European Environment Agency

Trends and projections in Europe 2023

EEA Report 07/2023

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

Luxembourg: Publications Office of the European Union, 2023

ISBN 978-92-9480-606-2
ISSN 1977-8449
DOI 10.2800/595102

Cover design: EEA
Cover photo: © Pedro Esteves, Well with Nature/EEA
Layout: Formato Verde/EEA

Contents

Acknowledgements

This report was prepared by the EEA and its European Topic Centre for Climate Change Mitigation (ETC CM).

Main authors: Jorre De Schrijver and Melanie Sporer (EEA); Hannah Förster, Sabine Gores, Verena Graichen, Christian Winger and Carina Zell-Ziegler (Öko-Institut); Nele Renders (Vito).

The authors would like to thank the EEA colleagues, national focal points and experts of the EEA member countries, as well as the European Commission, for their cooperation during the preparation of this report. The EEA acknowledges the comments received and has included them in the report as far as is practically feasible.

About this report and its scope

This report explores the historical trends, most recent progress and projected future progress on climate change mitigation through reduced GHG emissions, renewable energy gains and improved energy efficiency. It builds upon data reported by the EU-27 Member States, five EEA member countries and nine Contracting Parties of the Energy Community.

The report is accompanied by a technical background document that describes in more detail the data sources and targets mentioned in this report.

Throughout the report, the following scope is used:

- references to the EU relate to the EU-27;
- projections are those reported by countries in 2023 under Article 18 of the Regulation (2018/1999) on the Governance of the Energy Union and Climate Action;
- global warming potentials (GWPs) from AR5 are used to represent greenhouse gas emissions.

Executive summary

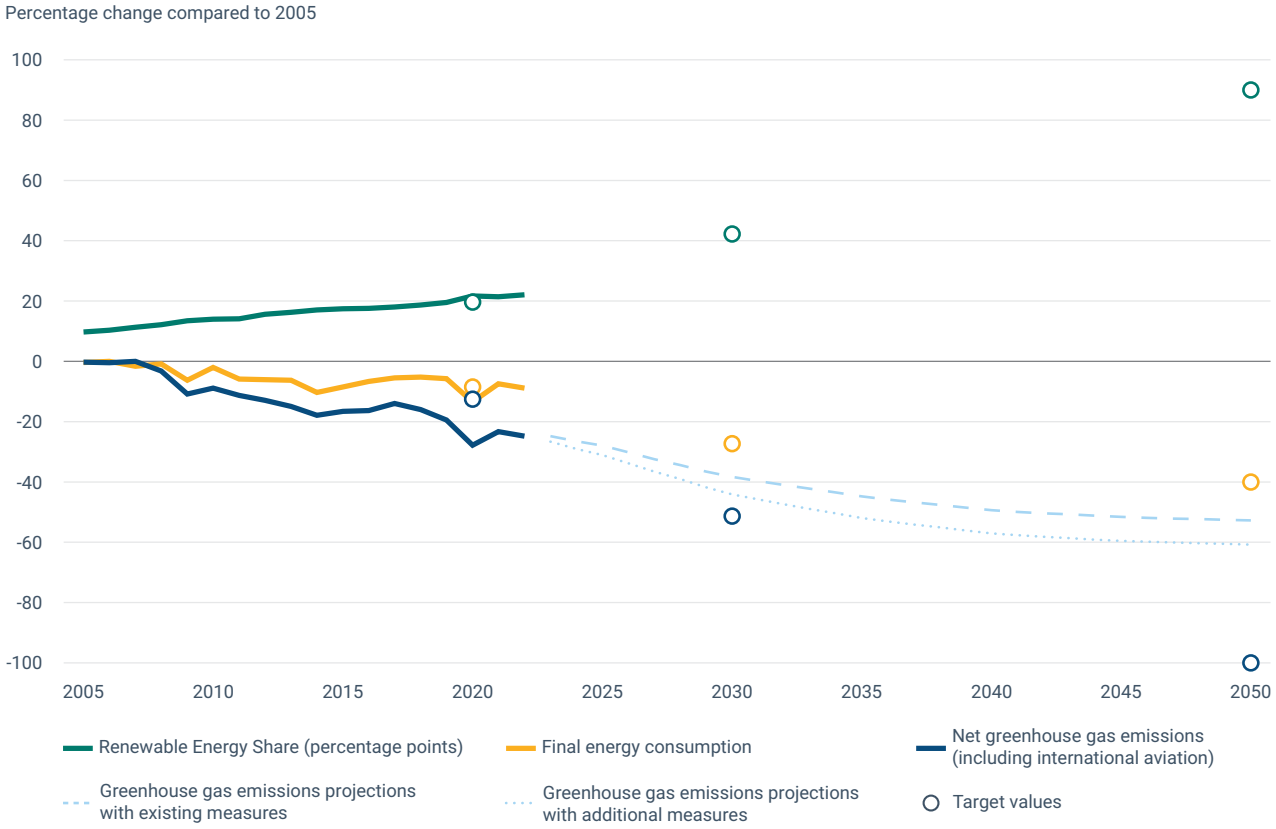
2030 climate and energy progress in Europe: urgent action required although encouraging trends appear

Climate change is happening now. Floods, droughts, heatwaves, and other climate-related hazards are becoming more intense, longer and more frequent (EEA, 2023a). Over the last decade, European surface temperatures were more than 2°C warmer than pre-industrial levels, while the summer of 2023 was globally the hottest summer on record and the fifth hottest for Europe. Every tonne of greenhouse gas saved contributes to mitigating the consequences of climate change, and the EU is committed to stepping up the efforts and taking decisive action on the path towards climate neutrality.

In recent decades, the EU has reduced its net greenhouse gas emissions, by almost one third while simultaneously fostering economic prosperity. Preliminary figures for 2022 indicate that total net **greenhouse gas emissions,** including international aviation GHG emissions ([1]), **had decreased by 31% compared to 1990**. Particularly within the sectors of energy supply and energy-intensive industries, both subject to the EU Emissions Trading System (EU ETS) since 2005, there has been a pronounced reduction in GHG emissions. However, the decrease in emissions covered by Member State targets within the effort sharing legislation, particularly in areas such as agriculture, transport, and buildings, has been slower. In parallel, according to the EEA's early estimates, the EU has successfully expanded the share of renewable energy consumption, with renewable sources **accounting for an estimated 22.5% share by 2022**. Furthermore, the EU has managed to reduce primary energy consumption by 16% since 2005 — attributed to more efficient energy conversions and an **8% reduction in final energy consumption**, according to the EEA's early estimates for 2022.

([1]) In this report, the EU total greenhouse gas emissions include emissions from land use, land use change, and forestry (LULUCF) activities, as well as GHG emissions from international aviation.

Figure ES.1 **EU 2020 achievement and progress towards 2030 and 2050 climate and energy targets**



Notes: This figure presents the progress of the EU's headline targets since 2005. These targets include reducing greenhouse gas emissions, increasing the renewable energy share, and improving energy efficiency. The data for the 2005-2021 period are from EEA (2023) and Eurostat (2023e), while the 2022 values are estimated by the EEA. The aggregated GHG emissions projections are based on the data submitted by Member States in March 2023 under Article 18 of the Governance Regulation. The reference points for 2030 refer to the targets outlined in the 2030 legislative framework. For 2050, the greenhouse gas target aligns with the EU's net climate neutrality goal, while the reference points for renewable energy and final energy consumption represent the indicative ambitions outlined in the climate target plan's impact assessment (EC, 2020a).

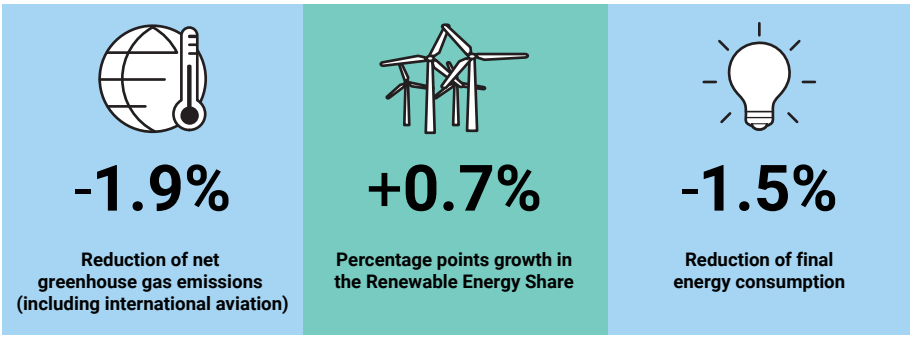
Sources: EC (2021b); EEA (2023b, forthcoming d, forthcoming b); Eurostat (2023e).

Despite these clear advancements, the current progress represents just the beginning of a necessary acceleration towards achieving climate neutrality by 2050, as mandated in the European Climate Law (ECL). In the last few years, the EU has established a robust climate and energy framework for 2030, which includes specific benchmarks to clarify the **path towards attaining climate neutrality**. In alignment with the previously set target of reducing net greenhouse gas emissions by at least 55% by 2030 relative to 1990 levels, the 2030 objectives encompass achieving a 42.5% renewable energy share in 2030 — with a potential increase up to 45% — and an 11.7% reduction in energy consumption compared with the forecasts for 2030 made in 2020. The overall GHG target is supported by increased greenhouse gas reduction targets under the EU ETS and the Effort Sharing Regulation as well as by substantial enhancement of CO_2 removal capacity through land use, land use change, and forestry activities.To **deliver** on these targets, the pace of annual **absolute GHG emission reductions must more than double** compared with the annual progress seen since 2005, with an acceleration that is particularly needed for the emissions covered under the Effort Sharing Regulation. For **energy consumption and the share of renewable energy**, annual efforts must accelerate even faster.

