the whole EU). It includes exposure and sensitivity in key areas of food, water, health, ecosystem services, human habitat, and infrastructure (using 36 indicators) and 'readiness' for climate change impacts across economic, social, and environmental dimensions (using nine indicators). These are combined into a single score.

Selected indicator:

Economic losses from climate-related extremes [bnEUR]

The EU (2021a) also aims to limit economic losses and other harm as a result of climate impacts. This includes, for example, losses of life and health impacts arising due to climate hazards including heatwaves as well as damage to infrastructure from e.g., floods and storms. The indicator '*economic losses from climate-related extremes*' provides a comprehensive picture across the EU and can support policy processes on climate change adaptation. Data is collected and reported across Member States in a coherent way over decades.

Enabler 1: Greening cities

Examples of 'green" measures for cities and buildings relate to the creation or improvement of green infrastructure like parks, open spaces, and green roofs. Increasing green space in urban areas provides a number of benefits, notably helping with cooling, providing shade, water absorption, and health benefits (EEA, 2012; Graça et al., 2022). A related indicator is '*share of green urban area*', which identifies land cover categorised as either green urban area, recreational area, natural and semi-natural areas, and water (EEA, 2022b). The EU Adaptation Strategy outlines that buildings must become more resilient to climate impacts, specifically mentioning green roofs (EC, 2021d). The development of green roofs are one of the green infrastructures (among others) which can reflect a broader urban greening dynamic. The indicator '*area of green roofs*' could track this progress but there is currently no EU wide data (EEA, 2015). It is also important to note that these indicators are not perfect: for example, urban greening projects can be considered maladaptive if they only benefit wealthy neighbourhoods, thus driving property prices up (Jelks et al., 2021).

Selected indicator:

Green urban areas [%]

Selected indicator:

Area of green roofs [m²]

Furthermore, green spaces and roofs are only two measures amongst a number of possible approaches to adapting cities. Therefore, we must keep in mind the limitations of such indicators as being representative of adaptation.

Enabler 2: Adapting agriculture and forestry

Climate change will have important effects on the agricultural sectors, though these vary by region. Increases in temperature, changed rainfall patterns, and increased frequency of extreme events will impact crop production and yields, and cause changes to the prevalence of pests and diseases. Concerns in the forestry sector are similar, with changes to water availability and extreme weather such as droughts and storms having important effects on timber production. Increased risks of forest fires and changed patters of pests and disease also pose a threat to forest management (COACCH, 2021).

The use of gentle tillage practices can have important benefits in terms of reducing both soil erosion and surface runoff, while also improving crop yields. Employing these conservation agricultural practices can be important in reducing the negative impacts of climate change on agriculture, while also ensuring stable yields under an uncertain and changing climate (EEA, 2019a). It is important to note here that gentle tillage is merely one practice amongst many, but one that can provide a useful indication of the overall systemic shift towards more adaptive agriculture. In the forestry sector, mixed forests (those containing over 25% of both coniferous and broad-leaved species in the canopy closure) are considered important in improving the resilience of forests to climate change, especially drought and storms. Among other benefits, mixed forests display increased rates of water retention overall, thus improving their resilience to extreme-weather events (Almeida et al., 2021; Schoenwiese, 2021). However, as with the concerns surrounding urban greening, these indicators do have their limits. For example, in revegetating a forest into mixed area, there is a risk of choosing a species requiring too much water, thus leading to a maladaptive outcome.

Selected indicator:

Share of gentle tillage practices [%]

Selected indicator:

Share of mixed forest area [%]

Enabler 3: Blue measures

In addition to the ‘green” measures outlined above, protecting the aquatic and marine environment through ‘blue” nature-based solutions is an equally important aspect of adaptation. Coastal regions, especially those including wetlands, are recognised for their mitigation potential through the sequestering of ‘blue” carbon, but also their potential to protect communities against extreme weather events

Selected indicator:

Share of wetlands [%]

and sea-level rise (von Unger et al., 2020). Thus, 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 (Moomaw et al., 2018).

Selected indicator:

River restoration [km]

In addition, freshwater environments also provide important potential for adaptation benefits. Especially important here is the provision of ecosystem services offered by rivers, which offer direct and indirect benefits for human well-being and economic value, e.g. through improved health and income potential (van Wesenbeeck et al., 2021). 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 (EC, 2021a).

4.12.2 Progress towards climate neutrality

Progress towards the objectives

ND-GAIN country index

This indicator shows past development in the average NG-GAIN country index score of EU countries (University of Notre Dame, 2023). No benchmark is available from an official EU source.

The data show an annual decrease of 0.2% or 0.1 points between 2015 and 2020. This development was heading in the wrong direction and must be reversed moving forward.

The goal of climate adaptation efforts, in line with the EU Adaptation Strategy, is to become a climate resilient society. While this is hugely challenging to summarise in a single figure, the University of Notre Dame's Global Adaptation Initiative (ND-GAIN) have developed a country index bringing together a range of indicators from a range of sectors and dimensions (University of Notre Dame, 2023). Scored out of 100, the average figure for the EU has remained relatively constant between the years 2015-2020, with a marginal decrease from 63.4 to 62.6. At the country level, there is a wide range of scores, with Romania scoring 51.1 and Finland scoring 72.0.
In order to meet the objective of building a climate resilient society, this indicator should however increase rapidly, both at the EU-level and within the individual Member States.

The other indicator selected to meet this objective is economic losses from climate-related extremes, such as floods and heatwaves. Effective adaptation should aim to reduce the effects of these extremes, thus reducing the economic losses. The trend shows a general increase of EUR 26 billion per year between 2016 and 2021; however, data for this indicator has fluctuated significantly in the past period, starting in 2016 just below EUR 10 billion, before jumping to EUR 27 billion in 2017, steadily decreasing to EUR 12 billion in 2020, and skyrocketing to almost EUR 60 billion following the severe flood events in 2021 (EEA, 2023a). It is worth noting that the EEA identifies a small number of climate-related events as responsible for the majority of the economic losses: 5% of events with the biggest losses are responsible for 57% of overall losses, with 1% causing 26% of losses. As such, there is strong variability between years, and identifying trends is especially difficult. To reduce these damages, the EU Adaptation Strategy calls for increased investment in resilient, climate-proof infrastructure, improved disaster risk reduction and prevention strategies, and improved coordination and coherence on standards, guidelines, targets, and knowledge.

Economic losses from climate-related extremes

This indicator shows past development of economic losses from climate-related extremes in Europe (EEA, 2023a). No benchmark is available from an official EU source.

The data show an annual increase of 5.3% between 2016 and 2021. This development was heading in the wrong direction and must be reversed moving forward.

Progress towards enabler 1: Greening cities

The enablers selected to track progress towards the EU becoming a climate resilient society are reflective of 'on-the-ground" adaptation measures in specific sectors: the urban context, agriculture and forestry, and the aquatic and marine environment.

Green urban areas

This indicator shows past development in the share of green urban areas in 721 European cities. No benchmark is available from an official EU source.

There is insufficient data to track progress with only one data point available.

Unfortunately, the indicators selected to measure this progress each have extremely limited data availability, which makes any concrete judgement on progress towards the objectives difficult. The data related to greening cities is limited to the point that a comment on progress is not feasible: currently, no indicator exists for tracking the area of green roofs, and the data on urban green space only has one annual data point

(3% urban green space in 2018, averaged across 721 European cities).

To continue to track progress of greening cities, it will be necessary to develop these indicators further. That said, while an increase in both green roofs and urban green space could be generally interpreted as a positive sign of climate adaptation – it must be noted that such urban adaptation measures may benefit only some inhabitants of cities, and not all. Opportunities available through EU frameworks such as the Covenant of Mayors and the Urban Agenda for the EU, as well as various funding opportunities (e.g. LIFE Programme, European Structural and Investment Funds) should be maximised in order to achieve successful adaptation on the local level, an important objective of the EU Adaptation Strategy.

Area of green roofs

For now, there is no EU-wide aggregated data on the area of green roofs available.

Progress towards enabler 2: Adapting agriculture and forestry

Share of gentle tillage practices

This indicator shows past development in the share of gentle tillage practices on arable land (Eurostat, 2020a). No benchmark is available from an official EU source.

Data is insufficient to draw a trendline with only two datapoint. However, these show a decrease from 29% to 26% between 2010 and 2016 showing that

While slightly more data is available on the indicators related to adapting agriculture and forestry, it is still generally difficult to confidently identify trends. With regards to agriculture, we observe that the share of gentle tillage practices reported in European farms has in fact decreased between 2010 (28.6%) and 2016 (25.8%) (Eurostat, 2020a). Given their important benefits both for farmers (e.g. improved yields) and the environment (e.g. reduced erosion, runoff) these sorts of tillage practices (both zero tillage and conservation tillage) must be further encouraged. This is underscored by the IPCC (2019) which emphasises the importance of conservation agriculture, including minimum soil disturbance, to help reduce the impacts of climate change on agriculture. Furthermore, adoption of sustainable soil management practices is highlighted as a key feature of achieving the objectives of the latest Common Agricultural Policy, specifically efficient natural resource management (EC, 2018a).

There are slightly more data points available to track the share of mixed forest area in Europe (Eurostat, 2022e). During the period 2009-2015, the share stayed relatively constant, hovering

between 10.3 and 10.5%. Unfortunately, the latest data point (2018) shows a marked decrease to 9.1% mixed forest area. Much like the conservation tillage, mixed forests have generally positive impacts on the overall resilience of forests, and thus should be a promoted practice. In line with the EU Forest Strategy for 2030 (EC, 2021e), forest management practices that lead to more resilient forests, such as mixed forest areas, should continue to be adopted.

Share of mixed forest area

This indicator shows past development in the share of mixed forest area in total forest area (Eurostat, 2022e). No benchmark is available from an official EU source.

The data show an annual decrease of 2% between 2009 and 2018 heading in the wrong direction.

Progress towards enabler 3: Blue measures

Only one of the two indicators related to blue adaptation measures has a suitable amount of data available for assessment. The share of wetlands on total land area stayed constant during the measured years of 2009, 2012, and 2015, at 1.7% (Eurostat, 2022e). In 2018, the last recorded year, this figure went up to 1.9%, denoting a slight increase and representing a positive development for wetland protection. There is hope for this trend to progress; all EEA member countries are signatories to the Ramsar Convention on Wetlands and thus must continue to preserve and restore wetlands. However, at the same time, wetlands across Europe continue to face pressure from agriculture, infrastructure, and other land uses, and the development and implementation of national strategies for wetlands may differ and take time.

Share of wetlands

This indicator shows past development in the share of wetlands on total land area in the EU (Eurostat, 2022e). No benchmark is available from an official EU source.

The data show an annual increase of 1.9% between 2009 and 2018. This development was heading in the right direction but was far too slow. This is underscored by the EU's Biodiversity Strategy 2030, which emphasises the importance of restoring free-flowing rivers, wetlands, and floodplains.

River restoration

The EU Biodiversity Strategy sets out a target of 25,000 km of river restoration by 2030. However, there is currently no data available to track the target.

In addition to wetlands, river restoration is another important measure linked to adaptation of the aquatic environment. The EU Biodiversity Strategy 2030 has set a target for the restoration of 25,000 km of free-flowing rivers through the removal of barriers and restoration of floodplains and wetlands. In addition to benefits for biodiversity, this would have important benefits for flood protection, water retention, and water availability, all important features of climate adaptation. Although river restoration is a well-recognised and researched topic (see the European Centre for River Restoration (2023) and the AMBER project (2023)), to date, no comprehensive EU-level indicator or data is available to track the amount of restored rivers. This indicator should soon be developed and integrated into Water Framework Directive reporting.

4.12.3 Conclusions and recommendations

Significant data gaps exist in terms of quality and availability

Due to the lack of reliable indicators available, we cannot offer a comprehensive overview of the state of climate change adaptation in the EU. Both the data available for the indicators for the overall objective of building a climate resilient Europe, and the data for their specific enablers, are incomplete and cannot be interpreted in such a way as to be representative of climate adaptation at large.

In general, there is a significant lack of relevant data tracking adaptation across all sectors, and where data is collected, it is not done regularly or made easily available. Improving this availability and access is in line with the EU Adaptation Strategy's objective to generate 'more and better climate-related risk and losses data. Harmonised monitoring guidelines should be developed for EU Member States, regions, and communities in order to improve the both the availability and quality of data.

Adaptation implementation is severely lacking

Although climate adaptation has generated significant interest in the last decade, and especially so in response to last year's extreme events in the EU, there remains a large implementation gap for adaptation actions and measures. Often, implementation of measures exist in pilot or test projects, as is the case with many urban greening projects. This increase in awareness around

climate adaptation now needs to be converted into action. Although climate strategies and action plans have been or are still in development, actual implementation of changes of practices on the ground is moving slowly. As such, it is imperative that implementation of these strategies, plans, and policies be strengthened and accelerated across sectors, Member States, and communities.

Box 16: National-level insights for Adaptation

More than 70% of EU wetlands are situated in just four Member States

Wetlands cover about 2% of the total land area in EU Member States. However, it is worth noting that over 70% of these wetlands are located in just four countries: Ireland, Sweden, Finland, and Estonia.

4.13 External Action

To support global climate neutrality, the EU must consider the extraterritorial impacts of its actions, engage in climate diplomacy, and support other countries in decarbonisation.

Overview

Addressing the complex and multidimensional challenge of climate change requires a collective and coordinated effort at the global level. Therefore, the EU's domestic and international agendas are closely interconnected. The EU has long been a leading international partner for climate, a role that it must uphold. It is thus crucial for the EU to consider the extraterritorial impact of its actions, including through trade policies and imported emissions, as well as the loss and damage caused globally by delays in emission reductions. To effectively tackle the magnitude of the climate change challenge and mitigate its worst impacts, the EU must also engage in climate diplomacy and collaborate with international partners to stay within a global limit of 1.5C of warming, as set out in the Paris Agreement. The European continent's wealth and know-how, along with its historical emissions, mean that the EU and its Member States have both the ability and the responsibility to support countries in their decarbonisation and adaptation efforts to achieve global climate neutrality (EC, 2021b). Supporting climate actions around the world also creates new opportunities for the EU and its partner countries and thus promotes sustainable economic development as well as security and prosperity.

Our assessment suggests that the EU's overall progress on external action has been far too slow. Even though the narrative of the EU Green Deal points in the right direction, it is not yet sufficiently backed up with action in all areas of EU foreign climate policy. Developments in areas such as the mobilisation of international climate finance or initiatives among Member States to improve coordination and prioritisation of climate diplomacy efforts are headed in the right direction at a promising but insufficient pace. Similarly, efforts to align all international public funds and trade agreements with the objectives of the Paris Agreement tend in the right direction, but at a pace well below what is required. In terms of imported emissions and the allocation of official development assistance (ODA) for climate-related purposes, the trends are regrettably even moving in the wrong direction.

4.13.1 Objectives and enablers

Objectives: Be a champion in the global response to climate change

To retain a frontrunner role in the global transition, the EU must demonstrate how it will rapidly move towards climate neutrality and undertake efforts to raise ambition worldwide. This includes strengthening the global response to climate change by supporting partner countries in their net zero transitions and reducing the EU's emissions abroad.

On the one hand, it is crucial that the EU and its Member States support shifting international financial flows to low-carbon and climate-resilient development. This can take varies forms, from providing international climate finance for climate change mitigation, adaptation, and loss and damage, to supporting the reform of the international financial architecture. The mobilisation and provision of climate finance from wealthier nations is widely acknowledged as a crucial factor in enabling and motivating climate action by developing countries. This financial assistance is seen as significant in three ways: symbolically, as a recognition of historical responsibility for the rising global temperatures; relationally, as a means of fostering trust and cooperation among nations; and instrumentally, by providing new and additional funding for climate action in countries with major resource constraints (Colenbrander et al., 2022). The EU and its Member States, among other developed countries, pledged to provide and mobilise USD 100 billion annually in international climate finance from 2020 to 2025. The mobilisation of 'international climate finance' in line with its fair share to support other countries to implement the Paris Agreement is therefore used as a proxy indicator.

Selected indicator:

International climate finance [mEUR]

On the other hand, it is critical for the EU to reduce its 'imported CO_2 emissions', i.e., those emissions emitted abroad serving domestic consumption. This is particularly important given the large size of the EU market. Developed countries, whose carbon intensity (which measures the emissions for one unit of gross domestic product, GDP) has stabilised or declined, have turned to other countries, such as Brazil, Russia, India, or China (i.e., the BRIC nations) for inputs and finished products, such as fuel, steel, and clothing. The resulting increase in emissions in the exporting countries is particularly problematic for BRIC countries whose GDP is now on average up to four times more carbon-intensive than industrialised nations, and who have consequently contributed to 90% of global emissions growth since 2005 (Sykes, 2022).

Selected indicator:

Imported CO_2 emissions [Gt CO_2]

Enabler 1: Ensure alignment of all international public and private finance with the Paris Agreement

It is important that the EU aligns all its international public and private finances with the Paris Agreement to ensure effective use of limited public resources and to ensure that its investments support and not undermine global efforts to combat climate change.

Selected indicators:

Public finance for international fossil fuel projects (by EIB) [mEUR];

Public finance for international clean energy projects (by EIB) [mEUR]

This has also been reiterated by the International Energy Agency (IEA), which has called to end new coal, oil, and gas funding and urgently shift public finance towards clean energy to limit global warming to 1.5C (IEA, 2021c). Between 2018 and 2020, G20 countries and Multilateral Development Banks (MDB) continued to support fossil fuels abroad with at least USD 188 billion, which was 2.5 times more than their support for renewable energy (Tucker & DeAngelis, 2021). Meanwhile, public finance for clean energy has stagnated since 2014, while investments into clean energy should grow to nearly USD 4 trillion annually by 2030 (IEA, 2021a).

The COP26 statement on international public support for the clean energy transition contains a historic pledge to cease international public fossil finance for coal, oil, and gas by 2022 (Messetchkova, 2021). The EU and its Member States should now be leading the way in delivering on this promise. However, the EU taxonomy, a common classification system for sustainable economic activities, has labelled gas as a sustainable investment. As one of the largest supranational lenders in the world, the EIB, also known as the European Climate Bank, has an important role to play in directing European investments towards clean energy projects while ending the use of public funds to support international fossil fuel projects. Given the institutional importance of the EIB, and in light of the data gaps on climate-related international financial flows as a whole, the indicators 'public finance for international fossil fuel projects (by EIB)' and 'public finance for international clean energy projects (by EIB)' have been chosen as proxies of whether EU public finance is aligned with the Paris Agreement.