When comparing the progress made up to this point, with the annual efforts needed towards 2030, it is evident that a transformative shift will become imperative. Yet, beneath the overarching figures, **encouraging** indicators come into view. While wind and solar held a modest presence in the 2005 electricity sector, their estimated share in electricity production has surpassed 20% in 2022, with those technologies redefining the energy supply sector for the coming years. Other sectors, too, have witnessed noteworthy acceleration, exemplified by the growing sales of heat pumps and electric vehicles. The **roll-out of technologies, such as solar PV, exceeds expectations**, and tipping points are reached in certain sectors toward net-zero emission technologies becoming the default investment option.

Furthermore, **year-to-year fluctuations** over the last decade show that the required emission reductions are not unprecedented. On multiple occasions since 2015, annual reductions of GHG emissions approached, or even exceeded, the required rate for the upcoming eight-year period. In 2020, this was primarily due to the effects of the COVID-19 pandemic, while in the preceding years, improved emission intensity and energy efficiency played a pivotal role.

Figure ES.2 **Assessing EU performance in 2022: annual changes between 2022 (estimates) and 2021**



Signs of encouragement emerged in **2022**. Although the total of EU emissions only **fell by 1.9% from 2021 to 2022** according to the GHG estimates, which is less than half the necessary pace, some sectors experienced notable emission reductions last year. This was among others driven by high energy prices induced by the Russian invasion of Ukraine, which led to some sectors experiencing exceptionally high GHG emissions reductions. In the **buildings sector,** estimates indicate a substantial 9% reduction in GHG emissions. This can be attributed to a milder winter, but also to reduced energy use related to increased consumer awareness and higher energy prices. Similarly, the **industrial sector** witnessed a significant decline in GHG emissions in 2022, primarily attributable to reduced production within energy-intensive industries due to elevated energy costs. In the **energy supply sector**, GHG emissions are anticipated to have increased by 3%, due to soaring natural gas prices that boosted coal competitiveness and there were unforeseen disruptions in nuclear and hydropower installations during 2022. Fortunately, the simultaneous strong growth of solar and wind energy played a key role in counterbalancing the GHG emissions growth, holding the promise of driving significant emission reductions in the energy supply sector in the future.

This effect is also observed in the growth of the **renewable energy share**, with a rise in the EU's share of renewable energy use in total gross final energy consumption growing from 21.8% in 2021 to 22.5% in 2022, according to early estimates. The rise was driven mainly by strong growth in solar power, and amplified by the reduction of **energy consumption** in the EU. Total final energy consumption (FEC) saw an estimated reduction between 2021 and 2022 of 1.5%, whereas primary energy consumption (PEC) experienced a more substantial decrease, estimated at 4%. Furthermore, preliminary estimates for 2022 show an increase in the CO_2 removal capacity of land use, land use change and the forestry sector, although approximated emissions carry a degree of uncertainty.

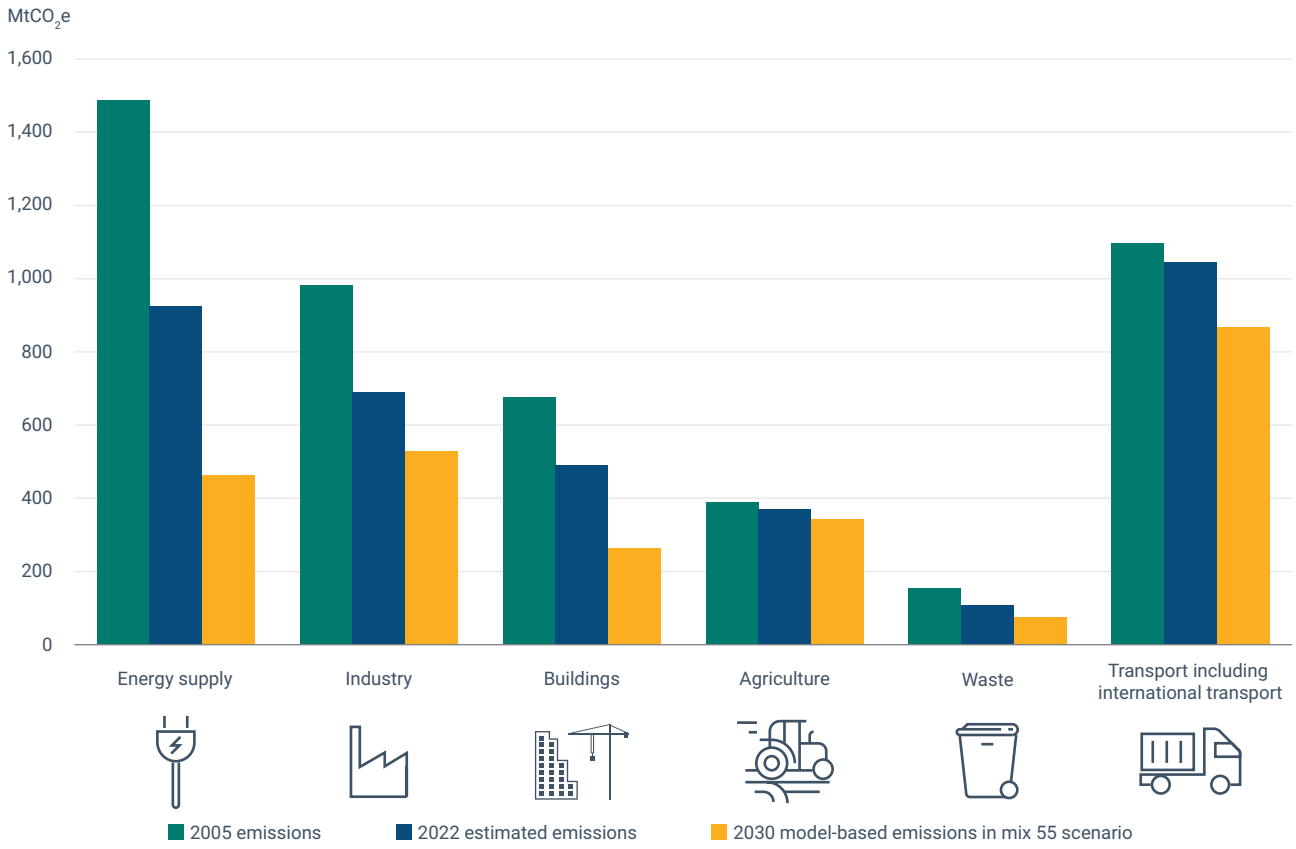
Stronger polices and measures by Member States are needed across sectors to deliver on the climate and energy targets

European countries are committed to adopting and implementing policies and taking the corresponding measures to deliver on the EU-wide climate and energy targets by 2030. With the latest submissions under the EU Regulation on the Governance of the Energy Union and Climate Action ((EU) 2018/1999) in 2023, Member States reported more than **3,000 policies and measures** to achieve the energy and climate objectives.

Taking into account the estimated effects of the policies and measures currently in place across Europe, **Member States project** to achieve a joint reduction in net emission levels of **43%** by 2030 compared to 1990. Adding currently planned additional measures, the projected GHG emission reduction rises to **48%**. Last year, Member States projected this reduction to total only 41%, which indicates a joint increase in ambition across Europe in the past year. However, even the 48% projection will still leave a deficit of 7 percentage points to reaching the EU 2030 target. **Sectoral GHG emissions projections** further underscore the necessity for heightened efforts across the board in order to reach the 2030 target (Figure ES.3). In particular for the **buildings sector**, planned policy measures would result in a 2030 emission level that lags considerably behind the cost-effective reduction pathway previously modelled by the European Commission.

Looking **beyond 2030**, the gap is even wider between the projected effects of current GHG emissions policies and measures and the targets. Taking into account currently adopted and planned measures, Member States' aggregated emissions are projected to fall by 60% below 1990 levels in 2040, and 64% in 2050. The gap to climate neutrality is substantial. When assessing various sectors within this timeframe, it becomes evident that there is also an urgent need to accelerate efforts in transportation and agriculture, which have lagged behind in terms of progress over the past few decades. Equally essential is the enhancement of the CO_2-removal capacity within the LULUCF sector.

Figure ES.3 Sectorial progress towards 2030



Notes: The model-based emissions in the mix 55-scenario refer to (EC, 2021b), a core policy scenario underpinning the 2030 Climate target plan.

Sources: EEA (2023b, forthcoming c, forthcoming e).