Enabler 2: Use all foreign policy channels to support the global transition

To expedite the global transformation, comprehensive measures are necessary, spanning various domains such as trade and development partnerships. Therefore, it is crucial for the EU to

leverage all available foreign policy avenues to bolster the global shift towards a low-carbon economy that is resilient to climate change impacts.

Trade is a critical channel for the EU to promote international decarbonisation efforts as the EU represents the world's largest single market economy and is highly globalised. EU foreign trade has doubled from 1999 to 2010 and now constitutes more than 30% of the bloc's GDP (EU, 2023b). This has led to regulations in the EU indirectly extending their reach beyond its borders by influencing markets through market mechanisms. This gives the EU enormous leverage to initiate changes beyond its borders, including in the area of climate-friendly technologies and measures.

In 2021, the EC published its new trade policy strategy to address multiple challenges, including economic recovery, climate change, environmental degradation, international tensions, and the impact of unilateralism on multilateral institutions. With this trade policy strategy, the EU aims to promote open strategic autonomy and a fair, sustainable, rules-based trading system (EC, 2021m). The EU's new trade policy places sustainability at its core, aiming to promote fair and sustainable trade while addressing global challenges like climate change. The strategy includes initiatives such as advocating for sustainability in the WTO, urging G20 countries to make their economies climate-neutral as a basis for concluding trade agreements, utilising trade agreements to engage partners on the EU Green Deal, making the Paris Agreement a key component of future trade agreements, and implementing rules on mandatory due diligence for companies to prevent forced labour in value chains. The strategy proposes policy initiatives to promote the transition to green trade, such as targeted trade liberalisation for sustainable goods and services and the implementation of sustainability standards in value chains. It also emphasises measures taken unilaterally by the EU, including the Carbon Border Adjustment Mechanism (CBAM), the deforestation-free value chains initiative, and upcoming legislation on due diligence to ensure responsible business conduct and traceability (Corporate Sustainability Due Diligence Directive-CSDDD) (Blot & Kettunen, 2021).

At present, there are no initiatives tracking the degree to which the EU's overall trade policy is in line with the Paris Agreement and information is unavailable on several fronts. Due to the challenge of operationalising the ideal indicator we rely on a proxy measuring the number of '*Paris Agreement references in trade agreements*'.

This indicator provides a limited perspective on trade policy as it solely focuses on a specific aspect and does not cover other significant elements related to imports and exports, such as unilateral measures. Furthermore, it is worth noting that the reference to the Paris Agreement does not inherently address the enforcement or implementation of its provisions, given their non-binding nature. Nevertheless, it is important to acknowledge that, due to the lack of

comprehensive data, this indicator does provide some insights into the extent to which trade agreements incorporate sustainability references, albeit with certain limitations.

At present, there are no initiatives tracking the degree to which the EU's overall trade policy is in line with the Paris Agreement and information is unavailable on several fronts. Due to the challenge of operationalising the ideal indicator we rely on a proxy measuring the number of '*Paris Agreement references in trade agreements*'.

Selected indicator:

Paris Agreement references in trade agreements [% of trade agreements]

This indicator provides a limited perspective on trade policy as it solely focuses on a specific aspect and does not cover other significant elements related to imports and exports, such as unilateral measures. Furthermore, it is worth noting that the reference to the Paris Agreement does not inherently address the enforcement or implementation of its provisions, given their non-binding nature. Nevertheless, it is important to acknowledge that, due to the lack of comprehensive data, this indicator does provide some insights into the extent to which trade agreements incorporate sustainability references, albeit with certain limitations.

Another important foreign policy channel to support the global transition is ODA (official development assistance). ODA remains an important source of funding for the world's poorest countries and has recently become even more important due to the impact of climate change, the COVID-19 pandemic, and the energy crisis caused by Russia's war against Ukraine. As such, ODA remains essential to achieve the climate change goals and the objectives set out in the 2030 Sustainable Development Agenda.
Collective ODA from the EU and its Member States amounted to EUR 70 billion in 2021, making it the largest global provider (Lenzu, 2022). In view of the important role of the EU in the provision of ODA and the importance of ODA for some partner countries, it is essential to ensure that climate change is given special priority in the allocation of ODA funds. This would take account of the fact that climate change has an impact on the achievement of the vast majority of the SDGs (NewClimate Institute, 2018). The indicator '*ODA related to climate action*' shows progress on this front.

Selected indicator:

ODA related to climate action [% of total bilateral ODA]

Enabler 3: Integrate climate in foreign policy

To effectively coordinate, align, and integrate climate-related issues in the international context, it is imperative to create the necessary structures to institutionalise climate throughout all foreign policy areas.

For this, it is essential to ensure that relevant 'climate-related capacities' are available in the main EU institutions and bodies. The fact that climate change has long ceased to be a niche topic must be appropriately reflected in the institutional set up of a broad range EU institutions and bodies. To be able to deal with foreign climate policy issues adequately, capacities in the form of budget and staff must also be built up in institutions that do not have a primary focus on climate, including the so-called RELEX DGs, which engage in external relations and include Directorate-Generals responsible for trade, international partnerships, or neighbourhood and enlargement negotiations.

Selected indicator:

Climate-relevant capacities [Number of staff]

And finally, the topic of climate diplomacy must be given a correspondingly high priority in the EU's and its Member States' general diplomatic efforts. Since 2011, the EU frequently updated its strategic documents on climate diplomacy (e.g., through EUCO conclusions on climate diplomacy), recognising its relevance as a foreign affairs topic and developing the concept of climate diplomacy beyond the UNFCCC negotiations (Tänzler et al., 2021). A small team of climate diplomats has been created within the European External Action Service (EEAS), EU's diplomatic service, over the last two years, led by an Ambassador at Large for Climate Diplomacy (Tollman & Pilsner, 2021). It is the EEAS's responsibility to, among others, coordinate the network of Member States' climate ambassadors with the aim to support developing joint climate diplomacy activities and strategies. Cooperation, coordination, and implementation of ambitious climate diplomacy measures by Member States is an important building block for effective and efficient European climate diplomacy. Alignment between EU and Member State climate diplomacy is essential, as is a 'Team Europe' approach. In October 2022, a number of EU Member States established a broad 'Group of Friends for ambitious EU climate diplomacy' to put climate at the heart of EU foreign and security policy (German Federal Foreign Office, 2022). The impact of climate diplomacy varies across Member States; those with larger economies are typically associated with higher emissions, exerting greater influence in this area. Therefore, the 'share of EU GHG emissions

Selected indicator:

Prioritisation of climate diplomacy [Share of EU GHG emissions covered by the 'Group of Friends for Ambitious EU Climate Diplomacy']

covered by the 'Group of Friends for Ambitious EU Climate Diplomacy', in the form of Member States joining this group, is used as an indication of prioritising climate diplomacy at the European level.

4.13.2 Progress towards climate neutrality

Progress towards the objectives

The EU and its Member States have a crucial role to play in achieving climate neutrality at the global level. To take a frontrunner role on climate action, the EU must support other countries and regions in the green transition, including by mobilising sufficient international climate finance, while simultaneously reducing its ecological footprint abroad.

International climate finance

This indicator shows past development of EU and EU Member State contributions to international public climate finance (Council of the European Union, 2022). No benchmark is available from an official EU source.

The data show an annual increase of 3.3% between 2016 and 2021. This development was going in the right direction but should be accelerated in the future. This is also underlined by the fact that developed nations, including the EU countries, have yet to reach their pledge to provide USD 100 billion per year in international climate finance between 2020 and 2025 (Colenbrander et al., 2022).

Developed countries have pledged to provide and mobilise USD 100 billion annually in international climate finance from 2020 to 2025. However, they failed to reach this goal in 2020 and 2021, and it seems probable that they will fall short once more in 2022 (Colenbrander et al., 2022). Contributions by the EU and its Member States have doubled since 2013 and accounted for 0.16% of EU GDP in 2021, making the EU and its Member States the largest net contributors to international public climate finance with over EUR 23 billion in 2021 (Council of the European Union, 2022). Despite the average annual increase of 3.3% between 2016 and 2021, progress is still too slow. Accordingly, current and future spending also falls short of what is considered a fair share (CAT, 2022). According to estimates by civil society actors, the EU's fair share should have been between USD 33 and 36 billion in 2018, significantly more than the actual contribution right under EUR 22 billion (equivalent to around USD 26 billion) (Hattle et al., 2021). To maintain credibility, the EU must increase international climate finance contributions to align with its fair share and encourage other donors to do the same (IPCC, 2022b). This would go a

long way to meeting the USD 100 billion goal in 2023 and ensuring the New Collective Quantified Goal (NCQG) is responsive to the needs of developing countries.

If the EU and its Member States continue to renege on their pledges, this amounts to a breach of trust *vis-à-vis* the poorer and most vulnerable countries and could undermine future climate diplomacy efforts. More seriously, without adequate international climate finance from developed countries and dedicated financing programmes, it will not be possible to scale up the deployment of low-carbon technologies in partner countries and phase out carbon-intensive technologies early enough to keep the 1.5C target within reach. National financial frameworks and public budgets in developing and emerging economies cannot provide the needed scale of finance alone, and high levels of debt already limit their capacity to fund the transformation, especially as the costs of dealing with climate change continue to rise (IPCC, 2022b).

To retain a frontrunner role in the global transition, the EU must, in addition to supporting partner countries in their net zero transitions also reduce its ecological footprint abroad in terms of imported CO_2 emissions. This is particularly important considering that the carbon intensity of goods imported into the EU in 2018 was more than double the carbon intensity of goods produced in the EU (OECD, 2022).

In 2019, the EU was a net importer of embodied CO_2 emissions (Eurostat, 2022b), meaning that the emissions produced from the goods and services imported into the EU were greater than those from the EU's exports. Between 2014 and 2019, the data indicates an annual rise of 2.1% in imported CO_2 emissions, which reflects a negative trend in terms of the EU's ecological footprint abroad. The trend observed in the years following 2016 is cause for concern. After experiencing a decline to their lowest point since 2010, imported emissions underwent a substantial increase, ultimately reaching their highest recorded level in 2018 since 2011. Although there was a slight decrease in value between 2018 and 2019, it was relatively insignificant, resulting in emissions remaining above the levels observed during the period of 2012–2017. This indicator is thus heading in the wrong direction, suggesting that additional efforts are needed to address the overall balance of embodied emissions.

Imported CO_2 emissions

This indicator shows past development in imported CO_2 emissions, i.e., emissions that are generated by the production of goods and services that are consumed within the EU, but produced outside the EU (Eurostat, 2022b). No benchmark is available from an official EU source.

The data show an annual increase of 2.1% between 2014 and 2019. This development was heading in the wrong direction.

Progress towards enabler 1: Ensure alignment of all international public finance with the Paris Agreement

The EU has integrated climate action into its budget by setting a 30% climate spending target for the Multiannual Financial Framework (MFF) 2021–2027 and Next Generation EU (NGEU) stimulus package, channelling an estimated EUR 557 billion towards climate action in the budget period (EC, 2023o). The majority of the EU's external finance is allocated to developing countries through the Neighbourhood, Development, and International Cooperation Instrument (NDICI-Global Europe). This instrument has a budget of EUR 79.5 billion and a climate-related spending target of 35% (EC, 2021i).

A budget classification system is needed to ensure that all international public finance that goes beyond the climate spending target is consistent with the objectives of the Paris Agreement. The EU employs adjusted OECD markers to monitor climate and biodiversity spending in all public funds (Levarlet et al., 2022). Moreover, the Global Europe Performance Monitoring System (GEPMS) was created to track identified priorities in external NDICI-Global Europe expenditures. The GEPMS includes a time-bound indicator framework, an explanation of how EU-funded interventions are intended to impact change, and a monitoring system that assesses intervention performance (EC, 2021b). However, these systems do not monitor the compatibility of external finance with the Paris Agreement or EU's green oath to 'do no significant harm'.

In the absence of data covering the entire EU budget, it is worth looking at other initiatives the EU has introduced to bring its finance in line with the Paris Agreement. One such initiative proposed by the President of the EC, Ursula von der Leyen, is to transform the EIB into Europe's 'climate bank' by aligning 'all its financing activities with the principles and goals of the Paris agreement by the end of 2020' (EIB, 2019).

Public finance for international fossil fuel projects (by EIB)

This indicator shows past development in public finance for international fossil fuel projects by the European Investment Bank (EIB) (Public Finance for Energy Database, 2023) in comparison to its target to bringing all its financial activities in line with the goals of the Paris Agreement by 2020 (EIB, 2019).

The data show an average annual decrease of EUR 6.3 million between 2016 and 2021. To meet the target, originally formulated for 2020, there must be a decrease of EUR 66.3 million between 2021 and 2022, which is more than 10 times faster than the current progress.

Contrary to this announcement, in 2021, the *EIB invested around EUR 66 million in fossil projects outside the EU* (Public Finance for Energy Database, 2023). Although this is a significant reduction compared to, for example, 2008 or 2018, when these investments amounted to around EUR 800 and 450 million, respectively, the EIB has missed its target to bring all its financing activities in line with the Paris Agreement by 2020 and should do so as soon as possible. In order to reach the target originally set, a significant decrease of more than ten times the average decrease rate of the past years is needed between 2021 and 2022.

'EIB investments in clean projects abroad' have demonstrated an average annual increase of 1.3% between 2016 and 2021, indicating a positive overall trend in supporting sustainable initiatives beyond the EU. However, it is noteworthy that investment levels have experienced a significant decline, dropping by nearly half from an interim peak of approximately EUR 547 million in 2019 to around EUR 311 million in 2021. While the average annual increase reflects a gradual increase in investments over the specified period, albeit well below the required pace, the recent decrease in funding for clean projects in particular is a concerning development. To maintain a strong

Public finance for international clean energy projects (by EIB)

This indicator shows past development in public finance for international clean energy projects by the European Investment Bank (EIB) (Public Finance for Energy Database, 2023). No benchmark is available from an official EU source.

The data show an annual increase of 1.3% between 2016 and 2021. This development was heading in the right direction but should accelerate in the future.

commitment to financing sustainable initiatives abroad, the EIB should prioritise the continuous growth of investments in these projects.

To ensure that financed projects align with the Paris Agreement, the EIB established the so-called Path Framework and provides support to borrowers in decarbonising their business portfolios. However, due to the energy crisis, the EIB Group has temporarily suspended its Path Framework until 2027 for renewable energy projects and electric vehicle charging infrastructure. This suspension allows energy companies, which are major contributors to GHG emissions, to access funding without presenting credible plans to reduce emissions in the medium to long term (Fossil Free EIB, 2022). Therefore, it is essential for the EIB to reconsider this exemption of energy companies from the Path Framework and ensure that its finance supports only those firms that have serious decarbonisation plans.

In summary, despite efforts by the EU to align its finance with the Paris Agreement, there is evidence to suggest that the EU's international climate finance is not consistently aligned with international climate goals. This is particularly evident in EU responses to the energy crisis and attempts to diversify EU energy supply by securing new fossil gas supplies and building new gas infrastructure in various regions worldwide, including Africa. However, this approach has been met with significant opposition, particularly when public funds are used to finance these initiatives, as they could result in additional emissions being locked in for decades to come (CCPI, 2023).

Progress towards enabler 2: Use all foreign policy channels to support the global transition

The EU Green Deal has played a pivotal role in elevating the significance of the climate crisis beyond the realm of UN negotiations and integrating it into EU foreign policy more broadly, with international cooperation and trade policy as critical facilitators. The success of the EU Green Deal thus also depends on the EU's ability to consistently integrate climate into all its policy domains (see section 4.11). While the EU has made efforts to mainstream climate considerations into all foreign policy channels, there is still room for improvement, as evidenced by the following analysis.

Over the last few years, there has been a paradigm shift for *trade and climate*, away from 'non-impediment' and towards 'positive contribution' (Weyand, 2021). Correspondingly, the EU Green Deal recognises trade policy as key to the global green transition (EC, 2019b). The EU generally integrates climate objectives into trade through bilateral and plurilateral partnerships, multilateral cooperation, and unilateral policies.

The EU engages in bilateral and plurilateral trade agreements to promote sustainable practices. Recent FTAs require trade partners to ratify and implement the Paris Agreement, with the possibility of trade sanctions for non-compliance (EC, 2022k). The EU-New Zealand FTA sets a precedent by committing parties to the objectives of the Paris Agreement (EC, 2022f). However, the climate ambition of future FTAs depends on partner engagement, and environmental provisions need stronger enforcement to support climate objectives. The proposed EU-Mercosur FTA has faced criticism for its potential negative impacts on deforestation and indigenous rights. To address these concerns, strong commitments to sustainability criteria are necessary.

As the EU does not provide a comprehensive overview of compliance with its goal to use trade policy as a vehicle to support the EU Green Deal in all its dimensions, it is difficult to assess the extent to which it has been achieved. The publicly available databases only cover bilateral and plurilateral trade agreements for the period up to 2018. Analysis of the data showed that the share of trade agreements containing a reference to the Paris Agreement increased steadily after its adoption but was still only 33% in 2018. This development is far too slow to achieve the EU's target of including chapters on trade and sustainable development in all modern EU trade agreements, which require effective implementation of the Paris Agreement. This is a particularly weak development, as it is not a binding declaration, but merely a reference, which alone cannot ensure that the climate targets are actually supported.

Paris Agreement references in trade agreements

This indicator shows past development in the share of trade agreements that reference the Paris Agreement (IDOS & Université Laval, 2018). This is compared against the announcement made by the EU in 2022 to include Trade and Sustainable Development chapters, which require effective implementation of the Paris Agreement, in all modern EU trade agreements (EC, 2022k).

The data show an annual increase of 11.5%-points between 2016 and 2018. To meet the target, the required annual change between 2021 and 2022 needs to be 16.8%-points, which is 1.5 times faster than the current rate of progress.

In addition to trade agreements, the EU actively participates in multilateral forums, particularly at the World Trade Organisation (WTO), to promote sustainable trade policies globally. A key medium-term objective is to reform the WTO to align with current trade dynamics. The EU plays an active role in integrating sustainability issues in WTO committees, such as the Committee on Trade and Environment (CTE), and has taken the lead in the Trade and Environmental Sustainability Structured Discussions (TESSD) . To strengthen engagement on the interplay between climate and trade and collaborate with like-minded nations on an ambitious

environmental agenda at the WTO, the EU has co-launched the Coalition of Trade Ministers on Climate, which currently includes over 50 ministers from 27 jurisdictions (EC, 2023w).

Another channel through which the EU aims to promote sustainable global trade includes unilateral regulations with extraterritorial impact. This includes for instance measures restricting access to the EU market for imports that do not meet EU standards, like deforestation-free supply chain regulations (EC, 2021l). The Corporate Sustainability Due Diligence Directive (CSDDD) aims to ensure that EU businesses address their environmental impact both within and outside of Europe. Additionally, the upcoming Carbon Border Adjustment Mechanism (CBAM) aims to discourage carbon leakage and promote sustainability by imposing costs on high-carbon production in specific sectors. It will be key for the EU to address the external impact of its domestic environmental and climate policies to build trust and respond to concerns. For CBAM, implementing the EP's proposal to allocate a portion of CBAM revenues to decarbonisation efforts in Least Developed Countries and Small Island Developing States could be considered.

Upon initial examination, the EU's new trade strategy appears to have undergone refinement and alignment with the objectives of the EU Green Deal. It emphasises the integration of sustainability principles into the EU's trade policy and offers initiatives to support these commitments. Regrettably, the strategy falls short in addressing the complex challenges associated with the implementation and enforcement of free trade agreements and achieving policy coherence between the EU's internal and external trade policies (Blot & Kettunen, 2021).

As part of its climate mainstreaming effort, the EU also aims to '*integrate climate considerations into its development policy*'. The European Consensus on Development requires the EU and its Member States to integrate climate change mitigation and adaptation into their development cooperation strategies and jointly implement the 2030 Sustainable Development Agenda and Paris Agreement (Council of the European Union, 2017). The Directorate-General on International Partnerships (DG INTPA) has become more receptive to climate considerations in recent years, which is evidenced by its 2021–2024 Strategic Plan that highlights climate change, environment, and energy as a central focus area (DG DEVCO, 2020). However, the prioritisation of climate-related action does not appear

ODA related to climate action

This indicator shows past development in Official Development Assistance (ODA) that is provided to support climate mitigation, adaptation and other related activities in developing countries (Donor Tracker, 2023). No benchmark is available from an official EU source.

The data show an annual decrease of 3.7% between 2016 and 2020. This development was heading in the wrong direction.

immediately evident in the allocation of ODA. An examination of the annual share of ODA dedicated to climate-related initiatives reveals a negative trend. Since 2016, there has been a decline in this allocation, characterised by an average annual decrease of 3.7%. In 2020, the share experienced a significant drop of 10%-points compared to the previous year, resulting in a share of 20%, the lowest recorded level since 2016.

Therefore, the EU must move beyond merely emphasising climate mainstreaming in its narrative and ensure that climate considerations are integrated and implemented across all aspects of its foreign policy, including in trade and international development corporation.

Progress towards enabler 3: Integrate climate in foreign policy

Incorporating climate change considerations into all aspects of foreign policy requires the integration of climate-related capacities in all EU institutions engaged in foreign policy and coordination structures both across EU institutions as well as between EU institutions and Member States.

Climate-relevant capacities

This indicator shows past development in climate-related capacities available to EU institutions engaged in foreign policy. Although the available data is limited, analysis indicates that several EU institutions responsible for climate-related matters face substantial deficits in terms of resources and capacity (Tänzler et al., 2021; Velasco & Peters, 2022)

Incorporating climate change considerations into foreign policy necessitates the '*development of climate expertise across all pertinent EU bodies*', particularly the RELEX DGs, which engage in external relations and include Directorate-Generals responsible for trade, international partnerships, or neighbourhood and enlargement negotiations. There is no data source that would enable a quantitative assessment of the existing climate-related capacities (e.g., in the form of number of employees, existence of a climate change focal points, or climate change departments). Various analyses and expert opinions, however, reveal that several EU institutions responsible for the EU's foreign climate policy, including the RELEX DGs, encounter significant resource and capacity deficits on climate-related matters (Tänzler et al., 2021). For instance, DG TRADE's officials exhibit less familiarity with climate-related topics, as exemplified by their outsourcing of environmental impact assessment preparation for FTAs to third-party organisations outside the EU (Velasco & Peters, 2022). Although EU climate diplomacy has increasingly recognised the importance of mainstreaming climate topics throughout external relations and international fora, there is still a substantial lack of skilled human resources and capacities on climate-related questions.

In 2019, EUCO established the High-Level Group of Wise Persons which was charged to determine how to maximise the added value of the EU financial architecture for development reported in 2019 that EU external action lacked coherence and that coordination structures for climate and development matters were inadequate (Wieser et al., 2019). Following the report's recommendations, the EU and its Member States have undertaken measures '*to prioritise and enhance the coordination of its climate diplomacy efforts*', establishing new formal channels and informal coalitions.

Prioritisation of climate diplomacy

This indicator shows past development in the share of EU GHG emissions that are covered by the 'Group of Friends for Ambitious EU Climate Diplomacy'. No benchmark is available from an official EU source.

This indicator refers to the Group of Friends for an Ambitious EU Climate Diplomacy, which has been launched in 2022. In 2022, 55% of EU GHG emissions originated from EU Member States also a part of this group, underscoring the need for an accelerated effort to encourage additional Member States to join.

In October 2022, a coalition of Member States known as the Group of Friends (GoF) of Climate Diplomacy was launched, with the goal of promoting coordination and the integration of climate considerations into foreign policy. Currently, 11 EU Member States have joined this initiative, indicating a prioritisation of climate diplomacy in foreign policy by these nations (German Federal Foreign Office, 2022). It is noteworthy that the participating countries represent 55% of the total EU emissions. To strengthen the Team Europe approach and to ensure broader support and a more effective implementation, it is important that the group of Member States supporting the objectives of the GoF grows.

Additional ad-hoc groups that aim to address the need for increased coordination and information sharing include the Climate Ambassador Network, which provides the EU with insight into Member States' climate diplomacy efforts through bi-weekly exchanges, and the Green Diplomacy Network, an informal exchange forum based in Brussels. Both groups are chaired by the EEAS and its Climate Ambassador (Biedenkopf & Petri, 2021). At the interface of the EC, EUCO, and the Member States, the EEAS can contribute to improved coordination between these institutions. However, the EEAS's resources for climate diplomacy in its first ten years of existence seems highly insufficient given the pressing climate challenge and considering its official mandate. Apart from the above-mentioned coordination role, the EEAS climate diplomacy unit (HCA01) also oversees implementation of the Just Energy Transition Partnership (JETP) with Viet Nam and represent the EU in the International Partner Group (IPG) for the other JETPs. Since its creation, this unit has never had more than five staff members (Biedenkopf & Petri, 2021). The fact that the position of the Climate Ambassador, created in the EEAS in 2019,

has been vacant since March 2023 makes it even more difficult to fulfil the mandate and does not speak to the topic being prioritised sufficiently.

4.13.3 Conclusions and recommendations

The need to put climate at the centre of the EU's geopolitical strategy

The EU Green Deal represents a repositioning of climate action within EU foreign policy and, as such, EU efforts on climate diplomacy are headed in the right direction. However, the EU has not lived up to its potential and more is needed to move climate from the technical niche of UN climate negotiations into all foreign policy channels and to leverage the Europe's influence and weight in global climate politics and effectively tackle the most pressing challenge of our times. The EU and its Member States should take a frontrunner role on climate action by supporting other countries in their green transition and reducing the Union's environmental footprint abroad.

The EU and its Member States have made progress in contributing to international climate finance, but their current and future spending falls short of the fair share, which is about 1.5 times higher than current contributions. Failing on international climate finance could undermine future climate diplomacy efforts and hinder the global transition to climate neutrality. The EU should increase its contributions to what would be a fair share and encourage other donors to do the same. This will help meet the USD 100 billion goal and ensure that developing countries have the necessary support to scale up low-carbon technologies and achieve domestic climate targets.

The EU's ecological footprint abroad, particularly in terms of imported CO_2 emissions, has increased annually and thus further actions are needed to address the balance of embodied emissions. This can be achieved through measures such as promoting sustainable trade practices, setting stringent environmental standards for imports, and supporting the deployment of renewable energy and energy-efficiency projects in partner countries.

Aligning international finance: Walking the talk towards the Paris Agreement's goals

The EU's international climate finance is not consistently aligned with the targets of the Paris Agreement. Although the EU has committed to the Glasgow Climate Pact and expressed the need to eliminate ineffective fossil-fuel subsidies, its Member States have not established

specific timelines for ending export credits. Furthermore, in response to the Russian war against Ukraine, the EU has implemented contingency measures and a diversification strategy that contradict the goals of the Paris Agreement. For instance, the EU and its Member States have actively endorsed the construction of new gas infrastructure abroad. The EU should thus further strengthen its efforts to align all public funding with the goals of the Paris Agreement. This includes implementing a budget classification system to monitor the compatibility of external finance, transforming the EIB into a true 'climate bank', and ensuring that financed projects support renewable energy, energy efficiency, and climate resilience measures while phasing out fossil fuel financing as quickly as possible. Finally, EU must ensure that its current contingency measures and diversification strategy do not hinder global long-term decarbonisation goals or send mixed signals.

Paving the way for climate mainstreaming in foreign policy

The importance of incorporating climate considerations into all aspects of foreign policy is emphasised in the EU Green Deal and regularly in conclusions from the Foreign Affairs Council (FAC). Although there is growing recognition of using foreign policy as a means for addressing climate change, the actual implementation varies between foreign policy areas. While climate change is recognised as a strategic priority within the EU's development cooperation and is increasingly incorporated into bilateral multi-annual indicative planning (MIPs), the integration of climate into trade policy is still in its early stages. One cause or explanation for this may be that important EU institutions lack the resources and capacities to effectively carry out their climate-related responsibilities.

The EU should thus integrate climate considerations into all relevant foreign policy channels, such as those related to finance and investment, international trade, international development cooperation, and industrial policy. In addition, the EU should deploy all international fora as well as bilateral and multilateral channels to proactively promote decarbonisation efforts in all sectors of the economy. For this to be successful, it is important to move from a narrative revolving around punitive measures to cooperation on equal footing among partners and create a positive agenda, e.g., on the nexus between trade and climate.

To create the conditions for this, the EU should expand climate competences and expertise in the EU's key foreign policy institutions to ensure sufficient and adequate capacity to address climate change issues effectively. In particular, the EU should empower the EU Climate Ambassador at Large for Climate Diplomacy with an expanded team and power to full fill its mandate.

Strengthening Team Europe for coordinated impact and synergistic success

The EU as a whole has huge potential to help shape global climate action. In order to live up to its potential, it is essential to improve the coordination between the EU and its Member States. To date, the EU and its Member States often fail to effectively mobilise all foreign policy levers of influence or consistently speak with one voice on climate-related foreign policies. The Team Europe Approach has had some success in combining institutions and Member States' expertise and knowledge in the development cooperation. Expanding the Team Europe Approach hand in hand with the Global Gateway for climate action and building on formal and informal channels of communication can help the EU to better leverage its enormous strengths and speak with a more consistent voice. More specifically, it will be key to use the EU's negotiating power in trade agreements to help ensure that globally ambitious environmental and climate goals are met, and sustainable and low-carbon practices are promoted worldwide. The EU should also actively promote global climate action through domestic action, using the EU's large market and resulting power to set global trends and drive ambitious standards and norms. The so-called 'Brussels effect," whereby EU regulations and standards often prevail worldwide, should be implemented in a way that promotes transition without patronising countries in the Global South. The EU should also support ambitious Member State initiatives, like the Group of Friends, which promotes enhanced climate mainstreaming in and coordination of EU and Member States' foreign policy.

Box 17: Highlights from the assessment of External Action

Top climate finance donor, but long way to go to meet the 'fair share'

The EU and its Member States have become the leading contributors to international public climate finance, doubling their contributions since 2013 to reach over EUR 23 billion in 2021. However, their current and projected spending falls below their equitable share, suggesting the need for approximately 1.5 times higher values compared to their current contributions.

EU's 'climate bank' continues to finance fossil fuels abroad

The European Investment Bank (EIB) aimed to become the EU's 'climate bank' by aligning all its financing activities with the Paris Agreement by the end of 2020. Although the EIB has shown a positive trend in investing in clean projects outside the EU, these investments have dropped nearly half from 2019 to 2021, while it still invested about EUR 66 million in fossil fuel projects outside the EU in 2021.

Action needed to match narrative of climate mainstreaming

The EU Green Deal has been instrumental in expanding the importance of climate-related issues beyond UN climate negotiations and incorporating them into the wider domain of foreign policy. However, the extent to which this shift has been implemented differs across foreign policy areas, with greater progress observed in sectors like international development cooperation and slower progress in areas like trade policy.

5. References

Literature references

Abokhoza, R., Mohamed, S. H., & Narula, S. (2019). How Advertising Reflect Culture and Values: A Qualitative Analysis Study. *Journal of Content, Community and Communication*, *10*(9), 114–122. https://doi.org/10.31620/JCCC.12.19/12

ACER. (2022). *Wholesale Electricity Market Monitoring 2022 – Key Developments*. European Union Agency for the Cooperation of Energy Regulators. https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER%20MACZT%20Report%202021.pdf

ACER. (2023). *Wholesale electricity market monitoring shows demand reduction and CO2 emissions increasing in 2022*. European Union Agency for the Cooperation of Energy Regulators. https://acer.europa.eu/news-and-events/news/wholesale-electricity-market-monitoring-shows-demand-reduction-and-co2-emissions-increasing-2022

Ademe. (2021). *Prospective—Transitions 2050—Rapport*. https://librairie.ademe.fr/recherche-et-innovation/5072-prospective-transitions-2050-rapport.html

Agora Energiewende. (2019). *The Liberalisation of Electricity Markets in Germany—History, Development and Current Status*. https://www.agora-energiewende.de/en/publications/the-liberalisation-of-electricity-markets-in-germany/

Agora Energiewende. (2021). *No-regret green hydrogen—Pathways*. Agora Energiewende. https://static.agora-energiewende.de/fileadmin/Success_Stories/PW/PW_EU_Green-H2/A-E_241_Succ_Stor_Pathways_EU_H2_hubs_WEB.pdf

Agora Energiewende. (2023). *Breaking free from fossil gas—A new path to a climate-neutral Europe*. https://static.agora-energiewende.de/fileadmin/Projekte/2021/2021_07_EU_GEXIT/A-EW_292_Breaking_free_WEB.pdf

Al-Enazi, A., Okonkwo, E., Bicer, Y., & Al-Ansari, T. (2021). A review of cleaner alternative fuels for maritime transportation. *Energy Reports*, *7*. https://doi.org/10.1016/j.egyr.2021.03.036.

Air Clim. (2022). *Case study: Stockholm BECCS*. Air Pollution & Climate Secretariat. https://www.airclim.org/acidnews/case-study-stockholm-beccs

Akenji, L., Bengtsson, M., Toivio, V., Lettenmeier, M., Fawcett, T., Parag, Y., Saheb, Y., Coote, A., Spangenberg, J., Capstick, S., Gore, S., Coscieme, L., Wackernagel, M., & Kenner, D. (2021). *1.5-Degree Lifestyles: Towards A Fair Consumption Space for All*. Hot or Cool Institute. https://hotorcool.org/1-5-degree-lifestyles-report/

Almeida, I., Rösch, C., & Saha, S. (2021). Converting monospecific into mixed forests: Stakeholders' views on ecosystem services in the Black Forest Region. *Ecology and Society*, *26*(4). https://doi.org/10.5751/ES-12723-260428

AMBER. (2023). *AMBER, Adaptive Management of Barriers in European Rivers*. Adaptive Management of Barriers in European Rivers. https://amber.international/

Amoroso, S., Aristodemou, L., & Criscuolo, C. (2021). World corporate top R&D investors: Paving the way to carbon neutrality. *European Commission, Joint Research Centre, Organisation for Economic Co-Operation and Development*. https://op.europa.eu/en/publication-detail/-/publication/910ccf7b-4c16-11ec-91ac-01aa75ed71a1/language-en

Anthonsen, K. L., & Christensen, N. P. (2021). *EU Geological CO2 storage summary—Prepared by Geological Survey of Denmark and Greenland for Clean Air Task Force* (No. 34; Geological Survey of Denmark and Greenland, p. 27). Danish Ministry of Climate, Energy and Utilities.

Asquith, M., Dumitru, A., Larsen, H., Maguire, C., Kern, F., & Hilsher, S. (2022). *Transforming Europe's food system—Assessing the EU policy mix* (Publication No. 14/2022). European Environment Agency. https://www.eea.europa.eu/publications/transforming-europes-food-system

Averchenkova, A., Fankhauser, S., & Finnegan, J. (2018). *The role of independent bodies in climate Governance: The UK's Committee on Climate Change* (pp. 1–28). http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2018/10/The-role-of-independent-bodies-in-climate-governance-the-UKs-Committee-on-Climate-Change_Averchenkova-et-al.pdf

Averchenkova, A., Fankhauser, S., & Finnegan, J. J. (2020). The impact of strategic climate legislation: Evidence from expert interviews on the UK Climate Change Act. *Climate Policy*, *21*(2), 251–263. https://doi.org/10.1080/14693062.2020.1819190

Azau, S. (2023). *Heat pump record: 3 million units sold in 2022, contributing to REPowerEU targets*. European Heat Pump Association. https://www.ehpa.org/press_releases/heat-pump-record-3-million-units-sold-in-2022-contributing-to-repowereu-targets/

Bali, A. S., Howlett, M., Lewis, J. M., & Ramesh, M. (2021). Procedural policy tools in theory and practice. *Policy and Society*, *40*(3), 295–311. https://doi.org/10.1080/14494035.2021.1965379

BBC. (2022). *Drax: UK power station owner cuts down primary forests in Canada*. BBC News - Science. https://www.bbc.com/news/science-environment-63089348

BECCS Stockholm. (2023). *Startsida—Beccs Stockholm*. https://beccs.se/

Bellassen, V., Angers, D., Kowalczewski, T., & Olesen, A. (2022). Soil carbon is the blind spot of European national GHG inventories. *Nature Climate Change*, *12*(4), 324–331. https://doi.org/10.1038/s41558-022-01321-9

Bey, N., McDonald, H., Maya-Drysdale, L., Stewart, R., Pätz, C., Hornsleth, M. N., Duin, L., Frelih-Larsen, A., Heller, C., & Zakkour, P. (2021). *Certification of Carbon Removals: Part 1—Synoptic review of carbon removal solutions.* (No. 0795). Environment Agency Austria. https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0795.pdf

Beyond Fossil Fuels. (2022). *All of Europe's existing and planned coal power plants (by status)*. Europe Beyond Coal. https://beyondfossilfuels.org/coal/

Biedenkopf, K., & Petri, F. (2021). The European External Action Service and EU Climate Diplomacy: Coordinator and supporter in Brussels and beyond. *European Foreign Affairs Review*, *26*(1), 71–86.