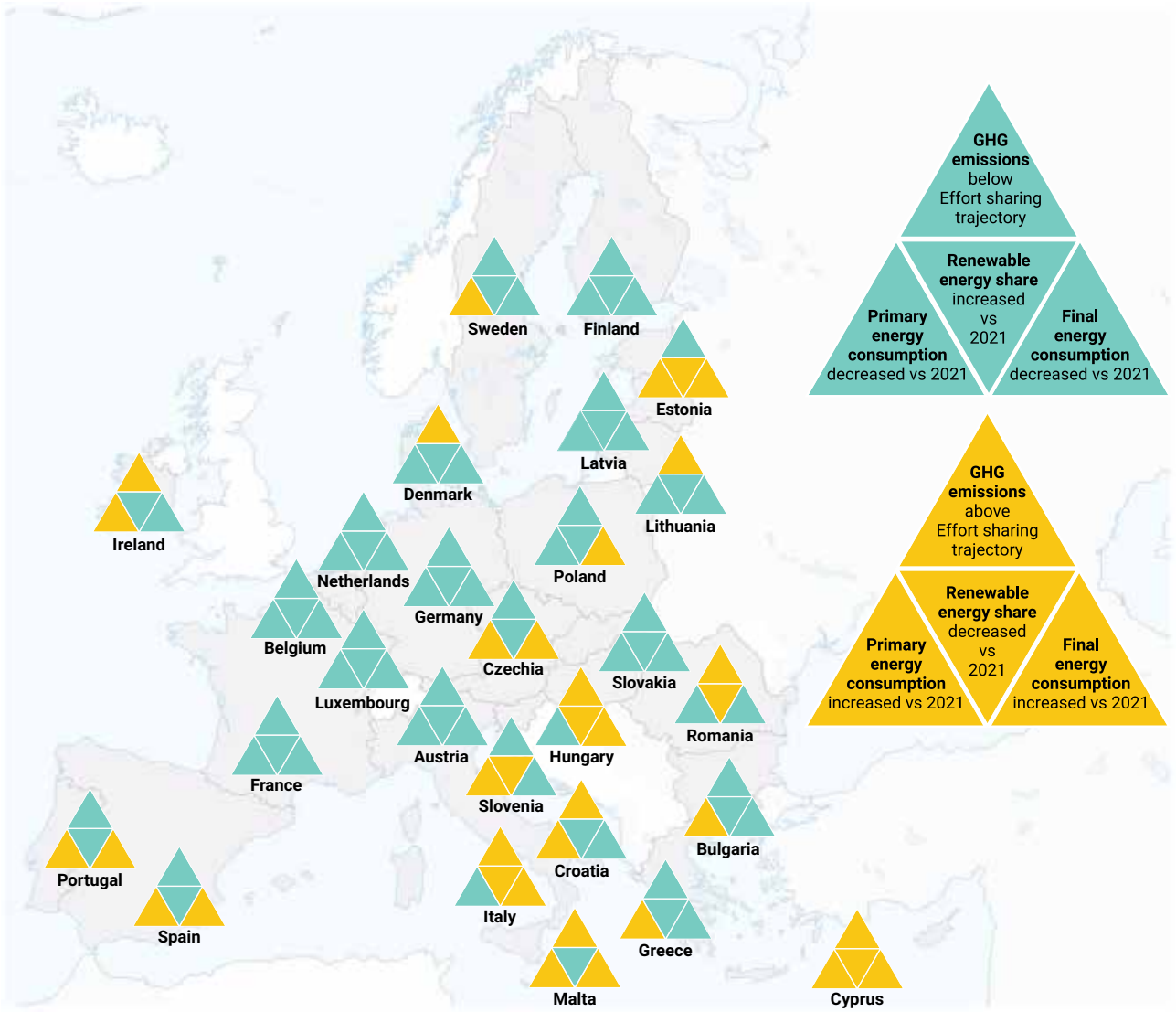
Country perspective: the majority of member states align with 2022 climate trajectories, but more ambition needed to bridge the gap by 2030

In 2022 and 2023, the EU-27 climate and energy targets for 2030 were revised within the framework of the Fit-For-55 package. For Member States, the climate targets under the Effort Sharing Regulation were brought in line with these more ambitious European targets, with both higher 2030 targets and more stringent annual emission limits from 2023 onwards. Furthermore, Member States were required to submit, by June 2023, a draft update of their National Energy and Climate Plans (NECPs) that were delivered in 2019, reflecting the revised EU 2030 climate and energy targets.

In five Member States (Austria, Cyprus, Denmark, Ireland and Italy), the **2021** GHG emissions covered by the effort sharing legislation were above their annual emission allocations (AEAs), indicating that these Member States have to make use of the flexibilities available under the legislative framework to comply with their annual emission limits. At the same time, the share of renewable energy remained below the binding baseline set by the 2020 renewable energy target in several countries (France, Ireland, the Netherlands and Romania). This means that, within one year, these Member States will have to take additional measures to cover the gap within the duration of a further year.

For **2022**, with regard to **greenhouse gas emissions**, initial estimates indicate that most Member States, except Croatia, Cyprus, Denmark, Hungary, Ireland, Italy, Lithuania, Malta and Romania, managed to stay below their allocated AEAs. Regarding **renewable energy**, preliminary estimates for 2022 suggest that the renewable energy source (RES) share increased in most Member States compared to 2021. However, based on those estimates, this would not be the case for Cyprus, Estonia, Hungary, Italy, Romania and Slovenia. Regarding **energy efficiency**, preliminary estimates for 2022 indicated that eighteen countries had reduced their final energy consumption compared to 2021, while fifteen countries reduced their levels of primary energy consumption.

Figure ES.4 **Assessing Member States' 2022 climate and energy performance, based on estimated data**



Notes: This figure illustrates the 2022 climate and energy performance of Member States – based on estimated data. For the GHG emissions dimension, it compares estimated 2022 GHG emissions under the Effort Sharing Regulation with the available annual emission allocation (AEA) for 2022. This is a first step towards the assessment of 2022 progress, given that Member States have flexibilities under the Effort Sharing Regulation to match the AEA with its emissions. For primary and final energy consumption, as well as the share of renewable energy, the figure illustrates the direction of change between the 2022 estimates and the 2021 values.

Sources: EEA (forthcoming a, forthcoming b, forthcoming c).

The current pace of progress described above, without yet fully accounting for the increased 55% ambition, underlines the imperative for substantial efforts to aim for the 2030 goals. This reality becomes more evident when assessing the GHG emissions projections for sectors covered by the effort sharing legislation. At present, only **six Member States** (Croatia, Greece, Luxembourg, Portugal, Spain and Sweden) **project to have 2030 emissions levels below their targets for that year when taking into account additional measures**.

Accelerating the climate and energy transformation

Europe has taken decisive steps with the **European Green Deal**, providing clear direction and urging countries, citizens, and companies to reduce their greenhouse emissions. The European Parliament and the Council have agreed on collective binding targets, and resources have been allocated accordingly. Now, the main focus is on **delivering** these targets.

The window of opportunity to implement the right decisions and technologies is limited, making it imperative to take climate neutrality into account in current decision-making across many sectors. Small optimisation policies will not suffice: EU Member States now need to ensure comprehensive acceleration.

With drafts being submitted since the summer of 2023, and with updated NECPs to be expected by 30 June 2024, the **update of the National Energy and Climate Plans (NECPs)** will provide the framework for Member States to establish stronger policies and measures, and to enhance ambition levels.

In addition, work must also continue at the European level on a **coherent and supportive policy framework**. While every sector faces a necessary intensification in its efforts, this report's findings emphasise the need for rapid implementation of the measures adopted at EU level, which could be accompanied by additional supportive policies in areas where more effort is needed. Within the buildings sector, realising cost-effective emission reductions by 2030 necessitates a rapid acceleration of the renovation wave, underscoring the significance of the forthcoming revision and implementation of the Energy Performance of Buildings Directive. The Green Deal Industrial Plan aims to position Europe as a leader in zero-emission technology, ensuring that future emissions reductions in industry are driven by innovation rather than production cuts, as seen in 2022. Moreover, the pursuit of climate neutrality necessitates a substantial shift to increase Europe's CO_2 removal capacity, a goal achievable only through effective incentives put into action.

Mainstreaming further emission mitigation across different sectors, identifying trade-offs and synergies, addressing the underlying drivers and increased dialogue between all the stakeholders concerned, are key ingredients to spur the required acceleration and open up the **path to achieving climate neutrality in 2050**.

© Nikolaus Spannbauer, Well with Nature/EEA

1 Greenhouse gas emissions and energy trends in the EU

Key messages

- In recent decades, the EU-27 has reduced net emissions of greenhouse gas (GHG) by almost one third, while simultaneously fostering economic prosperity. In 2021, net GHG emissions, including international aviations, decreased by 30% compared to 1990 levels, with renewable energy sources contributing a substantial 21.8% to the energy mix. The EU's commitment to energy efficiency has resulted in a reduction in energy consumption since 2005, both for primary energy (-12%) and for final energy (-7%).

- Early estimates for 2022 indicate that net GHG emissions decreased by a further 2% compared to 2021 levels, resulting in an overall reduction of 31% since 1990. Final energy consumption is estimated to have decreased by 1.5% from the previous year, with primary energy consumption showing a more substantial reduction of 4%. The EU's share of renewable energy use in total energy consumption is estimated to have risen from 21.8% in 2021 to 22.5% in 2022.

- To realise the newly-adopted energy and climate targets for 2030, as part of the trajectory towards achieving climate neutrality at the latest by 2050, an acceleration of efforts will be needed across all dimensions. 2022 and 2023 saw the establishment of a robust regulatory framework for energy and climate to deliver the 2030 milestone of at least 55% net GHG emission reductions compared to 1990. Compared to the period 2005-2022, the rate of absolute net GHG emission reductions must more than double, with acceleration particularly needed for those emissions covered under the Effort Sharing Regulation. For final energy consumption and the share of renewable energy, annual efforts must more than triple compared to the period 2005-2022.