Bieker, G. (2021). *A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars*. the International Council on Clean Transportation. https://theicct.org/publication/a-global-comparison-of-the-life-cycle-greenhouse-gas-emissions-of-combustion-engine-and-electric-passenger-cars/

Bizarro, S., and Ferreiro, M. de F. (2022). Sustainable public procurement in Portugal: The case of two public school canteens. Regional Science Policy & Practice, 14(3), 560–574. https://doi.org/10.1111/rsp3.12508

Blot, E., & Kettunen, M. (2021). *Trade policy review: How green is the future of EU trade?* https://ieep.eu/news/trade-policy-review-how-green-is-the-future-of-eu-trade/

BMUV. (2020). *Fuel Emission Allowance Trading Act (BEHG)*. Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. https://www.bmuv.de/en/law/fuel-emissions-trading-act

Boehm, S., Jeffery, L., Levin, K., Hecke, J., Schumer, C., Fyson, C., Majid, A., Jaeger, J., Nilsson, A., Naimoli, S., Thwaites, J., Cassidy, E., Lebling, K., Sims, M., Waite, R., Wilson, R., Castellanos, S., Singh, N., Lee, A., & Geiges, A. (2022). *State of Climate Action 2022*. https://www.wri.org/research/state-climate-action-2022

Bon, F. (2022). *Plus de produits bio et sains dans les cantines: La loi est-elle respectée depuis le 1er janvier ?* https://www.ouest-france.fr/economie/agriculture/mange-t-on-vraiment-mieux-dans-les-cantines-depuis-le-1er-janvier-2022-37d3933a-7226-11ec-8d9e-588470c235b8

Bounie, D., Camara, Y., Fize, E., Galbraith, J., Landais, C., Lavest, C., Pazem, T., & Savatier, B. (2020). Consumption dynamics in the Covid crisis: Real time insights from French transaction bank data. *Covid Economics*, *59*, 1–39.

BPIE. (2021). *Deep Renovation: Shifting from exception to standard practice in EU Policy > BPIE - Buildings Performance Institute Europe*. Buildings Performance Institute Europe. https://www.bpie.eu/publication/deep-renovation-shifting-from-exception-to-standard-practice-in-eu-policy/

BPIE. (2022). *Reducing carbon emissions over the life of a building: Opportunities in the 2022 EPBD recast > BPIE - Buildings Performance Institute Europe*. Buildings Performance Institute Europe. https://www.bpie.eu/publication/reducing-carbon-emissions-over-the-life-of-a-building-opportunities-in-the-2022-epbd-recast/

Brandt, S. (2021). *Public funding and strict monitoring needed for CO2 removal technologies to have an impact*. https://climatestrategies.org/public-funding-and-strict-monitoring-needed-for-co2-removal-technologies-to-have-an-impact/

Braun, A., & Rid, W. (2017). Energy consumption of an electric and an internal combustion passenger car. A comparative case study from real world data on the Erfurt circuit in Germany. *Transportation Research Procedia*, *27*, 468–475. https://doi.org/10.1016/j.trpro.2017.12.044

Brockway, P., Sorrell, S., Semieniuk, G., Kuperus Heun, M., & Court, V. (2021). *Energy efficiency and economy-wide rebound effects: A review of the evidence and its implications*. https://doi.org/10.1016/j.rser.2021.110781

Brook, L. (2022). *Organic Agriculture Helps Solve Climate Change*. Natural Resources Defense Council. https://www.nrdc.org/bio/lena-brook/organic-agriculture-helps-solve-climate-change

Bruegel. (2023a). *The fiscal side of Europe's energy crisis: The facts, problems and prospects*. https://www.bruegel.org/blog-post/fiscal-side-europes-energy-crisis-facts-problems-and-prospects#:~:text=As%20shown%20in%20the%20Bruegel,September%202021%20and%20January%202023.

Bruegel. (2023b). *National fiscal policy responses to the energy crisis*. https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices.

Brulle, R. J., & Young, L. E. (2007). Advertising, Individual Consumption Levels, and the Natural Environment, 1900–2000. *Sociological Inquiry*, *77*(4), 522–542. https://doi.org/10.1111/j.1475-682X.2007.00208.x

Buckwell, A., & Nadeu, E. (2018). *What is the Safe Operating Space for EU livestock?* RISE Foundation. https://risefoundation.eu/wp-content/uploads/2020/07/2018_RISE_Livestock_Full.pdf

Buenstorf, G., & Cordes, C. (2008). Can sustainable consumption be learned? A model of cultural evolution. *Ecological Economics*, *67*(4), 646–657.

Bundesregierung. (2023). *So soll das Deutschlandticket funktionieren*. https://www.bundesregierung.de/breg-de/aktuelles/deutschlandticket-2134074

CAN Europe. (2022). *Climate Laws in Europe—Essential for achieving climate neutrality*. CAN Europe. https://caneurope.org/climate-laws-in-europe-essential-for-achieving-climate-neutrality/

Carmichael, R. (2019). *Behaviour change, public engagement and Net Zero. A report for the Committee on Climate Change*. Imperial College London. https://d423d1558e1d71897434.b-cdn.net/wp-content/uploads/2019/10/Behaviour-change-public-engagement-and-Net-Zero-Imperial-College-London.pdf

Carrick, J. (2022). *Governance Structures and Practices of Climate Assemblies* (KNOCA Briefing No. 6). Knowledge Network on Climate Assemblies (KNOCA). https://knoca.eu/governance-structures-and-practices-of-climate-assemblies/

CAT. (2022). *EU country assessment—November 2022*. Climate Action Tracker. https://climateactiontracker.org/countries/eu/

CAT. (2023). *Website—Home*. Climate Action Tracker: New Climate Institute, Climate Analytics. https://climateactiontracker.org/

CATF. (2023). *Global Carbon Capture Project Map*. Clean Air Task Force. https://www.catf.us/ccsmapglobal/

CCPI. (2023). *European Union – Climate Performance Ranking 2023*. Climate Change Performance Index. https://ccpi.org/country/eu/

Ceccherini, G., Duveiller, G., Grassi, G., Lemoine, G., Avitabile, V., Pilli, R., & Cescatti, A. (2020). Abrupt increase in harvested forest area over Europe after 2015. *Nature*, *583*(7814), 72–77. https://doi.org/10.1038/s41586-020-2438-y

CEE Bankwatch. (2022). *Status of the Territorial Just Transition Plans in the Central and Eastern Europe. October 2022 update*. CEE Bankwatch Network. https://bankwatch.org/wp-content/uploads/2022/10/2022-10-07_Status-of-the-Territorial-Just-Transition-Plans-in-central-and-eastern-Europe.pdf

CEE Bankwatch. (2023). *What is the current state of play of the just transition processes in Bulgaria?* CEE Bankwatch Network. https://www.just-transition.info/wp-content/uploads/2023/01/2023-01-30_What-is-the-current-state-of-play-of-the-just-transition-processes-in-Bulgaria.pdf

CEPS & CoE. (2012). *The uptake of green public procurement in the EU27*. Centre for European Policy Studies, College of Europe. https://ec.europa.eu/environment/gpp/pdf/CEPS-CoE-GPP%20MAIN%20REPORT.pdf

Cervantes, M., Criscuolo, C., Dechezleprêtre, A., & Pilat, D. (2022). Driving low-carbon innovations for climate neutrality. *OECD Publishing*. https://www.oecd-ilibrary.org/science-and-technology/driving-low-carbon-innovations-for-climate-neutrality_8e6ae16b-en

Chan, A. P. C., & Adabre, M. A. (2019). Bridging the gap between sustainable housing and affordable housing: The required critical success criteria. *Building and Environment*, *151*, 112–125. https://doi.org/10.1016/j.buildenv.2019.01.029

Charalampakis, E., Fagandini, B., Henkel, L., & Osbat, C. (2022). *The impact of the recent rise in inflation on low-income households*. ECB. https://www.ecb.europa.eu/pub/economic-bulletin/focus/2022/html/ecb.ebbox202207_04~a89ec1a6fe.en.html

Ciocanel, A. B., & Pavelescu, F. M. (2015). *Innovation and Competitiveness in European Context*. https://www.sciencedirect.com/science/article/pii/S2212567115014550?via%3Dihub

City of Copenhagen. (2019). *The Bicycle Account 2018: Copenhagen City of Cyclists*. https://kk.sites.itera.dk/apps/kk_pub2/index.asp?mode=detalje&id=1962

Clausen, U., & Voll, R. (2013). A comparison of North American and European railway systems: Why Europe needs particular optimization models for railway freight traffic. *European Transport Research Review*, *5*(3), 129–133. https://doi.org/10.1007/s12544-013-0090-4

Cleantech for Europe. (2023). *Cleantech for Europe*. Cleantech for Europe. https://www.cleantechforeurope.com/

Clever. (2022). *Sufficiency's integration into climate and energy strategies*. Clever. https://negawatt.org/IMG/pdf/2210_sufficiency_briefing_note.pdf

COACCH. (2021). *The Economic Cost of Climate Change in Europe—Synthesis Report on COACCH Sector Results* (COACCH: CO-Designing the Assessment of Climate CHange Costs, p. 22). COACCH project. https://www.coacch.eu/wp-content/uploads/2018/03/COACCH-policy-brief-2-Sector-results-amended.pdf

Colenbrander, S., Pettinotti, L., & Cao, Y. (2022). *A fair share of climate finance?* ODI. https://unfccc.int/sites/default/files/resource/ODI_A_fair_share_of_climate_finance.pdf

Colthorpe, A. (2022). *Europe needs a 'massive rollout' of energy storage*. Energy Storage News. https://www.energy-storage.news/europe-needs-a-massive-rollout-of-energy-storage/

CoM. (2022). *Reporting Guidelines on Energy Poverty*. Covenant of Mayors for Climate and Energy. https://eu-mayors.ec.europa.eu/sites/default/files/2022-10/Covenant-reporting-guidelines-energy%20poverty-final.pdf

Council of the European Union. (2017). *The New European Consensus on Development "Our World, Our Dignity, Our Future."* https://international-partnerships.ec.europa.eu/system/files/2019-09/european-consensus-on-development-final-20170626_en.pdf

Council of the European Union. (2022). *Europe's contribution to climate finance (€bn)*. https://www.consilium.europa.eu/en/infographics/climate-finance/

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food*, *2*(3), 198–209. https://doi.org/10.1038/s43016-021-00225-9

Danguy, J., de Rassenfosse, G., & van Pottelsberghe de la Potterie, B. (2018). The R&D-patent relationship: An industry perspective. *European Investment Bank*. https://www.econstor.eu/bitstream/10419/44900/1/618781218.pdf

Dartevelle, O., Altomonte, S., Mlecnik, E., & Van Moeseke, G. (2022). Indoor Summer Thermal Comfort in a Changing Climate: The Case of a Nearly Zero Energy House in Wallonia (Belgium). *Energies*, *15*(7). https://dial.uclouvain.be/pr/boreal/object/boreal:260013

de Jong, F. (2023). *Building Europe's net-zero future*. European Climate Fondation. https://europeanclimate.org/wp-content/uploads/2022/03/ecf-building-emissions-problem-march2022.pdf

de Vivero-Serrano, G., Burges, K., Kurdziel, M.-J., & Hagemann, M. (2019). *Transition towards a decarbonised electricity sector—A framework of analysis for power system transformation*. NewClimate Institute.

Delre, A., La Placa, M., Alfieri, F., Faraca, G., Kowalska, M., Vidal Abarca Garrido, C., & Wolf, O. (2022). *Revision of the EU Green Public Procurement Criteria for Transport*. Joint Research Center. https://dx.doi.org/10.2760/661750

Deutsche Welle. (2019). *EU election: Surge for Greens and Euroskeptics*. https://www.dw.com/en/eu-election-surge-for-greens-and-euroskeptics-losses-for-centrist-blocs/a-48883806

DG DEVCO. (2020). *Strategic Plan 2020-2024: Directorate General for International Cooperation and Development—DG DEVCO*. European Commission. https://commission.europa.eu/system/files/2020-10/devco_sp_2020_2024_en.pdf

DG Energy, IPSOS, & Navigant. (2019). *Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU: Final report*. European Commission. https://data.europa.eu/doi/10.2833/14675

DNV. (2022). *Demand Side Flexibility—Quantification of benefits in the EU* (Vol. 21, Issue 1, pp. 1–9). DNV. https://www.dnv.com/Publications/demand-side-flexibility-quantification-of-benefits-in-the-eu-232342

Dubash, N. K., Pillai, A. V., Flachsland, C., Harrison, K., Hochstetler, K., Lockwood, M., MacNeil, R., Mildenberger, M., Paterson, M., Teng, F., & Tyler, E. (2021). National climate institutions complement targets and policies. *Science*, *374*(6568), 690–693. https://doi.org/10.1126/science.abm1157

Dubois, G., Sovacool, B., Aall, C., Nilsson, M., Barbier, C., Herrmann, A., Bruyère, S., Andersson, C., Skold, B., Nadaud, F., Dorner, F., Moberg, K. R., Ceron, J. P., Fischer, H., Amelung, D., Baltruszewicz, M., Fischer, J., Benevise, F., Louis, V. R., & Sauerborn, R. (2019). It starts at home? Climate policies targeting household consumption and behavioral decisions are key to low-carbon futures. *Energy Research & Social Science*, *52*, 144–158. https://doi.org/10.1016/j.erss.2019.02.001

Duwe, M. (2022). *Making EU Climate Governance Fit for Net Zero*. Umweltbundesamt, Deutschland. https://www.ecologic.eu/de/18516

Duwe, M., & Evans, N. (2020). *Climate Laws in Europe: Good Practices in Net-Zero Management*. Ecologic Institute; European Climate Foundation.

Duwe, M., Freundt, M., Iwaszuk, E., Knoblauch, D., Maxter, M., Mederake, L., Ostwald, R., Riedel, A., Umpfenbach, K., & Zelljadt, E. (2017). *"Paris compatible" governance: Long-term policy frameworks to drive transformational change*. Ecologic Institute.

Duwe, M., Graichen, J., & Böttcher, H. (2022). *Can current EU climate policy reliably achieve climate neutrality by 2050? Post-2030 crunch issues for the move to a net zero economy*. Ecologic Institute.

Duwe, M., & Spasova, D. (2021). *Measuring progress towards climate neutrality. Part II: Integrating net zero indicators in EU governance processes* (p. 80). Ecologic Institute, IDDRI.

E3G. (2023). *Climate transition plans for companies closer to becoming a rule in the EU - E3G press release*. E3G. https://www.e3g.org/news/climate-transition-plans-for-companies-closer-to-becoming-a-rule-in-the-eu/

EAFO. (2023). *Vehicles and fleet: European Union*. European Alternative Fuels Observatory. https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/vehicles-and-fleet

EC. (2007). *Guidelines for the monitoring and reporting of greenhouse gas emissions*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007D0589&from=EN

EC. (2011). *Analysis associated with the Roadmap to a Resource Efficient Europe Part II. SEC(2011) 1067 final.* European Commission. https://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

EC. (2016). *Buying green! A handbook on green public procurement*. European Commission. https://ec.europa.eu/environment/gpp/pdf/Buying-Green-Handbook-3rd-Edition.pdf

EC. (2017a). *CarbFix2—Upscaling and optimising subsurface, in situ carbon mineralization as an economically viable industrial option*. European Commission. https://cinea.ec.europa.eu/featured-projects/carbfix2_en

EC. (2017b). *Making Public Procurement work in and for Europe. COM/2017/0572 final.* European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2017%3A572%3AFIN

EC. (2018a). *CAP specific objectives explained—Brief No. 5—Efficient soil management*. European Commission. https://agriculture.ec.europa.eu/system/files/2018-12/cap-specific-objectives-brief-5-soil_en_0.pdf

EC. (2018b). *Communication: A Clean Planet for All—A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy* (COM(2018) 773 final). European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0773

EC. (2018c). *In-depth analysis in support on the COM(2018) 773: A Clean Planet for all—A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy* (Issue November). European Commission. https://ec.europa.eu/knowledge4policy/publication/depth-analysis-support-com2018-773-clean-planet-all-european-strategic-long-term-vision_en

EC. (2019a). *Clean Energy for All Europeans: Commission welcomes European Parliament's adoption of new electricity market design proposals. Press release*. European Commission. http://europa.eu/rapid/press-release_IP-19-1836_en.htm

EC. (2019b). *The European Green Deal*. European Commission.