- Current and planned policy measures across Europe are expected to help achieve the required acceleration. Member States project that the policies and measures they currently have in place, or are under preparation, will achieve a reduction of 48% in net emission levels by 2030, compared to 1990. Last year, Member States had projected the reduction to total only 41%, which indicates a shared increase in ambition across Europe in the past year. However, even the 48% projection will still leave a deficit of 7 percentage points in reaching the EU 2030 target, which will need to be addressed rapidly. For renewable energy and energy efficiency, the distance to the 2030 targets is more pronounced, because Member States' objectives are not yet aligned with the newly adopted EU targets.

1.1 Progress towards climate and energy targets

In 2022, Europe achieved significant milestones on its path towards climate neutrality by 2050, due to the expansion of its regulatory and incentivising framework. Building upon the foundations laid by the European Climate Law in 2021, which legally mandated targets of achieving net-zero greenhouse gas emissions by 2050 and reducing net GHG emissions by at least 55% by 2030, lawmakers successfully agreed upon crucial components of the Fit-for-55 package. This comprehensive package introduces ambitious policies aimed at accelerating the reduction of GHG emissions, fostering the adoption of renewable energy sources, and enhancing overall energy efficiency by 2030. With respect to this report, adopted amendments to the legislation on effort sharing, emission trading, land use, land-use change and forestry (LULUCF) are highly relevant, strengthening both ambition level and the regulatory framework. Also in the field of energy, key legislation is adopted, including the revision of the Energy Efficiency Directive (EED) and the Renewable Energy Directive (RED), which outline ambitious 2030 targets.

This report assesses Europe's progress towards its climate and energy targets. While the targets have been set for 2030, at the time of publication, implementation of the Fit-for-55 package is still in progress. Since the summer of 2023, EU Member States have been submitting draft updates of their National Energy and Climate Plans (NECPs) for 2030, and they are expected to finalise their updated 2030 NECPs by 30 June 2024. Thus, Member States are in the process of updating their national objectives, targets, policies and measures considering evolved energy and climate policies and geopolitical circumstances since the initial NECPs were prepared in 2019-2020. Consequently, the projections for 2030, included in this report, do not yet encompass all of the new measures and ambitions under the Fit-for-55 package.

At the same time, this publication is presented during a turbulent period with major economic and political developments affecting Europe's climate and energy framework. The post-COVID-19 pandemic economic recovery, in 2021 and 2022, led to increased production and transport volumes compared to the crisis year 2020, resulting in higher energy consumption and emissions. Additionally, from February 2022, Russia's invasion of Ukraine resulted in an energy crisis that drove energy prices to record highs, particularly for natural gas. The EU continues to react to the effects of this crisis by limiting high gas prices, improving solidarity and securing natural gas supplies, while at the same time, accelerating the green transition with the REPowerEU initiative. Despite clarity of the present level of ambition with the newly established 2030 targets, the task of identifying long-term trends has become more challenging in this year's report. The annual totals of greenhouse gas emissions, energy consumption and renewable energy, are heavily influenced by these recent fluctuations — potentially concealing long-term trends. Therefore, it is essential to consider both short-term variations and long-term patterns to gain a complete understanding of the progress towards climate change mitigation, renewable energy gains and improved energy efficiency, on the level of the EU totals, the sectors and the Member States.

Preliminary 2022 estimates indicate that EU-wide net GHG emissions, including LULUCF and international aviation emissions, stood at 31% below 1990 levels. This indicates a 2% decline of GHG emissions compared with 2021, marking a return to decreasing GHG emissions following the fluctuations observed in recent years. This decline follows a larger 10% drop in emissions in 2020 — due to the effects of the COVID-19 pandemic (EC, 2020d), followed by an increase in net GHG emissions of 6% in 2021, in parallel with economic recovery. Member States' GHG emission projections, submitted in March 2023, indicate that the EU-wide 2030 target of reducing net GHG emissions by 55% compared to 1990 will not be met. Based on existing measures alone, the EU projects to reduce net GHG emissions by 2030 to a level 43% below 1990 levels. Eighteen Member States have also submitted projections, taking into account additional measures that are currently planned. Adding in these additional measures ([2]), net GHG emissions in 2030 in the EU are projected to reach 48% below 1990 levels. The introduction of further measures across Europe will be necessary to ensure the 2030 target will be reached.

Preliminary estimates indicate that the total renewable energy share of gross final energy consumption was at 22.5% in 2022. In 2020, the total renewable energy share was 22.1%, which represented a growth of 2.2 percentage points compared to 2019. This growth was also due to a temporary decline in fossil fuel use during the COVID-19 pandemic. In 2021, however, the renewable energy share decreased to 21.8% because fossil fuel use rose during the recovery from the pandemic. Taken together, the 2030 renewable energy contributions of Member States, included in their 2019 NECPs, add up to a forecast of a 33.1-33.7% EU-wide renewable energy share for 2030, as estimated by the European Commission (EC, 2020a). The current 2030 contributions thus fall short of the EU-wide target of a renewable energy share of at least 42.5%. Member States' new draft NECPs may include updated 2030 contributions and pathways to 2030 but these were not available at the time of this publication for all Member States, and therefore not reflected here.

2022 preliminary estimates indicate that the EU has managed to reduce primary energy consumption by 16% since 2005, which is attributed to more efficient energy conversion and an 8% reduction in final energy consumption. This translates to an estimated reduction between 2021 and 2022 of 1.5% for final energy consumption and 4% for primary energy consumption. Parallel to GHG emissions, this is a reversion to diminished energy consumption following shifts in recent years. Energy consumption in 2020 was lower than the targets for that year, both for final and primary energy. They dropped by 8.1% and 8.7% respectively, compared to 2019. As the economy recovered in 2021, final energy consumption grew by 7% and primary energy consumption by 6%, compared to 2020. Similar to renewable energy, the contributions for energy consumption that Member States put forward in the NECPs submitted in 2019 were not sufficient for reaching the updated EU-wide energy efficiency target for 2030, and significant new efforts will be necessary. The draft updated NECPs may address this shortfall, at least in part.

([2]) The EU-wide scenario, including additional measures, is a conservative projection because, for Member States that did not submit a 'with additional measures' scenario, it is gap-filled with the projections based on existing measures.

Box 1.1

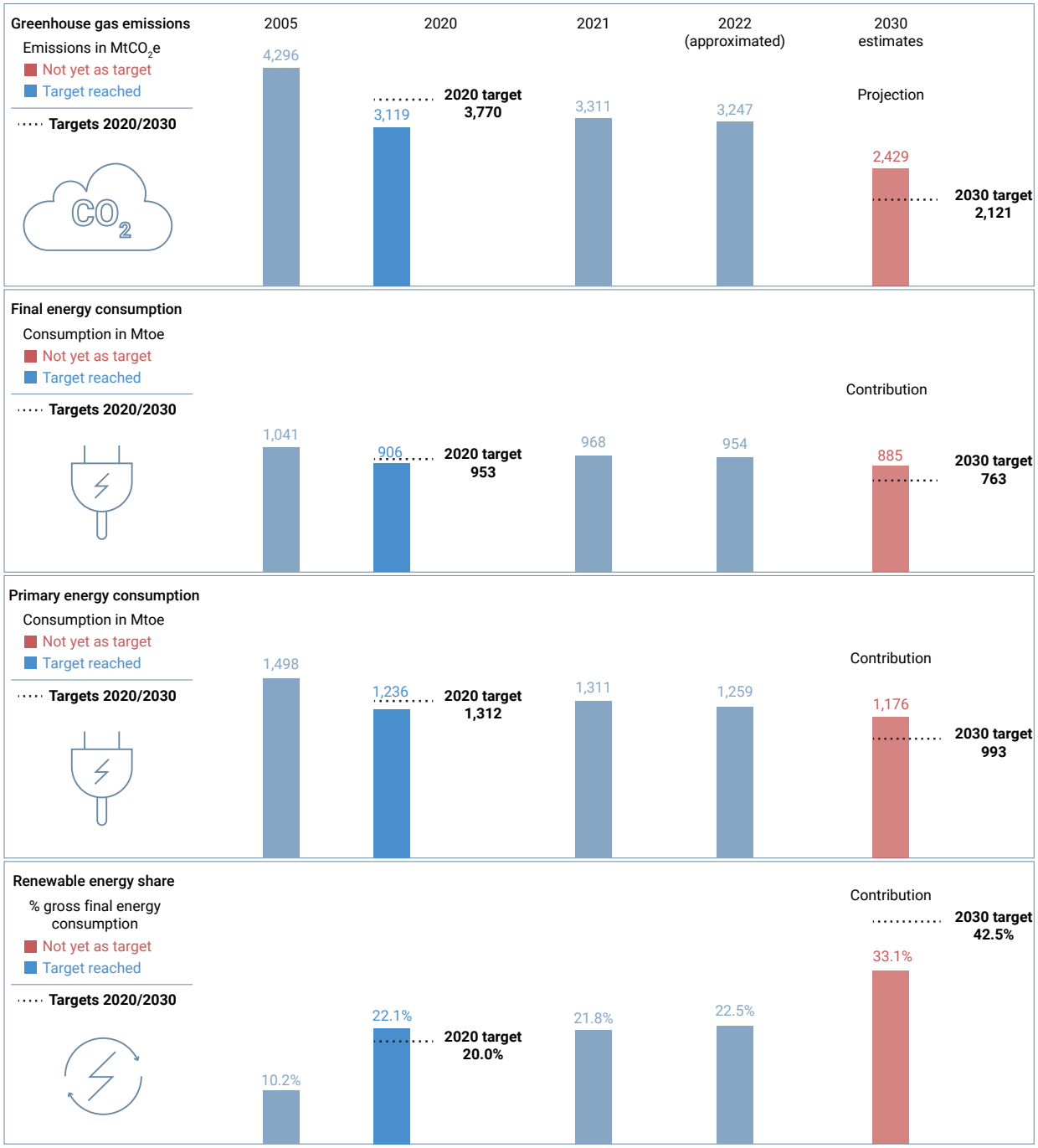
Scope of the greenhouse gas emissions included in this report

In the European Climate Law (EU, 2021), the EU has set the legal objective to balance union-wide greenhouse gas (GHG) emissions and removals, at the latest, by 2050. The law also sets the intermediate target of reducing net GHG emissions by at least 55% by 2030, compared to 1990 levels. These targets cover all GHG emissions and removals as regulated in Union law. This implies that the target for 2030 not only covers GHG emissions from the Effort Sharing Regulation and the current scope of the EU Emissions Trading System (EU ETS), but also includes emissions and removals from land use, land-use change and forestry (LULUCF), and emissions that will fall under the EU ETS in 2030.

Pending the inclusion of international navigation emissions under the EU ETS from 2024 onwards, in this report, the scope of the total GHG emissions is aligned with the EU's nationally determined contribution (NDC), as submitted in 2020 (Council of the European Union, 2020). As a result, emissions from international aviation, accounted through bunker fuels, are included in the total net GHG emissions, as are emissions and removals from LULUCF.

The way in which international transport is included in the scope is relevant for the assessment of target achievement. Different to other sectors, emissions of international transport increased considerably since 1990 and are projected to steadily increase further in Member State projections. Thus, their significance relative to other sectors becomes more pronounced. When focusing on net emissions, excluding international aviation emissions, the reduction between 1990 and 2021 reaches 30.4%, which is slightly more than the 29.7% reduction within the scope that includes international aviation. Looking ahead to 2030, the projected net emission reduction, excluding international aviation, is expected to be 50% in the scenario considering additional measures, compared to 48% within the scope that includes international aviation.

Figure 1.1 Progress towards achieving 2030 targets in the EU-27



Notes: Data on GHG emissions are shown as net emissions including international aviation emissions for all years. The 2020 target, defined without taking into account LULUCF emissions and removals, has been translated into a net emissions target by multiplying net 1990 emissions by 80%. The 2030 projection for GHG emissions with additional measures (WAMs) stems from the aggregation of national projections reported to the EEA, while EU-27 energy consumption and renewable energy contributions for 2030 were calculated as the sum of the Member State contributions stated in the final NECPs submitted in 2019 (EC, 2020a). The EU energy efficiency target for 2030 is based on the targets included in the revised Energy Efficiency Directive 2023/1791, as adopted by the Council on 25 July 2023. For renewable energy, the 2030 target included is from the Renewable Energy Directive, as adopted by the Council on 9 October 2023.

Sources: EEA (2023b, forthcoming a, forthcoming b, forthcoming e, forthcoming f); EU (2023b); Council of the European Union (2023b); Eurostat (2023d, 2023g).

1.2 EU-wide developments in emissions and energy

1.2.1 The main drivers of GHG emissions reduction

Figure 1.2 Drivers of GHG emission reduction in the period 2005-2022

Notes: Energy intensity, included in this figure, is determined by dividing the annual primary energy consumption by the GDP. Carbon intensity is derived by dividing the total net GHG emissions by the primary energy consumption. GDP data are based on gross domestic product data included in the AMECO database (at 2015 prices), and gap-filled by the EEA. The mix 55 results correspond to the parameter values included in the mix 55- scenario. Energy consumption and greenhouse gas emissions data for 2022 are based on estimates.

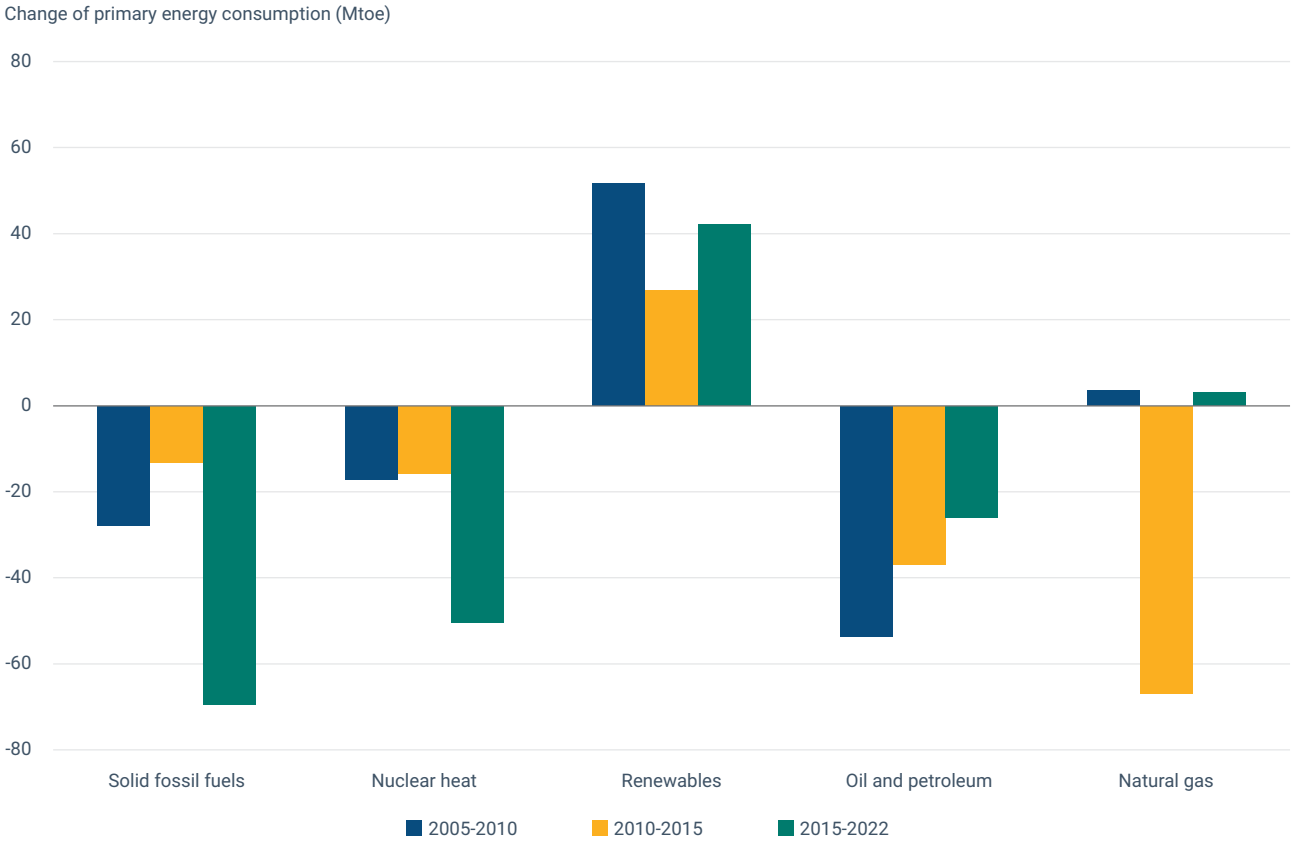
Sources: EC (2021b, 2023b); EEA (2023b); Eurostat (2023g, 2023f); EEA (forthcoming e, forthcoming a); own calculations.

The 2030 climate and energy framework, established by the European Climate Law and the Fit-for-55 package, builds on earlier climate and energy efforts and legislation in the EU. Over past decades, the EU has been actively engaged in initiatives aimed at reducing greenhouse gas emissions and promoting the adoption of energy efficiency and renewable energy sources. The progress achieved since 2005, as illustrated in Figure 1.2, is substantial and demonstrates the EU's commitment to addressing climate targets. At the same time, Figure 1.2 outlines the main drivers of GHG emission reductions from 2005 until 2022, with an outlook until 2030 in the form of a decomposition analysis ([3]).

([3]) Based on the Kaya identity, which was described in 1990 by Yoichi Kaya for the IPCC (Kaya, 1990), and used many times since, e.g. in the Assessment Reports of the IPCC (IPCC et al., 2014).

The EU's GHG emission reduction, illustrated in Figure 1.2, totalled 24% between 2005 and 2022, which coincided with an increase in GDP per capita, and a slight rise in the population. The main driver of the emission reduction was the decrease of the energy intensity by 32 % through an improvement of energy efficiency. Three quarters of GHG emissions are energy-related, so improvements in this field are essential. At the same time, the carbon intensity (emissions per energy used), decreased by 10% over this same period, due to switching to less CO_2-intensive fossil fuel sources and the increased use of renewable energy. Figure 1.3 illustrates this fuel switch in more detail. The estimated values for 2022 illustrate that during the period 2005-2022, the primary energy consumption of fossil fuels decreased considerably with the largest reductions in the use of solid fossil fuels by 40%, with oil and petroleum products reduced by 23% and natural gas by 17%. The increase in renewable energy is particularly striking over this period, with a doubling of primary energy consumption between 2005 and 2022. The long-term trend for nuclear heat is considerably declining. In addition to energy-related emissions, since 2005, process-related GHG emissions in the industry sector and GHG emissions from the waste sector have also fallen by more than a quarter ([4]).