EC. (2019c). *The European Pillar of Social Rights Action Plan*. European Commission. https://op.europa.eu/webpub/empl/european-pillar-of-social-rights/en/

EC. (2020a). *A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system*. European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:ea0f9f73-9ab2-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF

EC. (2020b). *A Renovation Wave for Europe—Greening our buildings, creating jobs, improving lives*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&uri=CELEX:52020DC0662

EC. (2020c). *Circular economy action plan: For a cleaner and more competitive Europe*. European Commission. https://data.europa.eu/doi/10.2779/05068

EC. (2020d). *Communication: Shaping Europe's digital future*. European Commission. https://commission.europa.eu/document/84c05739-547a-4b86-9564-76e834dc7a49_en

EC. (2020e). *Communication: Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people (COM/2020/562 final)*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562

EC. (2020f). *Impact Assessment. Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people*. European Commission. https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en

EC. (2020g). *Proposal for a Regulation of the European Parliament and of the Council Establishing the Just Transition Fund*. European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:b82780d8-3771-11ea-ba6e-01aa75ed71a1.0003.02/DOC_1&format=PDF

EC. (2020h). *The Transport and Mobility Sector*. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/fs_20_2350

EC. (2020i). *Transport and the Green Deal*. European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/transport-and-green-deal_en

EC. (2021a). *Biodiversity Strategy 2030—Barrier Removal for River Restoration*. European Commission. https://environment.ec.europa.eu/system/files/2021-12/Barrier%20removal%20for%20river%20restoration.pdf

EC. (2021b). *Commission Notice Technical guidance on the application of 'do no significant harm' under the Recovery and Resilience Facility Regulation*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021XC0218%2801%29

EC. (2021c). *Commission Staff Working Document accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: EU Soil Strategy for 2030 Reaping the benefits of healthy soils for people, food, nature and climate*. European Commission. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52021SC0323

EC. (2021d). *Communication: Forging a climate-resilient Europe—The new EU Strategy on Adaptation to Climate Change*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

EC. (2021e). *Communication: New EU Forest Strategy for 2030*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0572

EC. (2021f). *Communication: Sustainable Carbon Cycles*. European Commission. https://climate.ec.europa.eu/system/files/2021-12/com_2021_800_en_0.pdf

EC. (2021g). *Impact assessment for the Energy Efficiency Directive*. European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:c20a8b93-e574-11eb-a1a5-01aa75ed71a1.0001.02/DOC_2&format=PDF

EC. (2021h). *Innovation Fund—Driving clean innovative technologies towards the market: Beccs Stockholm: Bio Energy Carbon Capture and Storage by Stockholm Exergi*. European Commission. https://climate.ec.europa.eu/system/files/2022-07/if_pf_2022_beccs_en.pdf

EC. (2021i). *NDICI-Global Europe 'Global Challenges' thematic programme Multi-annual indicative programme 2021-2027* (p. 10). European Commission. https://international-partnerships.ec.europa.eu/system/files/2022-01/mip-2021-c2021-9157-global-challenges-annex_en.pdf

EC. (2021j). *Proposal for a Regulation of the European Parliament and of the Council amending Regulations (EU) 2018/841 as regards the scope, simplifying the compliance rules, setting out the targets of the Member States for 2030 and committing to the collective achievement of climate neutrality by 2035 in the land use, forestry and agriculture sector, and (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0554

EC. (2021k). *Proposal for a Regulation of the European Parliament and of the Council Establishing a Social Climate Fund*. European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:9e77b047-e4f0-11eb-a1a5-01aa75ed71a1.0001.02/DOC_3&format=PDF

EC. (2021l). *Proposal for a Regulation of the European Parliament and of the Council on the making available on the Union market as well as export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0706

EC. (2021m). *Questions and Answers: An open, sustainable and assertive trade policy*. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_645

EC. (2021n). *Register of Commission Documents—SWD(2021)305*. European Commission. https://ec.europa.eu/transparency/documents-register/detail?ref=SWD(2021)305&lang=en

EC. (2021o). *Sustainable and Smart Mobility Strategy*. European Commission. https://transport.ec.europa.eu/system/files/2021-04/2021-mobility-strategy-and-action-plan.pdf

EC. (2022a). *2022 Report on Energy Subsidies in the EU*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0642

EC. (2022b). *Application of EU health and environmental standards to imported agricultural and agri-food products*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0226

EC. (2022c). *Commission proposes certification of carbon removals* [Text]. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7156

EC. (2022d). *Commission Staff working Document implementing the Repower EU action plan: Investment needs, hydrogen accelerator and achieving the bio-methane targets accompanying the document communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions REpowerEU Plan*.

European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD%3A2022%3A230%3AFIN

EC. (2022e). Digitalising the energy system—EU action plan. In *SWD(2022) 341 final*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0552&qid=1666369684560

EC. (2022f). *Free Trade Agreement Between the European Union and New Zealand*. European Commission. https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/new-zealand/eu-new-zealand-agreement_en

EC. (2022g). *Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources, Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A222%3AFIN

EC. (2022h). *Proposal for a Regulation of the European Parliament and of the Council establishing a Union certification framework for carbon removals*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0672

EC. (2022i). *Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Accelerating the transition to climate neutrality for Europe's security and prosperity EU Climate Action Progress Report 2022*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0514

EC. (2022j). *REPowerEU Plan*. European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0001.02/DOC_1&format=PDF

EC. (2022k). *The power of trade partnerships: Together for green and just economic growth*. European Commission. https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/power-trade-partnerships-together-green-and-just-economic-growth

EC. (2022l). *Zero emission vehicles: First 'Fit for 55' deal will end the sale of new CO2 emitting cars in Europe by 2035* [Text]. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6462

EC. (2023a). *2030 zero-emissions target for new buses and trucks*. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_762

EC. (2023b). *A Green Deal Industrial Plan for the Net-Zero Age*. European Commission. https://commission.europa.eu/system/files/2023-02/COM_2023_62_2_EN_ACT_A%20Green%20Deal%20Industrial%20Plan%20for%20the%20Net-Zero%20Age.pdf

EC. (2023c). *Coal regions in transition—The EU supports coal regions on their path towards decarbonisation and a just transition.* European Commission. https://energy.ec.europa.eu/topics/oil-gas-and-coal/eu-coal-regions/coal-regions-transition_en

EC. (2023d). *Commission recommendations on how to exploit the potential of energy storage*. European Commission. https://energy.ec.europa.eu/news/commission-recommendations-how-exploit-potential-energy-storage-2023-03-14_en

EC. (2023e). *Eco-Innovation Scoreboard*. European Commission. https://green-business.ec.europa.eu/eco-innovation_en

EC. (2023f). *Electricity market design*. European Commission. https://energy.ec.europa.eu/topics/markets-and-consumers/market-legislation/electricity-market-design_en

EC. (2023g). *Energy performance of buildings: Climate neutrality by 2050 | Nieuws | Europees Parlement*. European Commission. https://www.europarl.europa.eu/news/nl/press-room/20230206IPR72112/energy-performance-of-buildings-climate-neutrality-by-2050

EC. (2023h). *Energy storage*. European Commission. https://energy.ec.europa.eu/topics/research-and-technology/energy-storage_en

EC. (2023i). *Environmental Integration*. European Commission. https://ec.europa.eu/environment/integration/integration.htm

EC. (2023j). *European innovation scoreboard*. European Commission. https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en

EC. (2023k). *Greece: Launch of the Just Transition Fund in Megalopolis*. European Commission. https://ec.europa.eu/regional_policy/whats-new/newsroom/20-04-2023-greece-launch-of-the-just-transition-fund-in-megalopolis_en

EC. (2023l). *Have Your Say Web Portal*. European Commission. https://ec.europa.eu/info/law/better-regulation/

EC. (2023m). *JTF: Leaving no one behind in the climate transition*. European Commission. https://cohesiondata.ec.europa.eu/stories/s/JTF-Leaving-no-region-behind-in-the-climate-transi/28yb-762c

EC. (2023n). *Just Transition Fund to ensure a smoother road to carbon-neutral regions*. European Commission. https://ec.europa.eu/regional_policy/whats-new/panorama/2023/04/19-04-2023-just-transition-fund-to-ensure-a-smoother-road-to-carbon-neutral-regions_en

EC. (2023o). *Mainstreaming in the EU budget*. European Commission. https://commission.europa.eu/strategy-and-policy/eu-budget/performance-and-reporting/mainstreaming_en#climate

EC. (2023p). *National long-term strategies*. European Commission. https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en

EC. (2023q). *Nearly zero-energy buildings*. European Commission. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en

EC. (2023r). *Net Zero Industry Act*. European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:6448c360-c4dd-11ed-a05c-01aa75ed71a1.0001.02/DOC_1&format=PDF

EC. (2023s). *Organic farming in the EU: A decade of organic growth*. European Commission, DG Agriculture and Rural Development. https://agriculture.ec.europa.eu/system/files/2023-04/agri-market-brief-20-organic-farming-eu_en.pdf

EC. (2023t). *Proposal for a Regulation of the European Parliament and of the Council amending Regulations (EU) 2019/943 and (EU) 2019/942 as well as Directives (EU) 2018/2001 and (EU) 2019/944 to improve the Union's electricity market design*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023PC0148

EC. (2023u). *Reform of the EU electricity market design*. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1591

EC. (2023v). *Renewable energy targets*. European Commission. https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en

EC. (2023w). *Trade and Climate: EU and partner countries launch the "Coalition of Trade Minsters on Climate."* European Commission. https://ec.europa.eu/commission/presscorner/detail/en/IP_23_248

EC SAM. (2020). *Towards a sustainable food system: Moving from food as a commodity to food as more of a common good: Independent expert report*. European Commission Group of Chief Scientific Advisors. https://data.europa.eu/doi/10.2777/282386

ECA. (2021a). *Common Agricultural Policy and climate: Half of EU climate spending but farm emissions are not decreasing*. European Court of Auditors. https://www.eca.europa.eu/Lists/ECADocuments/SR21_16/SR_CAP-and-Climate_EN.pdf

ECA. (2021b). *Sustainable finance: More consistent EU action needed to redirect finance towards sustainable investment*. European Court of Auditors. https://www.eca.europa.eu/Lists/ECADocuments/SR21_22/SR_sustainable-finance_EN.pdf

ECB. (2022). *Financial Integration and Structure in the Euro Area. ECB Committee on Financial Integration*. European Central Bank. https://www.ecb.europa.eu/pub/pdf/fie/ecb.fie202204~4c4f5f572f.en.pdf

ECCP. (2016). *Working Group Sinks Related to Agricultural Soils—Final Report*. European Climate Change Programme. https://climate.ec.europa.eu/system/files/2016-11/finalreport_agricsoils_en.pdf

Eco-innovation Scoreboard. (2022). *Eco-index 2022—Indicators and methodology*. Eco-innovation Scoreboard. https://circabc.europa.eu/ui/group/96ccdecd-11b4-4a35-a046-30e01459ea9e/library/ddb0a147-f2fc-4555-849a-215c95ba592d/details

Ecologic Institute. (2022). *The use of auctioning revenues from the EU ETS for climate action*. Ecologic Institute. https://www.ecologic.eu/sites/default/files/publication/2022/EcologicInstitute-2022-UseAucRevClimate-FullReport.pdf

Economidou, M., Todeschi, V., & Bertoldi, P. (2019). *Accelerating energy renovation investments in buildings*. JRC Publications Repository. https://doi.org/10.2760/086805

ECRR. (2023). *Welcome to the ECRR website*. European Centre for River Restoration. https://www.ecrr.org/

Edenhofer, O., Franks, M., Kalkuhl, M., & Runge-Metzger, A. (2023). On the Governance of Carbon Dioxide Removal–A Public Economics Perspective. *CESifo Working Paper*, *10370*. https://www.cesifo.org/DocDL/cesifo1_wp10370.pdf

EEA. (2000). *Occupancy rates*. European Environment Agency. https://www.eea.europa.eu/publications/ENVISSUENo12/page029.html

EEA. (2012). *Urban adaptation to climate change in Europe—European Environment Agency*. European Environment Agency. https://www.eea.europa.eu/publications/urban-adaptation-to-climate-change

EEA. (2015). *Percentage of green urban areas in EU-27 core cities* [Figure]. European Environment Agency. https://www.eea.europa.eu/data-and-maps/figures/percentage-of-green-urban-areas-1

EEA. (2017). *Forest: Growing stock, increment and fellings* [Indicator Assessment]. European Environment Agency. https://www.eea.europa.eu/data-and-maps/indicators/forest-growing-stock-increment-and-fellings-3/assessment

EEA. (2019a). *Climate change adaptation in the agriculture sector in Europe* [Publication]. European Environment Agency. https://www.eea.europa.eu/publications/cc-adaptation-agriculture

EEA. (2019b). *Food consumption – animal based protein* (No. 19/2018). European Environment Agency. https://www.eea.europa.eu/airs/2018/resource-efficiency-and-low-carbon-economy/food-consumption-animal-based

EEA. (2020). *The European environment — state and outlook 2020: Knowledge for transition to a sustainable Europe*. European Environment Agency. https://www.eea.europa.eu/soer/2020

EEA. (2021a). *Economic losses from climate-related extremes in Europe*. European Environment Agency. https://www.eea.europa.eu/ims/economic-losses-from-climate-related

EEA. (2021b). *The contribution of national advisory bodies to climate policy in Europe*. European Environment Agency (EEA).

EEA. (2022a). *Greenhouse gas emissions from energy use in buildings in Europe*. European Environment Agency. https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-energy

EEA. (2022b). *Percentage of total green infrastructure, urban green space, and urban tree cover in the area of EEA-38 capital cities (excluding Liechtenstein)* [Data Visualization]. European Environment Agency.

https://www.eea.europa.eu/data-and-maps/daviz/percentage-of-total-green-infrastructure#tab-googlechartid_chart_11

EEA. (2022c). *Soil carbon*. European Environment Agency. https://www.eea.europa.eu/publications/soil-carbon/soil-carbon

EEA. (2022d). *Transforming Europe's food system: Assessing the EU policy mix*. European Environment Agency. https://data.europa.eu/doi/10.2800/295264

EEA. (2022e). *Transport and environment report 2022: Digitalisation in the mobility system: challenges and opportunities.* European Environment Agency. https://data.europa.eu/doi/10.2800/47438

EEA. (2022f). *Trends and projections in Europe 2022*. European Environment Agency. https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2022

EEA. (2023a). *Economic losses from climate-related extremes in Europe (8th EAP)*. European Environment Agency. https://www.eea.europa.eu/ims/economic-losses-from-climate-related

EEA. (2023b). *EEA greenhouse gases—Data viewer on greenhouse gas emissions and removals, sent by countries to UNFCCC and the EU Greenhouse Gas Monitoring Mechanism (EU Member States).* European Environment Agency. https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

EEA. (2023c). *Greenhouse gas emissions from transport in Europe*. European Environment Agency. https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-transport

EEA. (2023d). *LULUCF sector emissions and removals in the EU, by main land use category* [Data Visualization]. European Environment Agency. https://www.eea.europa.eu/data-and-maps/daviz/eu-emissions-and-removals-of-1#tab-chart_2

EEA. (2023e). *Use of auctioning revenues generated under the EU Emissions Trading System*. European Environment Agency. https://www.eea.europa.eu/ims/use-of-auctioning-revenues-generated

EIB. (2019). *EIB Group's Climate Bank Roadmap*. European Investment Bank. https://www.eib.org/en/about/priorities/climate-action/cbr/index.htm

EIB. (2023). *Investment report 2022/2023 Key findings, resilience and renewal in Europe*. European Investment Bank. https://www.eib.org/attachments/lucalli/20230024_economic_investment_report_2022_2023_key_findings_en.pdf

Elstub, S., Carrick, J., Farrell, D. M., & Mockler, P. (2021). The Scope of Climate Assemblies: Lessons from the Climate Assembly UK. *Sustainability*, *13*(20). https://doi.org/10.3390/su132011272

Ember. (2022a). *European Union | Electricity Transition*. Ember. https://ember-climate.org/countries-and-regions/regions/european-union/

Ember. (2022b). *New Generation: Building a clean European electricity system by 2035* (Issue June). Ember. https://ember-climate.org/insights/research/new-generation/

Ember. (2023). *European Electricity Review 2023*. Ember. https://ember-climate.org/insights/research/european-electricity-review-2023/

Enerdata. (2022). *Study on energy subsidies and other government interventions in the European Union – 2022 edition*. Publications Office to the European Union. https://op.europa.eu/en/publication-detail/-/publication/34a55767-55a1-11ed-92ed-01aa75ed71a1

Energiesprong. (2023). *Energiesprong*. Global Energiesprong Alliance. https://energiesprong.org/

EP. (2020). *European Parliament resolution of 22 October 2020 with recommendations to the Commission on an EU legal framework to halt and reverse EU-driven global deforestation (2020/2006(INL))*. European Parliament. https://www.europarl.europa.eu/doceo/document/TA-9-2020-0285_EN.html

EP. (2022). *UN Climate Change Conference 2022 in Sharm-el-Sheikh, Egypt (COP27) European Parliament resolution of 20 October 2022 on the 2022 UN Climate Change Conference in Sharm El-Sheikh, Egypt (COP27) (2022/2673(RSP))*. European Parliament. https://www.europarl.europa.eu/doceo/document/TA-9-2022-0373_EN.pdf

EPRS. (2023). *Revision of the LULUCF Regulation Strengthening the role of the land use, land-use change and forestry sector in climate action—Briefing*. European Parliamentary Research Service. https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698843/EPRS_BRI(2021)698843_EN.pdf

Eräjää, S. (2021). *Marketing Meat. How EU Promotional Funds Favour Meat and Dairy.* Greenpeace. https://www.greenpeace.org/static/planet4-eu-unit-stateless/2021/04/20210408-Greenpeace-report-Marketing-Meat.pdf

EU. (2023a). *2023 Common Reporting Format (CRF) Table* [Data set]. https://unfccc.int/documents/627830

EU. (2023b). *Towards open and fair world-wide trade*. European Union. https://european-union.europa.eu/priorities-and-actions/actions-topic/trade_en

EU Survey. (2022). *EFRAG Sustainability Reporting Board Consultation Survey 2* [Data set]. https://ec.europa.eu/eusurvey/publication/5948e319-2d2b-233b-7be5-980274eb1131

EUCO. (2023). *Council and Parliament reach provisional deal on renewable energy directive*. Council of the European Union. https://www.consilium.europa.eu/en/press/press-releases/2023/03/30/council-and-parliament-reach-provisional-deal-on-renewable-energy-directive/

Eurobarometer. (2011). *Special Eurobarometer 372—Climate Change* (No. 372; Climate Change). https://europa.eu/eurobarometer/surveys/detail/1007

Eurobarometer. (2014). *Special Eurobarometer 409—Climate Change* (No. 409; Climate Change). https://europa.eu/eurobarometer/surveys/detail/1084

Eurobarometer. (2015). *Special Eurobarometer 435—Climate Change* (No. 435; Climate Change). https://europa.eu/eurobarometer/surveys/detail/2060

Eurobarometer. (2017). *Special Eurobarometer 459—Climate Change* (No. 459; Climate Change). https://europa.eu/eurobarometer/surveys/detail/2140

Eurobarometer. (2019). *Special Eurobarometer 490—Climate Change* (No. 490; Climate Change). https://europa.eu/eurobarometer/surveys/detail/2212

Eurobarometer. (2021). *Special Eurobarometer 513—Climate Change* (No. 513; Climate Change). https://europa.eu/eurobarometer/surveys/detail/2273