Figure 1.3 Evolution of primary energy consumption (2005-2022)



Notes: This figure illustrates the progress of primary energy consumption per source since 2005 in the EU, segmented into intervals. The primary energy consumption is determined by subtracting the final consumption of non-energy use from the gross inland energy consumption. The values for 2022 used in the calculations are based on the EEA's approximated estimates for the primary and final consumption of energy.

Sources: Eurostat (2023a); EEA (forthcoming e); own calculations.

([4]) For more detailed discussion of sector specific evolutions, see Chapter 2.

Rapidly decreasing energy intensity and a further decrease in carbon intensity are also the ingredients for the future reduction of greenhouse gas emissions by 2030. The mix 55-scenario (EC, 2021b) – a core policy scenario underpinning the 2030 Climate target plan published in 2020, projects a strong reduction of both parameters for 2025 and 2030, as shown in Figure 1.2. This scenario is a target-driven scenario, which means that parameters have been designed in a way that the emission reduction target 2030 is achieved as a modelling result. In addition to sector-specific GHG emissions for 2030, this scenario includes an EU-wide RES share of 38%, while final energy consumption in 2030 is at 791 Mtoe (million tonnes of oil equivalent). The objectives finally set, with regard to renewable energy (42.5 + 2.5%) and energy efficiency (763 Mtoe), go even further than the mix 55-scenario results. This is partially an outcome of the REPowerEU discussions after Russia's invasion of Ukraine.

The EU is also ambitious regarding further decoupling of GHG emissions from the GDP. In its 2023 Strategic Foresight Report (EC, 2023a), the European Commission stated the 'need for a new economic model, focused on the wellbeing of people and nature, decoupling economic growth from resource use, and shifting to more sustainable production and consumption'. This shall 'be achieved by reducing pollution and waste through circularity, resource and energy efficiency, and sufficiency measures' (EC, 2023d, p. 6). Furthermore, the EU is reviewing its 'consumption footprint, which considers the embedded environmental impacts of trade', which has not decreased in the past decade in the way domestic emissions have, but rather increased by 4% (EC, 2023d, p. 6).

1.2.2 The way forward to 2050

Just as the new 2030 framework is not the beginning for the European energy and climate framework, it is also not the final destination. The European Climate Law explicitly establishes the objective of achieving climate neutrality by 2050 and aims to achieve negative emissions thereafter. The EU target of climate neutrality at the latest by 2050 prescribes considerable emission reductions. It defines a net zero target, which means that EU-wide GHG emissions and removals regulated in EU law shall be balanced by 2050 at the latest and aiming to achieve negative emissions thereafter. The level of residual emissions in 2050 is not yet defined, giving room for interpretation of the potential size of technical and nature-based sinks from the LULUCF sector.

In addition to the benchmark target for 2030, the pathway to climate neutrality will be defined by an emission target for 2040. A proposal and an impact assessment are expected from the European Commission at the beginning of next year. The European Scientific Advisory Board on Climate Change (ESABCC) has recommended a 2040 target of net emissions reduction in the range of 90-95% compared to 1990, corresponding to a budget of 11-14 $GtCO_2e$ in years 2030-2050 (EUSABCC, 2023).

The ESABCC selected three iconic pathways from 36 scenarios, which are consistent with the Paris Agreement objective, to illustrate the different societal choices and strategies. The highest reductions of energy demand are envisaged in the transport sector (EUSABCC, 2023), while the strongest emission decreases are expected in the building sector (Meyer-Ohlendorf et al., 2023). For both sectors, reductions of energy demand and emissions are strongly related to electrification strategies, which mean an additional need for the expansion of renewable electricity production in parallel. This matches the result in EUSABCC (2023), where the share of electricity in the final energy demand is expected to rise, until reaching a level in 2040 that is double the current level.

With the EU Emissions Trading System (EU ETS), emissions currently covered by this sector are expected to be close to zero around the year 2040. This decrease is closely followed by emissions reductions from fossil fuels in other sectors. Carbon removals from the LULUCF sector in 2040 are predicted to be in the range of 100-400 $MtCO_2$ in the scenarios considered. Technical removals, through bioenergy with carbon capture and storage (BECCS), and direct air carbon capture and storage (DACCS), are predicted to vary between 50-200 Mt in 2040.

Modelling results from scenarios up to 2050 (EC 2018), predict residual emissions in carbon neutrality scenarios in the range of 343-494 $MtCO_2e$. These residual emissions are balanced by the removal of 250-472 $MtCO_2e$ from the LULUCF sector and 281-606 $MtCO_2e$ from carbon capture technologies.

The results of these scenarios, which are designed to explain how long-term targets can be achieved, can be compared with national GHG emissions projections. These are driven by countries' assessments of existing or planned policies and measures, and indicate possible ambition gaps to be closed in order to achieve the targets. In 2023, for the first time, all national projections cover the time span to 2050. These projections are not explicit about technical removals, but they include important information on residual emissions and nature-based removals from the LULUCF sector. With existing policies and measures, projected net emission reductions, compared to 1990, reach a level of 53% in 2040 and 56% in 2050. These emissions are further reduced with additional policies and measures to levels of 60% below 1990 in 2040 and 64% below 1990 in 2050. Nature-based sinks are already included in this calculation, yet there are still net emissions of 1,717 $MtCO_2e$. Even if it has to be considered that the EU aggregate of additional measures is a conservative scenario, because not all Member States reported the effects of additional measures ([5]), this residual amount is far higher than what is included as possible contributions from carbon capture and storage technologies in the previously mentioned climate neutrality scenarios for 2050 (EC, 2018).

1.3 EU-wide evolutions in greenhouse gas emissions towards 2030

To achieve the total EU-wide 2030 net emission target of a reduction of 55% compared to 1990, overall annual average emission reductions have to be on average 141 $MtCO_2e$ in each of the years leading to 2030. This signifies more than doubling the reduction rate since 2005, with an average annual reduction of 62 $MtCO_2e$ in the period 2005-2022. At the same time, the last eight years show that an emission reduction of around 141 $MtCO_2e$ was achieved in only two of those years, with the reduction in 2020 mainly related to the effects of the pandemic (Figure 1.5).

Three key EU policies comprise the core of the EU climate framework, which aim to achieve the European climate targets:

1. The EU Emissions Trading System (ETS) 2003/87/EG amended by (EU) 2023/959;
2. The Effort Sharing Regulation (EU) 2018/842 amended by (EU) 2023/857;
3. The Regulation on emissions and removals from LULUCF (EU) 2018/841 amended by (EU) 2023/839, which provides a system targeted at improving the natural sink capacities in the EU.

All three policies have undergone considerable revisions to adapt to the more ambitious 2030 target of reducing total net EU GHG emissions by 55% compared to 1990.

([5]) Austria, Cyprus, Denmark, France, Greece, Hungary, Italy, Malta and Sweden did not submit a 'with additional measures' scenario.

The EU ETS is a 'cap and trade' system. The cap sets the total amount of greenhouse gases that can be emitted by operators in the sectors covered by the system. Within the cap, operators buy or receive emissions allowances, which they can trade with one another as needed (EC, 2023f). With the revision of the ETS Directive in 2023 (EU, 2023a), the cap of the EU ETS has been tightened, leading to an emission reduction of 62% by 2030 compared to 2005, instead of 42%. The new target covers an expanded ETS scope: emissions from power generation, energy-intensive industries and aviation as previously legislated; adding carbon dioxide emissions from maritime transport from 2024, further extended to methane and nitrous oxide as of 2026. The EU ETS applies to the EU-27 Member States, Iceland, Liechtenstein, Norway as well as to Northern Ireland in respect to electricity generation. In 2022, EU-27 ETS emissions had decreased by 38% compared to 2005. The reductions have been particularly strong in the energy-related industries. These include emissions from electricity and heat generation, petroleum refining and the manufacturing of solid fuels and other energy industries, as well as fugitive emissions from fuel. This reflects an interplay of trends and developments in recent years.

Emissions increased considerably between 2020 and 2021, alongside Europe's recovery from the COVID-19 pandemic and a shift from the use of natural gas to coal due to increasing gas prices. Figure 1.4 shows that for 2021 and 2022, emissions have been below the cap which means that more certificates came to the market than were needed.