EurObserv'ER. (2022). *The State of Renewable Energies in Europe. Edition 2022.* (No. 21th). EurObserv'ER. https://www.eurobserv-er.org/21st-annual-overview-barometer/#more-9219

Europe Jacques Delors. (2022). *New European Sustainable Standards proposals: Major progress for corporate transparency*. Europe Jacques Delors. https://www.europejacquesdelors.eu/publications/les-nouvelles-propositions-de-normes-durables-europeennes

Eurostat. (2014). *Getting messages across using indicators—A handbook based on experiences from assessing Sustainable Development Indicators*. Eurostat. https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-GQ-12-001

Eurostat. (2019). *The EU's population projected up to 2100*. Eurostat. https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190710-1

Eurostat. (2020a). *Agricultural practices*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/ef_mp_prac/default/table?lang=en

Eurostat. (2020b). *Classification of Environmental Protection Activities and Expenditure (CEPA) and Classification of Resource Management Activities (CReMA)*. Eurostat.

https://ec.europa.eu/eurostat/documents/1798247/12177560/CEPA+and+CReMA+explanatory+notes+-+technical+note.pdf/b3517fb9-1cb3-7cd9-85bd-4e3a3807e28a?t=1609863934103

Eurostat. (2020c). *Tax-to-GDP ratio at 41.1% in EU A one-to-two ratio across Member States newsrealease*. Eurostat. https://ec.europa.eu/eurostat/documents/2995521/11469100/2-29102020-BP-EN.pdf/059a7672-ed6d-f12c-2b0e-10ab4b34ed07?t=1603959306000

Eurostat. (2021a). *Metadata for circular material use rate*. Eurostat. https://ec.europa.eu/eurostat/cache/metadata/en/env_ac_cur_esms.htm

Eurostat. (2021b). *National accounts aggregates by industry*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/nama_10_a64/default/table?lang=en

Eurostat. (2022a). *Emissions of greenhouse gases and air pollutants from final use of CPA08 products—Input-output analysis, ESA 2010*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/env_ac_io10/default/table?lang=en

Eurostat. (2022b). *EU's CO2 footprint continues to decrease*. Eurostat. https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220524-1

Eurostat. (2022c). *Food waste and food waste prevention—Estimates*. Eurostat. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Food_waste_and_food_waste_prevention_-_estimates

Eurostat. (2022d). *Freight transport statistics—Modal split*. Eurostat. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Freight_transport_statistics_-_modal_split

Eurostat. (2022e). *Land cover overview by NUTS 2 regions*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/lan_lcv_ovw/default/table?lang=en

Eurostat. (2022f). *Material footprint*. Eurostat. https://ec.europa.eu/eurostat/cache/metadata/en/cei_pc020_esmsip2.htm

Eurostat. (2022g). *Metadata for material flow accounts*. Eurostat. https://ec.europa.eu/eurostat/cache/metadata/en/env_ac_mfa_sims.htm

Eurostat. (2022h). *Population and population change statistics*. Eurostat. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_and_population_change_statistics

Eurostat. (2022i). *Quarterly greenhouse gas emissions in the EU*. Eurostat. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Quarterly_greenhouse_gas_emissions_in_the_EU

Eurostat. (2022j). *R&D personnel and researchers by sector of performance, fields of R&D and sex*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/rd_p_perssci/default/table?lang=en

Eurostat. (2023a). *Arrears (mortgage or rent, utility bills or hire purchase) from 2003 onwards—EU-SILC survey* [Data set]. https://data.europa.eu/data/datasets/53q4fzmgoktcwj13j3dr7q?locale=en

Eurostat. (2023b). *Complete energy balances. Online data code: NRG_BAL_C*.

Eurostat. (2023c). *Environmental goods and services sector* [Data set]. https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_EGSS1__custom_5978189/default/table?lang=en

Eurostat. (2023d). *Environmental tax revenues* [Data set]. https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_TAX/default/table?lang=en

Eurostat. (2023e). *Heating and cooling from renewables gradually increasing*. Eurostat. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/DDN-20230203-1#:~:text=As%20a%20result%2C%20the%20share,2020%20to%2022.9%25%20in%202021.

Eurostat. (2023f). *Inability to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day—EU-SILC survey* [Data set]. https://ec.europa.eu/eurostat/databrowser/view/ILC_MDES03$DEFAULTVIEW/default/table

Eurostat. (2023g). *Inability to afford paying for one week annual holiday away from home—EU-SILC survey* [Data set]. https://ec.europa.eu/eurostat/databrowser/view/ILC_MDES02$DEFAULTVIEW/default/table

Eurostat. (2023h). *Inability to face unexpected financial expenses—EU-SILC survey* [Data set]. https://ec.europa.eu/eurostat/databrowser/view/ILC_MDES04$DEFAULTVIEW/default/table

Eurostat. (2023i). *Metadata for environmental goods and services sector*. Eurostat. https://ec.europa.eu/eurostat/cache/metadata/en/env_egs_esms.htm

Eurostat. (2023j). *People at risk of poverty or social exclusion by NUTS 2 regions* [Data set]. https://ec.europa.eu/eurostat/databrowser/view/TGS00107/default/table?lang=en&category=livcon.ilc.ilc_pe.ilc_peps

Eurostat. (2023k). *Persons at risk of poverty or social exclusion by age and sex—EU 2020 strategy*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/ILC_PEPS01__custom_3939887/default/table?lang=en

Eurostat. (2023l). *Production, value added and exports in the environmental goods and services sector* [Data set]. https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_EGSS2/default/table?lang=en&category=env.env_egs

Evans, N., & Duwe, M. (2021). *Climate governance systems in Europe: The role of national advisory bodies* (p. 67). Ecologic Institute, IDDRI.

FAO. (2022). *GLEAM v3 Dashboard*. Food and Agriculture Organization. https://foodandagricultureorganization.shinyapps.io/GLEAMV3_Public/

Finance Watch. (2022). *Finance Watch response to the EFRAG consultation on the exposure drafts for the European Sustainability Reporting Standards (ESRS)*. Finance Watch. https://www.finance-watch.org/wp-content/uploads/2022/08/Finance-Watch-Response_EFRAG-consultation_ESRS-sustainability-reporting-standards.pdf

Finnegan, J. J. (2022). Institutions, Climate Change, and the Foundations of Long-Term Policymaking. *Comparative Political Studies*, *55*(7), 1198–1235. https://doi.org/10.1177/00104140211047416

Finnish Climate Panel. (2021). *Finland's climate panel presents recommendations for the emission and sink targets of the Climate Act*. https://www.ilmastopaneeli.fi/tiedotteet/suomen-ilmastopaneeli-esittaa-suositukset-ilmastolain-paasto-ja-nielutavoitteiksi/

Forest Europe. (2020). *FOREST EUROPE | State of Europe's Forests 2020*. https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

Fossil Free EIB. (2022). *EIB Backtracks on Path to Becoming Climate Bank*. Fossil Free EIB. http://fossilfree-eib.eu/wp-content/uploads/2022/11/PATH-Framework-Position-Paper-14112022.pdf

Frelih-Larsen, A., Riedel, A., Hobeika, M., Scheid, A., Gattinger, A., Niether, W., & Siemons, A. (2022). *Role of soils in climate change mitigation*. Umweltbundesamt. https://www.umweltbundesamt.de/publikationen/role-of-soils-in-climate-change-mitigation

Furtado, F. M. B. A. (2013). U.S. and European Freight Railways: The Differences That Matter. *Journal of the Transportation Research Forum*. https://doi.org/10.5399/osu/jtrf.52.2.4174

Fuss, S., Lamb, W. F., Callaghan, M. W., Hilaire, J., Creutzig, F., Amann, T., Beringer, T., de Oliveira Garcia, W., Hartmann, J., Khanna, T., Luderer, G., Nemet, G. F., Rogelj, J., Smith, P., Vicente, J. L. V., Wilcox, J., del Mar Zamora Dominguez, M., & Minx, J. C. (2018). Negative emissions—Part 2: Costs, potentials and side effects. *Environmental Research Letters*, *13*(6), 063002. https://doi.org/10.1088/1748-9326/aabf9f

Garnett, E. E., Balmford, A., Sandbrook, C., Pilling, M. A., & Marteau, T. M. (2019). Impact of increasing vegetarian availability on meal selection and sales in cafeterias. *Proceedings of the National Academy of Sciences*, *116*(42), 20923–20929. https://doi.org/10.1073/pnas.1907207116

German Federal Foreign Office. (2022). *Launch of the Group of Friends for an Ambitious EU Climate Diplomacy* [Press Release]. https://www.auswaertiges-amt.de/en/newsroom/news/group-of-friends-eu-climate/2558706

German, R., Raoult, J., Schmid, C., Mandl, N., & Peglidou, P. (2021). *Agricultural climate mitigation policies and measures: Good practice, challenge, and future perspectives* (ETC/CME Eionet Report No. 6). European Topic Centre on Climate Change Mitigation and Energy. https://www.eionet.europa.eu/etcs/etc-cme/products/etc-cme-reports/etc-cme-report-6-2021-agricultural-climate-mitigation-policies-and-measures-good-practice-challenges-and-future-perspectives

Gibb, D., Thomas, S., & Rosenow, T. (2022). *Metrics matter: Efficient renewable heating and cooling in the Renewable Energy Directive*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/metrics-matter-efficient-renewable-heating-cooling-renewable-energy-directive/

GLCN. (2023). *Global Lead City Network on Sustainable Procurement: Food & Catering*. Global Lead City Network. https://glcn-on-sp.org/priority-sectors/foodandcatering

Gouveia, J. P., Palma, P., Bessa, S., Mahoney, K., & Sequeira, M. (2022). Energy Poverty National Indicators: Insights for a more effective measuring. *Energy Poverty Advisory Hub*. https://energy-poverty.ec.europa.eu/discover/publications/publications/energy-poverty-national-indicators-insights-more-effective-measuring_en

Government of Iceland. (2023). *Energy*. https://www.government.is/topics/business-and-industry/energy/

Graça, M., Cruz, S., Monteiro, A., & Neset, T.-S. (2022). Designing urban green spaces for climate adaptation: A critical review of research outputs. *Urban Climate*, *42*, 101126. https://doi.org/10.1016/j.uclim.2022.101126

Greenpeace. (2019). *Feeding the problem: The dangerous intensification of animal farming in Europe*. Greenpeace. https://www.greenpeace.org/static/planet4-eu-unit-stateless/2019/02/83254ee1-190212-feeding-the-problem-dangerous-intensification-of-animal-farming-in-europe.pdf

Guy, J., Shears, E., & Meckling, J. (2023). National models of climate governance among major emitters. *Nature Climate Change*. https://doi.org/10.1038/s41558-022-01589-x

Hattle, A., Dejgaard, H. P., Pinderup, L., & Roy, C. (2021). *Setting the Standard: Climate Finance from EU and EFTA Member States* (p. 19). ACT Alliance EU.

Hegarty, R. S., Passetti, R. A. C., Dittmer, K. M., Wang, Y., Shelton, S., Emmet-Booth, J., Wollenberg, E., McAllister, T., Leahy, S., Beauchemin, K., & Gurwick, N. (2021). *An evaluation of evidence for efficacy and applicability of methane inhibiting feed additives for livestock*. New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC), Global Research Alliance on Agricultural Greenhouse Gases (GRA), Climate Change, Agriculture and Food Security (CCAFS). https://www.climatelinks.org/sites/default/files/asset/document/2022-01/An%20evaluation%20of%20evidence%20for%20efficacy%20and%20applicability%20of%20methane%20inhibiting%20feed%20additives%20for%20livestock%20FINAL.pdf

Hockenos, P. (2023). *Germans Want Climate Policy—Just Not in Their Homes*. Foreign Policy. https://foreignpolicy.com/2023/05/11/germany-climate-heat-pump-habeck/

Hook, A., Court, V., Sovacool, B. K., & Sorrell, S. (2020). A systematic review of the energy and climate impacts of teleworking. *Environmental Research Letters*, *15*(9), 093003. https://doi.org/10.1088/1748-9326/ab8a84

Howlett, M., Ramesh, M., & Perl, A. (2020). *Studying public policy: Principles and processes* (Fourth edition). Oxford University Press.

Hulme, M. (2009). *Why We Disagree about Climate Change: Understanding Controversy, Inaction and Opportunity*. Cambridge University Press.

Hülsbergen, K.-J., Schmid, H., Chmelikova, L., Rahmann, G., Paulsen, H. M., & Köpke, U. (2023). *Umwelt- und Klimawirkungen des ökologischen Landbaus* (1. Auflage). Verlag Dr. Köster.

I4CE. (2022a). *Global carbon accounts in 2022*. Institute for Climate Economics. https://www.i4ce.org/en/publication/global-carbon-acounts-2022-climate/

I4CE. (2022b). *Implementing prudential transition plans for banks: What are the expected impacts?* I4CE. https://www.i4ce.org/en/publication/implementing-prudential-transition-plans-banks-what-are-expexted-impacts-climate/

I4CE. (2023). *Landscape of climate finance in France – 2022 edition*. https://www.i4ce.org/en/publication/landscape-climate-finance-2022-edition-climate/

Iacobuta, G., Dubash, N. K., Upadhyaya, P., Deribe, M., & Höhne, N. (2018). National climate change mitigation legislation, strategy and targets: A global update. *Climate Policy*, *18*(9), 1114–1132. https://doi.org/10.1080/14693062.2018.1489772

ICAP. (2022). *German National Emissions Trading System*. International Carbon Action Partnership. https://icapcarbonaction.com/en/ets/german-national-emissions-trading-system

ICLEI & IFOAM Organics Europe. (2021). *Sustainable public procurement of food: A goal within reach*. ICLEI - Local Governments for Sustainability, IFOAM Organics Europe. https://foodpolicycoalition.eu/wp-content/uploads/2021/06/Sustainable-public-procurement-of-food-a-goal-within-reach_EU-FPC-website.pdf

IDDRI. (2018). *The creation of a French High Council for Climate is necessary but is not the answer to the "yellow vests" protests*. Institut du Développement Durable et des Relations Internationales. https://www.iddri.org/en/publications-and-events/blog-post/creation-french-high-council-climate-necessary-not-answer-yellow

IEA. (2017). *Co-benefits of energy related building renovation—Demonstration of their impact on the assessment of energy related building renovation (Annex 56)*. International Energy Agency. https://www.iea-ebc.org/Data/publications/EBC_Annex_56_Co-benefits_Energy_Related_Building_Renovation.pdf

IEA. (2018). *World Energy Outlook 2018*. International Energy Agency. https://www.iea.org/weo2018/

IEA. (2021a). *Executive summary – World Energy Outlook 2021 – Analysis*. International Energy Agency. https://www.iea.org/reports/world-energy-outlook-2021/executive-summary

IEA. (2021b). *Net Zero by 2050 – A Roadmap for the Global Energy Sector*. International Energy Agency. https://www.iea.org/reports/net-zero-by-2050

IEA. (2021c). *Net Zero by 2050 – Analysis*. International Energy Agency. https://www.iea.org/reports/net-zero-by-2050

IEA. (2022a). *Direct Air Capture—A key technology for net zero* (p. 74). International Energy Agency. https://www.iea.org/reports/direct-air-capture-2022

IEA. (2022b). *Energy Technology RD&D Budgets*. International Energy Agency. https://www.iea.org/data-and-statistics/data-tools/energy-technology-rdd-budgets-data-explorer

IEA. (2022c). *Is the European Union on track to meet its REPowerEU goals? – Analysis*. International Energy Agency. https://www.iea.org/reports/is-the-european-union-on-track-to-meet-its-repowereu-goals

IEA. (2022d). *World Energy Investment 2022*. International Energy Agency. https://www.iea.org/reports/world-energy-investment-2022

IEA. (2022e). *World Energy Investment 2022*. International Energy Agency. https://www.iea.org/reports/world-energy-investment-2022

IEA. (2022f). *World Energy Outlook 2022 – Analysis*. International Energy Agency. https://www.iea.org/reports/world-energy-outlook-2022

IEA. (2023a). *Energy technology perspectives 2023*. International Energy Agency. https://iea.blob.core.windows.net/assets/a86b480e-2b03-4e25-bae1-da1395e0b620/EnergyTechnologyPerspectives2023.pdf

IEA. (2023b). *Global EV Outlook 2023: Catching up with climate ambitions* (GEVO). IEA. https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf

IEA. (2023c). *Tracking Clean Energy Progress – Methodology*. International Energy Agency. https://www.iea.org/topics/tracking-clean-energy-progress

ILO. (2013). *Resolution concerning sustainable development, decent work and green jobs*. International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_223785.pdf

ILO. (2016). *What is a green job?* International Labour Organization. https://www.ilo.org/global/topics/green-jobs/news/WCMS_220248/lang--en/index.htm

ILO. (2018). *World Employment and Social Outlook 2018: Greening with jobs*. International Labour Organization. https://www.ilo.org/weso-greening/documents/WESO_Greening_EN_web2.pdf

Institut Louis Bachelier, I4CE, CGDD, & WWF. (2020). *The Alignment Cookbook—A Technical Review of Methodologies Assessing a Portfolio's Alignment with Low-carbon Trajectories or Temperature Goal*. https://www.institutlouisbachelier.org/wp-content/uploads/2021/03/the-alignment-cookbook-a-technical-review-of-methodologies-assessing-a-portfolios-alignment-with-low-carbon-trajectories-or-temperature-goal.pdf

IPCC. (2014). *AR5 Climate Change 2014: Mitigation of Climate Change*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar5/wg3/

IPCC. (2018a). *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways.* Intergovernmental Panel on Climate Change. https://www.ipcc.ch/sr15/

IPCC. (2018b). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfeld (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,* (pp. 3–24). Cambridge University Press. https://doi.org/10.1017/9781009157940.001

IPCC. (2019). *Special Report on Climate Change and Land*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/srccl/

IPCC. (2021). *Summary for policymakers* (In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change). IPCC. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

IPCC. (2022a). *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg2/

IPCC. (2022b). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/

IPCC. (2022c). *Climate Change 2022: Mitigation of Climate Change, IPCC Sixth Assessment Report, Working Group III*. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg3/

IPCC. (2023). *AR6 Synthesis Report: Climate Change 2023*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/syr/

IRENA. (2019). Demand-side flexibility for power sector transformation. In *Analytical Brief*. International Renewable Energy Agency. https://www.irena.org/publications/2019/Dec/Demand-side-flexibility-for-power-sector-transformation