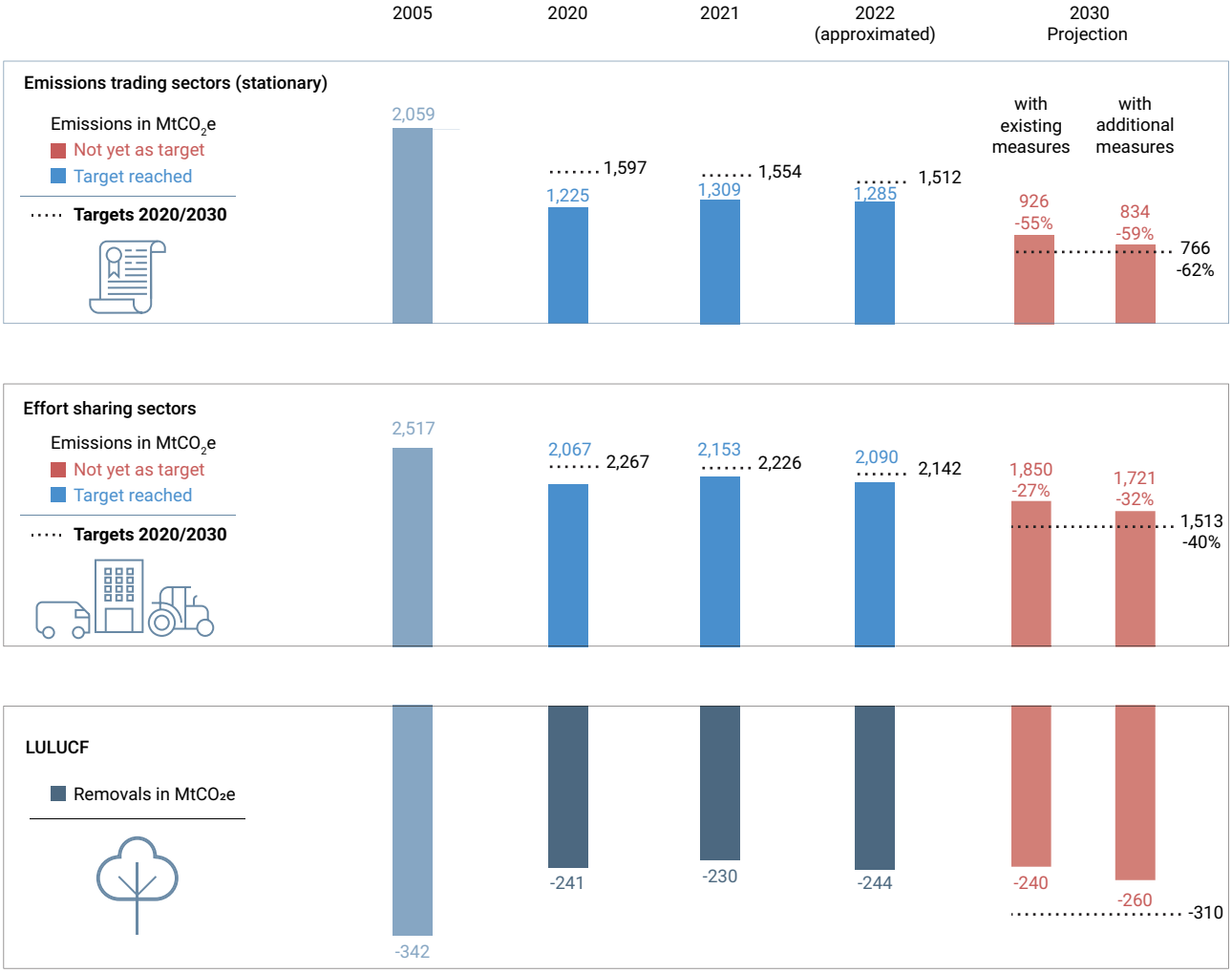
In order to meet the established 2030 objective, ETS emissions need to decline annually by 65 $MtCO_2e$ until 2030, which surpasses the average yearly reduction of 46 $MtCO_2e$ spanning from 2005 to 2022. Furthermore, as shown in Figure 1.5, in the past eight years the required reduction rate has been successfully attained in some years. During 2019 and 2020, the annual greenhouse gas reduction under the ETS significantly surpassed the required rate. For 2020, this was related to the COVID-19 pandemic, and in 2019, the reduction was achieved through a shift to less CO_2-intensive fuels. With the latest GHG emissions projections submitted by Member States in 2023 reflecting existing measures, ETS emissions are projected to decrease by 55% compared to 2005. Considering additional measures would increase the emission reduction to 59%, thus falling short of the overall ETS reduction target of 62%.

The Effort Sharing Regulation, meanwhile, sets binding national targets for emission reductions in the sectors covered by this Regulation for each of the years 2021 to 2030. These mainly include emissions from domestic transport, buildings, agriculture, specific parts of the energy and industrial sector (typically small installations not covered by ETS), and waste. With the revision of the Effort Sharing Regulation, collective national targets now result in a 2030 emission reduction of 40% compared to 2005, instead of the emission reduction target of 30% as originally set by this Regulation in 2018. Until 2021, effort sharing emissions decreased by 14% compared to 2005 ([6]). With approximated emissions for 2022, a 17% reduction is expected. 2021 aggregated ESR emissions have been below the annual reduction target and preliminary estimates indicate this also the case for 2022 (Figure 1.4). Similar to ETS emissions, ESR emissions increased between 2020 and 2021 reflecting economic recovery from the COVID-19 pandemic. For GHG emissions under the Effort Sharing Regulation, the annual average emission reduction between 2022 and 2005 amounts to 25 $MtCO_2e$. Member States' 2030 targets will require an annual reduction of 72 $MtCO_2e$ to achieve the 2030 target. Under the Effort Sharing Decision that applied in the period 2013-2020, such a reduction was achieved in 2014 and in the 2020 pandemic year when an emission reduction of 142 $MtCO_2e$

([6]) The final ESR emissions for 2021 will only be established after a comprehensive review, which will take place in 2027.

was achieved (Figure 1.5). National GHG emissions projections, taking into account the existing measures, indicate a reduction of 27% by 2030. Considering additional measures sees a decrease of 32% for 2030, which leaves a considerable gap to reach the overall 2030 target, and indicates an area where further policies and measures will need to be rapidly identified and deployed.

Figure 1.4 **Breakdown of GHG emissions trends in the sectors covered by the EU ETS, ESR and LULUCF Regulation**

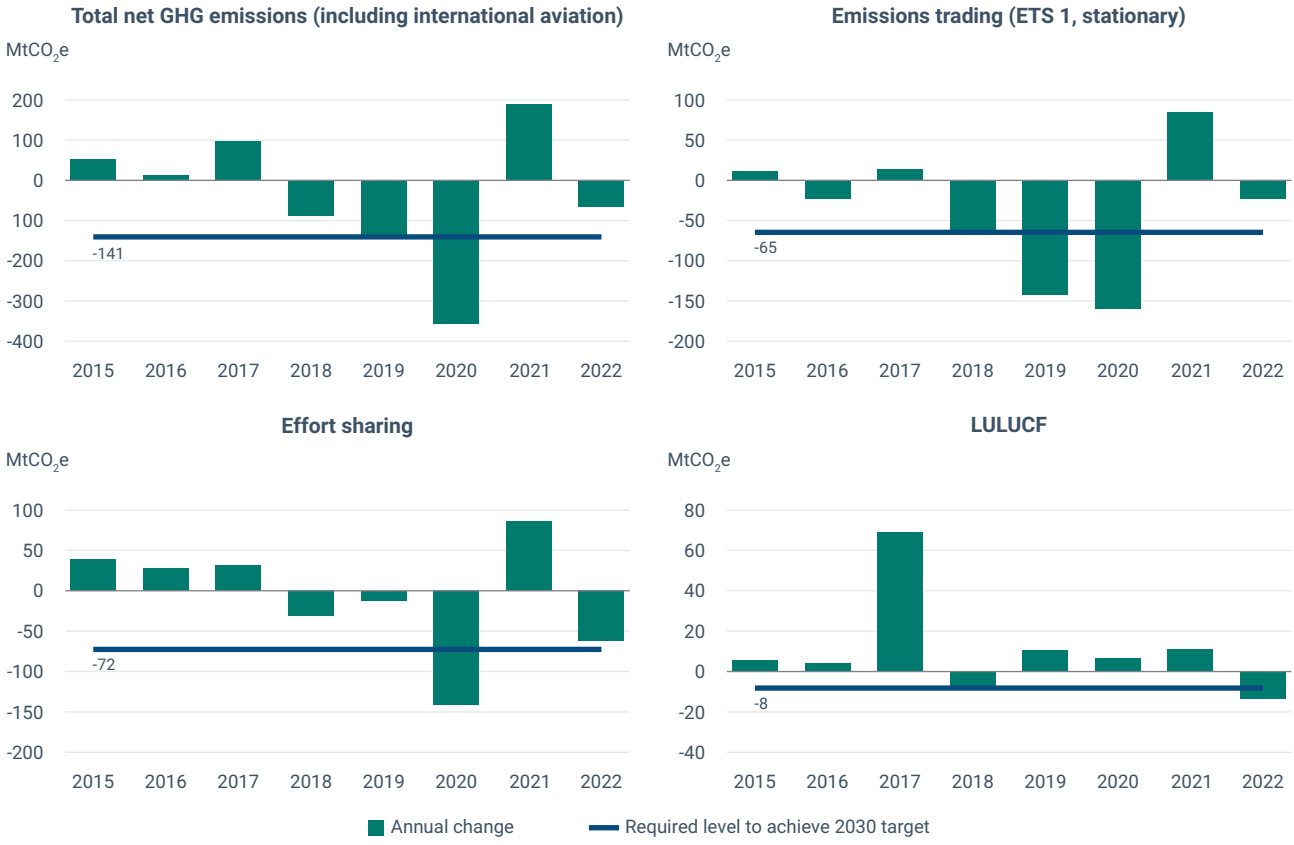


Notes: This figure shows an overview of GHG emissions and associated targets covered by the Emissions Trading System (stationary installations under ETS 1), the effort sharing legislation and the Land Use, Land Use Change and Forestry Regulation. The 2030 projection for the GHG emissions stem from the aggregation of national projections reported to the EEA in March 2023. The LULUCF values reflect the net removals of GHG by this sector. The negative values signify that the LULUCF sector has effectively removed more CO_2 from the atmosphere than it has emitted.

Sources: EC (2022a, 2022b); EEA EU (2023b).