IRENA. (2021). *Renewable Power Generation Costs in 2021*. International Renewable Energy Agency. https://www.irena.org/publications/2022/Jul/Renewable-Power-Generation-Costs-in-2021

Jacques Delors Institute. (2022, May 30). *United in diversity? National responses to the european energy crisis*. https://institutdelors.eu/en/publications/united-in-diversity-national-responses-to-the-european-energy-crisis/

Jelks, N. O., Jennings, V., & Rigolon, A. (2021). Green Gentrification and Health: A Scoping Review. *International Journal of Environmental Research and Public Health*, *18*(3), 907. https://doi.org/10.3390/ijerph18030907

Jensen, L., & Scalamandrè, C. (2023). *Climate impact of the EU agrifood system*. European Parliamentary Research Service. https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/739327/EPRS_ATA(2023)739327_EN.pdf

Joppa, L., Luers, A., Willmott, E., Friedmann, S. J., Hamburg, S. P., & Broze, R. (2021). Microsoft's million-tonne CO2-removal purchase—Lessons for net zero. *Nature*, *597*(7878), 629–632. https://doi.org/10.1038/d41586-021-02606-3

Jordan, A., Lorenzoni, I., Tosun, J., i Saus, J. E., Geese, L., Kenny, J., Saad, E. L., Moore, B., & Schaub, S. G. (2022). The political challenges of deep decarbonisation: Towards a more integrated agenda. *Climate Action*, *1*(1), 6. https://doi.org/10.1007/s44168-022-00004-7

JRC. (2020). *SETIS research and innovation data* [Data set]. https://setis.ec.europa.eu/publications/setis-research-and-innovation-data_en?fbclid=IwAR1yIqGV6bbNwwPoP2nVyOJU4STVu6x0E8GM2fUeg7gHPtCGvo9eKJvckME

JRC. (2021). *The future of jobs is green.* European Commission, Joint Research Center. https://data.europa.eu/doi/10.2760/218792

Kahan, D. M., Wittlin, M., Peters, E., Slovic, P., Ouellette, L. L., Braman, D., & Mandel, G. N. (2011). The Tragedy of the Risk-Perception Commons: Culture Conflict, Rationality Conflict, and Climate Change. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1871503

Kettner, C., & Kletzan-Slamanig, D. (2020). Is there climate policy integration in European Union energy efficiency and renewable energy policies? Yes, no, maybe. *Environmental Policy and Governance*, *30*(3), 141–150. https://doi.org/10.1002/eet.1880

KNOCA. (2023). *Knowledge Network On Climate Assemblies*. https://knoca.eu/

Köninger, J., Lugato, E., Panagos, P., Kochupillai, M., Orgiazzi, A., & Briones, M. J. I. (2021). Manure management and soil biodiversity: Towards more sustainable food systems in the EU. *Agricultural Systems*, *194*, 103251. https://doi.org/10.1016/j.agsy.2021.103251

Kost, C., Shammugam, S., Fluri, V., Peper, D., Memar, A. D., & Schlegl, T. (2021). *Levelized Cost of Electricity Renewable Energy Technologies* (p. 48). Frauhofer Institute for Solar Energy Systems ISE.

Kraus, S., & Koch, N. (2021). Provisional COVID-19 infrastructure induces large, rapid increases in cycling. *Proceedings of the National Academy of Sciences*, *118*(15), e2024399118. https://doi.org/10.1073/pnas.2024399118

Kreusel, J., Timbus, A., & Oudalov, A. (2022). *Enabling Europe's net zero vision by proactively developing its power grids*. Hitachi Energy.

https://proceedings.windeurope.org/biplatform/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBbklEIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--864be4c461fca59812d4928690333619f9395240/Hitachi-WindEurope-ProActive-Grid-Development.pdf

Küster, F., and Muste, N. (2022). The state of national cycling strategies in Europe—2nd edition (2022). https://www.ecf.com/files/reports/state-national-cycling-strategies-europe-second-edition-2022

Lähteenmäki-Uutela, A., Rahikainen, M., Lonkila, A., & Yang, B. (2021). Alternative proteins and EU food law. *Food Control*, *130*, 108336. https://doi.org/10.1016/j.foodcont.2021.108336

Lazaric, N., Le Guel, F., Belin, J., Oltra, V., Lavaud, S., & Douai, A. (2020). Determinants of sustainable consumption in France: The importance of social influence and environmental values. *Journal of Evolutionary Economics*, *30*(5), 1337–1366. https://doi.org/10.1007/s00191-019-00654-7

Lenzu, M. D. (2022). *Official development assistance: The EU and its member states remain the biggest global provider*. Council of the European Union. https://www.consilium.europa.eu/en/press/press-releases/2022/07/18/official-development-assistance-the-eu-and-its-member-states-remain-the-biggest-global-provider/

Levarlet, F., Alessandrini, M., Schratzenstaller-Altzinger, M., & Franceschelli, N. (2022). *Climate Mainstreaming in the EU Budget: 2022 Update*. European Parliament. https://www.europarl.europa.eu/thinktank/de/document/IPOL_STU(2022)732007

Lockwood, M. (2021). Routes to credible climate commitment: The UK and Denmark compared. *Climate Policy*, *21*(9), 1234–1247. https://doi.org/10.1080/14693062.2020.1868391

Marcu, A., Fernando López Hernández, J., Alberola, E., Faure, A., Qin, B., O'Neill, M., Schleicher, S., Caneill, J.-Y., Bonfiglio, E., & Vollmer, A. (2022). *2022 State of the EU ETS Report*. European Roundtable on Climate Change and Sustainable Transition. https://ercst.org/state-of-the-eu-ets-report-2022/

Marquardt, J. (2020). Fridays for Future's Disruptive Potential: An Inconvenient Youth Between Moderate and Radical Ideas. *Frontiers in Communication*, *5*. https://doi.org/10.3389/fcomm.2020.00048

MASA. (2018). *Article 24—LOI n° 2018-938 du 30 octobre 2018 pour l'équilibre des relations commerciales dans le secteur agricole et alimentaire et une alimentation saine, durable et accessible à tous (1)—Légifrance*. Ministère de l'agriculture et de l'alimentation souveraine. https://www.legifrance.gouv.fr/loda/article_lc/JORFARTI000037547983/

Matti, S., Petersson, C., & Söderberg, C. (2021). The Swedish climate policy framework as a means for climate policy integration: An assessment. *Climate Policy*, *21*(9), 1146–1158. https://doi.org/10.1080/14693062.2021.1930510

McDonald, H., Bodle, D. R., LLM, Hobeika, M., Scheid, A., Siemons, A., & Schneider, L. (2023). *QU.A.L.ITY Soil Carbon Removals?* https://www.ecologic.eu/de/19080

Messetchkova, I. (2021). *Statement on International Public Support for the Clean Energy Transition*. UN Climate Change Conference (COP26) at the SEC. https://ukcop26.org/statement-on-international-public-support-for-the-clean-energy-transition/

Meyer-Ohlendorf, N., Siemons, A., Schneider, L., & Böttcher, H. (2023). *Certification of Carbon Dioxide Removals: Evaluation of the Commission Proposal*. Ecologic Institute, Öko-Institut. Publisher: German Environment Agency. https://www.umweltbundesamt.de/en/publikationen/certification-of-carbon-dioxide-removals

Moomaw, W. R., Chmura, G. L., Davies, G. T., Finlayson, C. M., Middleton, B. A., Natali, S. M., Perry, J. E., Roulet, N., & Sutton-Grier, A. E. (2018). Wetlands In a Changing Climate: Science, Policy and Management. *Wetlands*, *38*(2), 183–205. https://doi.org/10.1007/s13157-018-1023-8

Morris, C., & Jungjohann, A. (2016). *Energy Democracy: Germany's Energiewende to Renewables*. Springer International Publishing. https://doi.org/10.1007/978-3-319-31891-2

Mulhollem, J. (2019). *Seaweed feed additive cuts livestock methane but poses questions*. Pennsylvania State University. https://www.psu.edu/news/research/story/seaweed-feed-additive-cuts-livestock-methane-poses-questions/

Nabe, C., & Staschus, K. (2023). *Partner Publications—Electricity Market Design for Climate Neutrality*. Agora Energiewende. https://www.agora-energiewende.de/en/publications/electricity-market-design-for-climate-neutrality/

Nash, S. L., & Steurer, R. (2019). Taking stock of Climate Change Acts in Europe: Living policy processes or symbolic gestures? *Climate Policy*, *19*(8), 1052–1065. https://doi.org/10.1080/14693062.2019.1623164

Nemcová, T., Nyssens-James, C., Caiati, S., Dhaskali, M., Gurreck, M., Henningson, L., & Kachler, J. (2022). *New CAP unpacked…and unfit*. European Environmental Bureau, BirdLife Europe, Nature and Biodiversity Conservation Union. https://eeb.org/wp-content/uploads/2022/12/New_CAP_Unpacked-6.pdf

NewClimate Institute. (2018). *The SCAN-tool: A new way to explore links between climate action and SDGs*. NewClimate Institute. https://newclimate.org/news/the-scan-tool-a-new-way-to-explore-links-between-climate-action-and-sdgs

Oberthür, S., Moore, B., von Homeyer, I., & Söebech, Ò. (2023). *Towards an EU Climate Governance Framework to Deliver on the European Green Deal | BSoG*. GreenDeal-NET, VUB Brussels School of Governance Centre for Environment, Economy and Energy. https://brussels-school.be/publications/other-publications/towards-eu-climate-governance-framework-deliver-european-green-deal

OECD. (2020). *Green Budgeting Database*. Organisation of Economic Cooperation and Development. https://qdd.oecd.org/subject.aspx?Subject=GOV_GREENBUD

OECD. (2022). *Trade in Embodied CO2 Database (TECO2)* (Carbon dioxide emissions embodied in international trade (2021 ed.)) [Data set]. https://stats.oecd.org/Index.aspx?DataSetCode=IO_GHG_2021

OECD. (2023). *Regional Industrial Transitions to Climate Neutrality*. Organisation for Economic Cooperation and Development. https://www.oecd-ilibrary.org/sites/35247cc7-en/index.html?itemId=/content/publication/35247cc7-en

Ohlendorf, N., Jakob, M., Minx, J. C., Schröder, C., & Steckel, J. C. (2021). Distributional Impacts of Carbon Pricing: A Meta-Analysis. *Environmental and Resource Economics*, *78*(1), 1–42. https://doi.org/10.1007/s10640-020-00521-1

O'Riordan, V., Rogan, F., Ó Gallachóir, B., MacUidhir, T., & Daly, H. (2022). How and Why We Travel – Mobility Demand and Emissions from Passenger Transport. *Transportation Research Part D: Transport and Environmen*, *104*. https://doi.org/10.1016/j.trd.2022.103195

O'Rourke, D., & Lollo, N. (2015). Transforming Consumption: From Decoupling, to Behavior Change, to System Changes for Sustainable Consumption. *Annual Review of Environment and Resources*, *40*(1), 233–259. https://doi.org/10.1146/annurev-environ-102014-021224

Pagliano, L., & Erba, S. (2022). *Literature review for analysis of lifestyle changes*. Politecnico di Milano. https://fulfill-sufficiency.eu/wp-content/uploads/2022/12/D2.1-Literature-Review.pdf

Pais, D. F., Marques, A. C., & Fuinhas, J. A. (2022). The cost of healthier and more sustainable food choices: Do plant-based consumers spend more on food? *Agricultural and Food Economics*, *10*(1), 18. https://doi.org/10.1186/s40100-022-00224-9

Pauthier, A. (2019). *A Framework for Alignment with the Paris Agreement: Why, What and How for Financial Institutions?* I4CE. https://www.i4ce.org/en/publication/framework-alignment-with-paris-agreement-why-what-and-how-for-financial-institutions/

Pestiaux, J., Cornet, M., Jossen, Q., Martin, B., Matton, V., Meessen, J., Taylor, E., & Vermeulen, P. (2018). *Net zero by 2050: From whether to how. Zero emissions pathways to the Europe we want.* European Climate Foundation.

https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=web&cd=&ved=0CAIQw7AJahcKEwjYj5Ph6o3_AhUAAAAAHQAAAAAQAg&url=https%3A%2F%2Feuropeanclimate.org%2Fwp-content%2Fuploads%2F2019%2F11%2F09-18-net-zero-by-2050-from-whether-to-how.pdf&psig=AOvVaw2OA6pbcHaY-fMm9sauYU4j&ust=1685013543243647

Peyruad, J., & MacLeod, M. (2020). *Future of EU livestock: How to contribute to a sustainable agricultural sector?: Final report*. European Commission. https://data.europa.eu/doi/10.2762/3440

PG&E. (2012). *SmartMeter™ Installation Progress*. Pacific Gas & Electric. https://www.pge.com/myhome/customerservice/smartmeter/deployment/

Pietzcker, R., Feuerhahn, J., Haywood, L., Knopf, B., Leukhardt, F., Luderer, G., Osorio, S., Pahle, M., Rodrigues, R., & Edenhofer, O. (2021). *Hintergrund: Notwendige CO2-Preise zum Erreichen des europäischen Klimaziels 2030*. Ariadne. https://ariadneprojekt.de/publikation/notwendige-co2-preise-zum-erreichen-des-europaeischen-klimaziels-2030/

Polleau, A., & Biermann, G. (2021). Eat local to save the planet? Contrasting scientific evidence and consumers' perceptions of healthy and environmentally friendly diets. *Current Research in Environmental Sustainability*, *3*, 100054. https://doi.org/10.1016/j.crsust.2021.100054

Poralla, M., Honegger, M., Ahonen, H.-M., Michaelowa, A., & Weber, A.-K. (2021). *Sewage Treatment for the Skies. Mobilising carbon dioxide removal through public policies and private financing* (p. 56). NET RAPIDO & Perspectives Climate Research. https://climatestrategies.org/publication/sewage-treatment-for-the-skies-mobilising-carbon-dioxide-removal-through-public-policies-and-private-financing/

Procura+ Network. (2016). *Procura+ | MANUAL*. https://procuraplus.org/manual/

ProVeg. (2022). *Plant-based meat now cheaper on average than conventional meat in Netherlands*. https://proveg.com/press-release/plant-based-meat-now-cheaper-than-conventional-meat-in-netherlands/

Public Finance for Energy Database. (2023). *Data Dashboard*. Public Finance for Energy Database. https://energyfinance.org/#/data

Rack, Y. (2021). *Europe's distribution grids need at least 50% more investment in 2020s – study*. S&P Global Market Intelligence. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/europe-s-distribution-grids-need-at-least-50-more-investment-in-2020s-8211-study-62116858

Rajão, R., Soares-Filho, B., Nunes, F., Börner, J., Machado, L., Assis, D., Oliveira, A., Pinto, L., Ribeiro, V., Rausch, L., Gibbs, H., & Figueira, D. (2020). The rotten apples of Brazil's agribusiness. *Science*, *369*(6501), 246–248. https://doi.org/10.1126/science.aba6646

Reclaim Finance. (2022). *EU Corporate Sustainability Regulations: A key step towards accountability*. Reclaim Finance. https://reclaimfinance.org/site/en/2022/07/26/eu-corporate-sustainability-regulations-a-key-step-towards-accountability/

Rehder, L. (2023). *EU Consumers save on food and buy less organic in 2022* (No. E42023-0005). USDA Foreign Agricultural Service. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=EU%20Consumers%20save%20on%20food%20and%20buy%20less%20organic%20in%202022_Berlin_European%20Union_E42023-0005.pdf

Reisch, L. A., & Sunstein, C. R. (2021). Plant-Based By Default. *One Earth*, *4*(9), 1205–1208. https://doi.org/10.1016/j.oneear.2021.08.007

Rodrigues, L., Hardy, B., Huyghebeart, B., Fohrafellner, J., Fornara, D., Barančíková, G., Bárcena, T. G., De Boever, M., Di Bene, C., Feizienė, D., Kätterer, T., Laszlo, P., O'Sullivan, L., Seitz, D., & Leifeld, J. (2021). Achievable agricultural soil carbon sequestration across Europe from country-specific estimates. *Global Change Biology*, *27*(24), 6363–6380. https://doi.org/10.1111/gcb.15897

Roe, S., Streck, C., Beach, R., Busch, J., Chapman, M., Daioglou, V., Deppermann, A., Doelman, J., Emmet-Booth, J., Engelmann, J., Fricko, O., Frischmann, C., Funk, J., Grassi, G., Griscom, B., Havlik, P., Hanssen, S., Humpenöder, F., Landholm, D., … Lawrence, D. (2021). Land-based measures to mitigate climate change: Potential and feasibility by country. *Global Change Biology*, *27*(23), 6025–6058. https://doi.org/10.1111/gcb.15873

Ross, K., Schumer, C., Fransen, T., Wang, S., & Elliott, C. (2021). *Insights on the first 29 long-term climate strategies submitted to the United Nations Framework Convention on Climate Change*. World Resources Institute. https://www.wri.org/research/insights-first-29-long-term-climate-strategies-submitted-united-nations-framework

RSB. (2021). *Annual Report 2021*. European Commission. https://commission.europa.eu/law/law-making-process/regulatory-scrutiny-board_en#documents

Rúa, J., Bui, M., Nord, L. O., & Mac Dowell, N. (2020). Does CCS reduce power generation flexibility? A dynamic study of combined cycles with post-combustion CO2 capture. *International Journal of Greenhouse Gas Control*, *95*, 102984.

Rüdinger, A., Voss-Stemping, J., Sartor, O., & Duwe, M. (2018). *Towards Paris-compatible climate governance frameworks: An overview of findings from recent research into 2050 climate laws and strategies* (Studies N°04/18; p. 20). IDDRI.

Šajn, N. (2020). *Sustainable consumption. Helping consumers make eco-friendly choices* (p. 10). European Parliamentary Research Service. https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/659295/EPRS_BRI(2020)659295_EN.pdf

Sapir, A., Tagliapietra, S., & Schraepen, T. (2022). *Green Public Procurement: A Neglected Tool in the European Green Deal Toolbox?* https://www.intereconomics.eu/contents/year/2022/number/3/article/green-public-procurement-a-neglected-tool-in-the-european-green-deal-toolbox.html

Schenuit, F., Colvin, R., Fridahl, M., McMullin, B., Reisinger, A., Sanchez, D. L., Smith, S. M., Torvanger, A., Wreford, A., & Geden, O. (2021). Carbon dioxide removal policy in the making: Assessing developments in 9 OECD cases. *Frontiers in Climate*, *3*.

Schenuit, F., & Geden, O. (2022). Carbon Dioxide Removal: Climbing up the EU Climate Policy Agenda 1. *SWP Berlin: Working Paper Research Division EU*, *1*, 18.

Scherhaufer, S., Moates, G., Hartikainen, H., Waldron, K., & Obersteiner, G. (2018). Environmental impacts of food waste in Europe. *Waste Management*, *77*, 98–113. https://doi.org/10.1016/j.wasman.2018.04.038

Schmidt, N. M., & Fleig, A. (2018). Global patterns of national climate policies: Analyzing 171 country portfolios on climate policy integration. *Environmental Science & Policy*, *84*, 177–185. https://doi.org/10.1016/j.envsci.2018.03.003

Schoenwiese, G. (2021). *FW-R-1: Mixed stands*. Umweltbundesamt. https://www.umweltbundesamt.de/en/topics/climate-energy/climate-impacts-adaptation/impacts-of-climate-change/monitoring-report-2019/indicators-of-climate-change-impacts-adaptation/cluster-woodland-forestry/fw-r-1-mixed-stands

Schumer, C., Jaeger, J., Boehm, S., Jeffery, L., Levin, K., Hecke, J., Fyson, C., Naimoli, S., Majid, A., Lebling, K., Sims, M., Castellanos, S., Nilsson, A., Thwaites, J., Waite, R., Cassidy, E., Geiges, A., Wilson, R., Lee, A., & Singh, N. (2022). *Methodology Underpinning the State of Climate Action Series*. Bezos Earth Fund, Climate Action Tracker, Climate Analytics, ClimateWorks Foundation, NewClimate Institute, the United Nations Climate Change High-Level Champions, and World Resources Institute. https://www.wri.org/research/methodology-underpinning-state-climate-action-series

Schwanen, T. (2021). Achieving just transitions to low-carbon urban mobility. *Nature Energy*, *6*, 685–687.

Searchinger, T., Waite, R., Hanson, C., Ranganathan, J., & Matthews, Emily. (2019). *Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050*. https://research.wri.org/sites/default/files/2019-07/WRR_Food_Full_Report_0.pdf

Sensfuß, F., Bernath, C., Kleinschmitt, C., Resch, G., Geipel, J., Hiesl, A., Liebmann, L., Lumbreras, S., Olmos, L., Ramos, A., & Ploussard, Q. (2019). *D7.8: Summary report - Energy systems: Supply perspective*. https://doi.org/10.24406/PUBLICA-FHG-299761

SES. (2018). *In der anderen Stadt verkehren*. Schweizerische Energie-Stiftung. https://www.youtube.com/watch?v=L-NsVnJ70Uc

Shove, E., Pantzar, M., & Watson, M. (2023). *The Dynamics of Social Practice*. https://uk.sagepub.com/en-gb/eur/the-dynamics-of-social-practice/book235021

Smart Protein Project. (2021). *Plant-based foods in Europe: How big is the market?* Smart Protein Project, European Union's Horizon 2020 research and innovation programme (No 862957). https://smartproteinproject.eu/wp-content/uploads/Smart-Protein-Plant-based-Food-Sector-Report-2.pdf

Smith, P., Soussana, J., Angers, D., Schipper, L., Chenu, C., Rasse, D. P., Batjes, N. H., Egmond, F., McNeill, S., Kuhnert, M., Arias-Navarro, C., Olesen, J. E., Chirinda, N., Fornara, D., Wollenberg, E., Álvaro-Fuentes, J., Sanz-Cobena, A., & Klumpp, K. (2020). How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal. *Global Change Biology*, *26*(1), 219–241. https://doi.org/10.1111/gcb.14815

Smith, S. M., Geden, O., Minx, J. C., Nemet, G. F., Gidden, M., Lamb, W. F., & Powis, C. (2023). *The State of Carbon Dioxide Removal Report 2023*. https://policycommons.net/artifacts/3444788/untitled/4244826/

SolarPower Europe. (2022). *New report reveals EU solar power soars by almost 50% in 2022—SolarPower Europe*. https://www.solarpowereurope.org/press-releases/new-report-reveals-eu-solar-power-soars-by-almost-50-in-2022

Solnit, R. (2021). Big oil coined 'carbon footprints' to blame us for their greed. Keep them on the hook. *The Guardian*. https://www.theguardian.com/commentisfree/2021/aug/23/big-oil-coined-carbon-footprints-to-blame-us-for-their-greed-keep-them-on-the-hook

Springmann, M., Clark, M. A., Rayner, M., Scarborough, P., & Webb, P. (2021). The global and regional costs of healthy and sustainable dietary patterns: A modelling study. *The Lancet Planetary Health*, *5*(11), e797–e807. https://doi.org/10.1016/S2542-5196(21)00251-5

Stoknes, P. E. (2014). Rethinking climate communications and the "psychological climate paradox." *Energy Research & Social Science*, *1*, 161–170. https://doi.org/10.1016/j.erss.2014.03.007

Sykes, E. (2022, April 6). Emissions from Imports: An Untapped Opportunity for Decarbonization. *Climate Leadership Council*. https://clcouncil.org/blog/emissions-from-imports-an-untapped-opportunity-for-decarbonization/

Tänzler, D., Ivleva, D., & Hausotter, T. (2021). *EU climate change diplomacy in a post-Covid-19 world*. adelphi. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/653643/EXPO_STU(2021)653643_EN.pdf

Terlouw, T., Bauer, C., Rosa, L., & Mazzotti, M. (2021). Life cycle assessment of carbon dioxide removal technologies: A critical review. *Energy & Environmental Science*, *14*(4), 1701–1721. https://doi.org/10.1039/D0EE03757E

Thaler, R. H., & Sunstein, C. R. (2021). *Nudge: The Final Edition*. Yale University Press.

Thorman, D., & Capstick, S. (2022). *KNOCA briefing No. 4: Planning and assessing the impact and legacy of climate assemblies*. Centre for Climate Change and Social Transformations, Cardiff University.

Tingley, D., & Tomz, M. (2020). International commitments and domestic opinion: The effect of the Paris Agreement on public support for policies to address climate change. *Environmental Politics*, *29*(7), 1135–1156. https://doi.org/10.1080/09644016.2019.1705056

Tollman, J., & Pilsner, L. (2021). *Paris-Aligned EU External Action for a Climate Just World* (p. 56). E3G. https://www.e3g.org/wp-content/uploads/Report-Paris-Aligned-EU-External-Action-for-a-Climate-Just-World-for-All.pdf

Tosun, J., & Lang, A. (2017). Policy integration: Mapping the different concepts. *Policy Studies*, *38*(6), 553–570. https://doi.org/10.1080/01442872.2017.1339239

Transport & Environment. (2022). *Addressing the heavy-duty climate problem*. Transport & Environment. https://www.transportenvironment.org/wp-content/uploads/2022/09/2022_09_Addressing_heavy-duty_climate_problem_final.pdf

Trinomics. (2018). *Quantifying the benefits of circular economy actions on the decarbonisation of EU economy*. Trinomics. https://trinomics.eu/wp-content/uploads/2020/04/Trinomics-2018-Quantifying-the-benefits-of-circular-economy-actions-on-the-decarbonisation-of-EU-economy_final-report.pdf

Tsiropoulos, I., Nijs, W., Tarvydas, D., & Ruiz, P. (2020). *Towards net-zero emissions in the EU energy system by 2050: Insights from scenarios in line with the 2030 and 2050 ambitions of the European Green Deal*. (JRC Technical Reports). European Commission, Joint Research Center. https://data.europa.eu/doi/10.2760/081488

Tucker, B., & DeAngelis, K. (2021). *Past Last Call: G20 public finance institutions are still bankrolling fossil fuels*. Oil Change International. https://priceofoil.org/content/uploads/2021/10/Past-Last-Call-G20-Public-Finance-Report.pdf

Twidale, S., Abnett, K., Chestney, N., & Chestney, N. (2023, February 21). EU carbon hits 100 euros taking cost of polluting to record high. *Reuters*. https://www.reuters.com/markets/carbon/europes-carbon-price-hits-record-high-100-euros-2023-02-21/

UKCCC. (2022). *CCC Monitoring Framework*. UK Climate Change Committee. https://www.theccc.org.uk/publication/ccc-monitoring-framework/

UN. (2021). *Theme Report On Enabling SDGs Through Inclusive, Just Energy Transitions: Executive summary*. United Nations. https://www.un.org/sites/un2.un.org/files/2021-twg_3-exesummarie-062321.pdf

UNEP. (2022). *Emissions Gap Report 2022*. United Nations Environment Programme. http://www.unep.org/resources/emissions-gap-report-2022

UNFCCC. (2015). *The Paris Agreement*. United Nations Framework Convention on Climate Change. https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

UNFCCC. (2020). *Just transition of the workforce, and the creation of decent work and quality jobs*. United Nations Framework Convention on Climate Change. https://unfccc.int/sites/default/files/resource/Just%20transition.pdf

University of Notre Dame. (2023). *Rankings // Notre Dame Global Adaptation Initiative*. University of Notre Dame. https://gain.nd.edu/our-work/country-index/rankings/

Urry, J. (2004). The 'System' of Automobility. *Theory, Culture & Society*, *21*(4–5), 25–39. https://doi.org/10.1177/0263276404046059

van Wesenbeeck, B., Kok, S., Avila, C. B., Gwee, R., & Penning, E. (2021). *Economic rationale of NBS in freshwater ecosystems* (p. 63). Deltares. https://wwfint.awsassets.panda.org/downloads/economic_rationale_of_nbs_in_freshwater_ecosystems_1.pdf

Velasco, I. A., & Peters, J. (2022). *How EU Trade Deals Can Increase Climate Action* [Briefing Paper]. E3G. https://www.e3g.org/publications/how-eu-trade-deals-can-increase-climate-action/

Velten, E. K., Evans, N., Spasova, D., Duwe, M., de la Vega, R., Duin, L., & Branner, H. (2022). *Charting a path to net zero: An assessment of national long-term strategies in the EU*. Ecologic Institute. https://www.ecologic.eu/sites/default/files/publication/2022/50058-charting-a-path-to-net-zero-Full-Report-web.pdf

Velten, E. K., Haase, I., Berghmans, N., Duwe, M., & Evans, N. (2021). *Measuring progress towards climate neutrality—Part I: Assessing structural change through net zero indicators* (ECF Net-Zero 2050 Series). Ecologic Institut, IDDRI. https://www.ecologic.eu/18153

Vera, I., Bowman, M., & Mechielsen, F. (2022). *No time to waste: Why the EU needs to adopt ambitious legally binding food waste reduction targets*. Feedback EU. https://feedbackglobal.org/wp-content/uploads/2022/09/Feedback-EU-2022-No-Time-To-Waste-report.pdf

von Unger, M., Seneviratne, T., Herr, D., & Castillo Cartín, G. (2020). *Blue Nature-Based Solutions in Nationally Determined Contributions. A booklet for successfuul implementation* (p. 57). GIZ. https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/610/original/NbS_in_NDCs._A_Booklet_for_Successful_Implementation.pdf?1606858312

Wang, X., & Lo, K. (2021). Just transition: A conceptual review. *Energy Research & Social Science*. https://www.sciencedirect.com/science/article/abs/pii/S2214629621003832

Weaver, S., Lötjönen, S., & Ollikainen, M. (2019). *Overview of national climate change advisory councils* (Vol. 3/2019). Suomen ilmastopaneeli. https://www.ilmastopaneeli.fi/wp-content/uploads/2019/05/Overview-of-national-CCCs.pdf

WEF. (2022). *The European Union has cut greenhouse gas emissions in every sector—Except this one*. World Economic Forum. https://www.weforum.org/agenda/2022/09/eu-greenhouse-gas-emissions-transport/

Weyand, S. (2021, October 16). Sabine Weyand on role of trade policy in fighting climate change. *The Economist*. https://www.economist.com/by-invitation/2021/10/16/sabine-weyand-on-role-of-trade-policy-in-fighting-climate-change

Wieser, T., Alonso, J. A., Barbut, M., Berglöf, E., Dominik, J., Kleiterp, N., Kloppenburg, N., Passacantando, F., & Ulbæk, S. (2019). *Europe in the World: The future of the European financial architecture for development* (p. 56). High Level Group of Wise Persons on the European financial architecture for development. https://www.consilium.europa.eu/media/40967/efad-report_final.pdf

WindEurope. (2023). *Wind energy in Europe: 2022 Statistics and the outlook for 2023-2027*. WindEurope. https://windeurope.org/data-and-analysis/product/wind-energy-in-europe-2022-statistics-and-the-outlook-for-2023-2027

Wintschnig, B. (2021). The Attitude-Behavior Gap – Drivers and Barriers of Sustainable Consumption. *Junior Management Science*, *6*(2), 324–346.

World GBC. (2023). *BUILD UPON2*. World Green Building Council. https://worldgbc.org/build-upon/

WWF. (2022a). *EU Commission's advisory group publishes the first set of sustainability reporting standards*. World Wide Fund for Nature. https://www.wwf.eu/?8284941/EU-Commissions-advisory-group-publishes-the-first-set-of-sustainability-reporting-standards

WWF. (2022b). *Europe eats the world: How the EU's food production and consumption impact the planet*. World Wide Fund for Nature. https://wwfeu.awsassets.panda.org/downloads/europe_eats_the_world_report_ws.pdf

WWF. (2022c). *Where did all the money go? How Member States spent their ETS revenues and why tighter rules are needed*. World Wide Fund for Nature. https://wwfeu.awsassets.panda.org/downloads/ets_revenues_report_2022___web___final.pdf

XPRIZE. (2023). *XPRIZE Carbon Removal*. https://www.xprize.org/prizes/carbonremoval

Legal references

8th Environmental Action Programme: Decision (EU) 2022/591 of the European Parliament and of the Council of 6 April 2022 on a General Union Environment Action Programme to 2030

Austrian Climate Protection Act: Bundesgesetz zur Einhaltung von Höchstmengen von Treibhausgasemissionen und zur Erarbeitung von wirksamen Maßnahmen zum Klimaschutz (Klimaschutzgesetz – KSG)

Corporate Sustainability Due Diligence Directive: Proposal for a Directive of the European Parliament and of the Council on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937

Corporate Sustainability Reporting Directive: Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting (Text with EEA relevance)

Council Regulation accelerate the deployment of renewable energy: Council Regulation (EU) 2022/2577 laying down a framework to accelerate the deployment of renewable energy

Ecodesign Directive: Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast) (Text with EEA relevance)

Electricity Market Directive: Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast)

Electricity Market Regulation: Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast) (Text with EEA relevance.)

Energy Performance for Buildings Directive: Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)

EU Climate Law: Regulation (EU) 2021/1119 of the European Parliament and of the Council establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')

EU ETS Directive: Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (Text with EEA relevance)

German Climate Protection Act: Bundes-Klimaschutzgesetz vom 12. Dezember 2019 (BGBl. I S. 2513), das durch Artikel 1 des Gesetzes vom 18. August 2021 (BGBl. I S. 3905) geändert worden ist

Governance Regulation: Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action

Industrial Emissions Directive: Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Recast) (Text with EEA relevance)

LULUCF Regulation: Regulation (EU) 2018/841of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU

Renewable Energy Directive: Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance.)

Swedish Climate Act: Klimatlag (2017:720), Svensk författningssamling 2017:720.

Trans-European Energy Infrastructure Regulation: Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 (Text with EEA relevance)

Trans-European Networks for Energy (TEN-E) Regulation: Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on guidelines for trans-European energy infrastructure

Waste Framework Directive: Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance)

Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

6. Indexes

6.1 Figures

6.2 Tables

6.3 Boxes

6.4 Abbreviations

BECCS	Bioenergy carbon capture and storage
bnEUR	Billion Euro
CBAM	Carbon border adjustment mechanism
CCS	Carbon capture and storage
CDR	Carbon dioxide removal
CEE	Central and Eastern Europe
CEPA	Classification of environmental protection activities and expenditure

COVID-19	Coronavirus disease 2019
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CReMA	Classification of resource management activities
CRT	Carbon dioxide removal technology
CSDDD	Corporate Sustainability Due Diligence Directive
CSRD	Corporate Sustainability Reporting Directive
CTE	Committee on Trade and Environment
DACCS	Direct air carbon capture and storage
DSM	Demand-side management
EC	European Commission
EEAS	European External Action Service
EGD	European Green Deal
EEA	European Environment Agency
EIB	European Investment Bank
EP	European Parliament
EV	Electric vehicles
ESD	Effort Sharing Decision
ETS	Emissions Trading System
EUCO	European Council
EUR	Euros
FAC	Foreign Affairs Council
GoF	Group of Friends
GPP	Green public procurement
GDP	Gross domestic product
GEPMS	Global Europe Performance Monitoring System
GHG	Greenhouse gas
LTS	Long-term strategy
LULUCF	Land use, land use change, and forestry
ICE	Internal combustion engines
IPCC	Intergovernmental panel on climate change
IPG	International Partner Group

JETP	Just Energy Transition Partnership
JTF	Just transition fund
MDB	Multilateral development bank
mEUR	Million Euro
MiP	Multi-annual indicative planning
MFF	Multiannual financial framework
Mt	Million tonnes
ND-GAIN	Notre Dame's Global Adaptation Initiative
NDC	Nationally determined contribution
NDICI	Neighbourhood, Development, and International Cooperation Instrument
NECP	National energy and climate plan
NECPR	National energy and climate progress reports
NGEU	Next Generation EU
ODA	Official development assistance
OECD	Organisation for Economic Co-operation and Development
PaMs	Policies and measures
R&D	Research and development
RDD&D	Research, development, demonstration, and deployment
SAF	Sustainable aviation fuels
TED	Tenders electronic daily
TESSD	Trade and Environmental Sustainability Structured Discussions
TJTP	Territorial Just Transition Plan
TRL	Technology readiness level
TYNDP	Ten-year network development Plan
TSO	Transmission system operators
USD	United States dollar
WTO	World Trade Organisation
ZEV	Zero-emission vehicles
ZEF	Zero-emission fuels

ecno

European Climate
Neutrality Observatory

Visit our online progress platform:

climateobservatory.eu