The LULUCF Regulation (EC, 2023c; EU, 2023c) sets an accounting framework for the years 2021-2025 for GHG emissions and removals from forest land, forest products, cropland, grasslands, and land conversions to and from wetlands and settlements. Following the revision in 2023, the main objective of this framework was changed to an EU-wide net removal target for 2030 of 310 $MtCO_2e$. Forest management and the land sink have a critical role in sequestering carbon, playing an increasingly important part in achieving the EU's net GHG emissions targets. The EU net removals in the LULUCF sector have decreased, compared to 2005, and this trend will need to be reversed to achieve the targets for LULUCF (Figure 1.4). In the last eight years, the sink only increased consecutively from one year to the next in 2018 and 2022, with preliminary estimates (Figure 1.5). The sum of the national GHG emissions projections foresees a reversal of the trend, but not at a growth rate that would permit achievement of the removals target level of 310 $MtCO_2e$ by 2030.

Figure 1.5 Annual changes of GHG emissions in the last eight years



Notes: The figure illustrates the annual difference of year x compared with x -1 for four parameters: total net GHG emissions, GHG emissions covered by the Emissions Trading System (stationary, ETS 1), GHG emissions covered by the effort sharing legislation and GHG emissions covered by the Land Use, Land Use Change and Forestry Regulation LULUCF). For the latter, the values shown in the graph refer to the difference in net emissions of this sector. The period spans eight years, serving as a comparison base for the trajectory required to meet the objectives set for the upcoming eight years leading to the 2030 targets. The required level to attain the 2030 target is calculated as the difference between the 2030 target and the estimated emissions for 2022, divided by 8.

Sources: EC (2022a, 2022b); EEA (2023b, 2023c, forthcoming a).

Box 1.2

The introduction of a new emissions trading system (ETS-2)

With the revision of the EU ETS Directive ([7]), a new emissions trading system will be established (ETS-2), for buildings, road transport and additional sectors, e.g. fuel combustion by industry not covered by the existing EU ETS. Separate from the existing EU ETS, the ETS-2 is an upstream system regulating fuel suppliers rather than households and car users. It comes into operation in 2027, while the monitoring and reporting of emissions will start in 2025. The cap is set to achieve an emission reduction of 42% by 2030 compared to 2005 levels. Measures are put in place to ensure a smooth start of the new system, i.e. fostering market stability and mitigating excessive price increases.

Alongside the new ETS-2, a Social Climate Fund is being created (EU, 2023f), to address social impacts on vulnerable groups in the EU arising from the new system. The Fund will start operating from 2026, ahead of the ETS-2 launch. The total budget of the Social Climate Fund is estimated at EUR 86.7 billion over the period 2026-2032.

Emissions from sectors covered by the ETS-2 remain covered by Member States' emission reduction targets under the Effort Sharing Regulation (ESR). This means that the ETS-2 complements national efforts to bring down emissions in the ESR sectors. It is estimated that by 2030, half of the ESR emissions will be covered under the ETS-2. The ETS-2 does not cover non-CO_2 emissions which are mainly from agriculture and waste management.

1.4 EU-wide evolutions in Renewable Energy Sources (RES)

In October 2023, the new Renewable Energy Directive was adopted, raising the target share of renewable sources in the EU's gross final energy consumption to 42.5 % by 2030, with an additional top-up of 2.5% (Council of the European Union, 2023b). Each Member State will contribute to this target, with a contribution to be included in its updated NECP.

This new 2030 target implies a doubling of the share of renewable energy compared to 2021. The EU-wide total renewable energy share on gross final energy consumption (RES-Total) grew from 10.2% in 2005 to 21.8% in 2021 (Figure 1.6). This is an average annual linear growth of 0.7 percentage points. Preliminary estimates indicate the RES-total share for 2022 is 22.5%. Although this value represents a historical high, the growth in the rate has slowed since 2020. When looking at absolute values, renewable consumption grew by a modest 1.4 million tonnes oil equivalent (Mtoe) between 2021 and 2022, as rapid growth of solar and wind resources was counterbalanced by drought-related reductions of hydropower availability. Non-renewables, on the contrary, saw a significant reduction (-2%) linked to high gas prices and nuclear shutdowns. This in turn increased the relative share of renewables in total energy consumption.

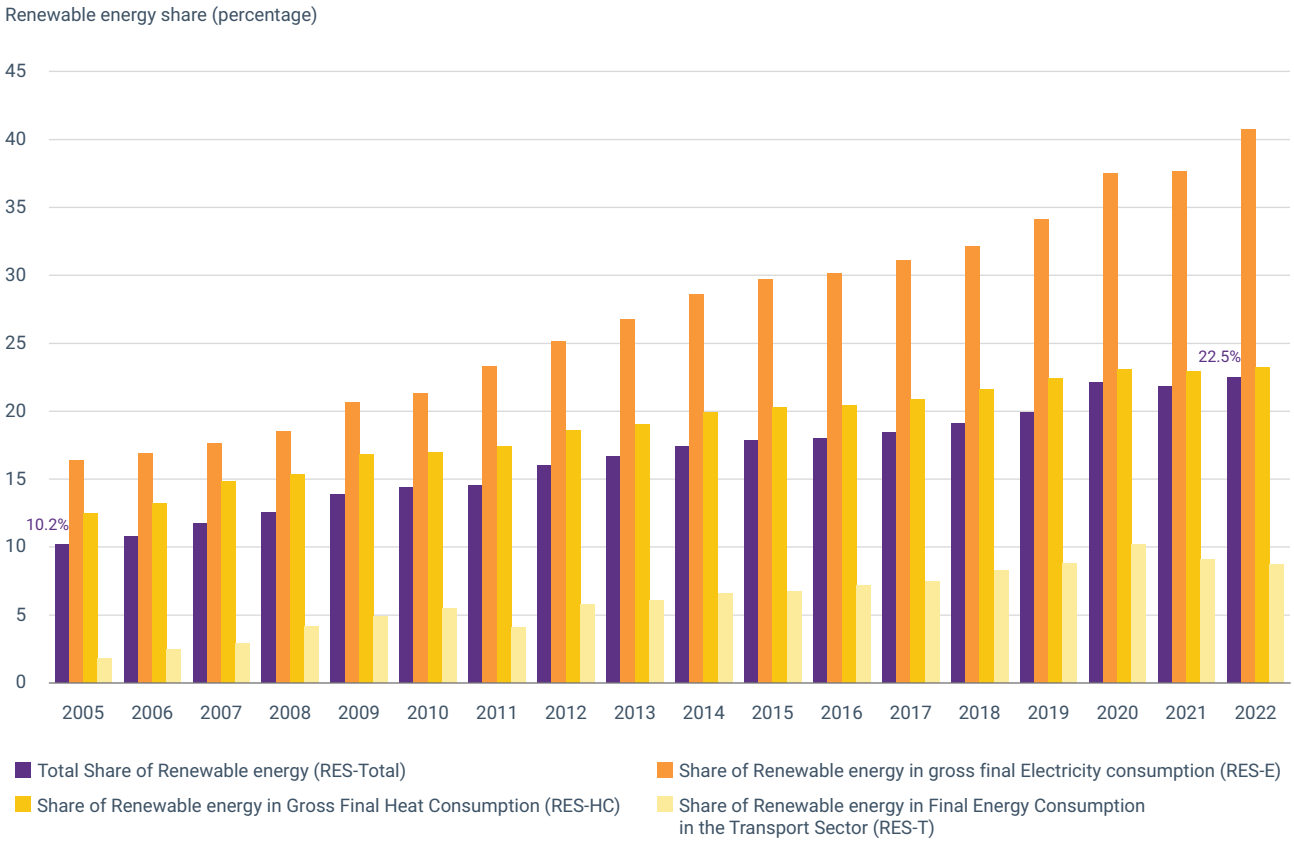
The electricity sector (RES-E) accounted for the largest share and the largest average annual growth from 2005-2021. The RES-E share grew from 16.4% in 2005 to 37.6% in 2021, equal to an average annual linear growth of 1.3 percentage points. Preliminary estimates indicate that RES-E stood at 40.7% in 2022.

([7]) Directive (EU) 2023/959 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading system, OJ L 130, 16.5.2023, pp. 134-202. Consolidated version available here.

The renewable energy share in heating and cooling (RES-HC) grew from 12.4% in 2005 to 22.9% in 2021, averaging a 0.7 percentage points increase per year. RES-HC shares are preliminarily estimated to be 23.2% in 2022.

With more modest growth, renewable energy shares in transport (RES-T) grew from 1.8% in 2005 to 9.1% in 2021, averaging an increase of 0.5 percentage points per year. For 2022, preliminary estimates suggest a RES-T share at 8.7%.

Figure 1.6 Renewable energy shares on gross final energy consumption (2005-2022)



Notes: This figure shows the share of renewable energy utilised in the EU-27 across the sectors of electricity, heating and cooling, transportation, and overall energy use. These percentages are presented as a share of the gross final energy consumption across the different categories, with the 2022 values referring to estimates.

Sources: Eurostat (2023g); EEA (forthcoming e).

To reach the target level of 42.5% in 2030, RES-Total shares will need to grow continuously by an average of 2.2 percentage points each year from 2022-2030, which is three times the growth during the period 2005-2022. Figure 1.7 shows that over the past eight years only 2020 achieved the growth rate of 2.2%, but this was due to the strong decline of gross final energy consumption related to the COVID-19 pandemic. In 2020, the reduced utilisation of fossil fuels led to a considerably greater decline in the denominator used for calculating the RES share, amounting to approximately 8%. In contrast, during the period 2014-2020, the gross final energy consumption only decreased by 0.5% per year on average — calculated using Eurostat, (2023g).

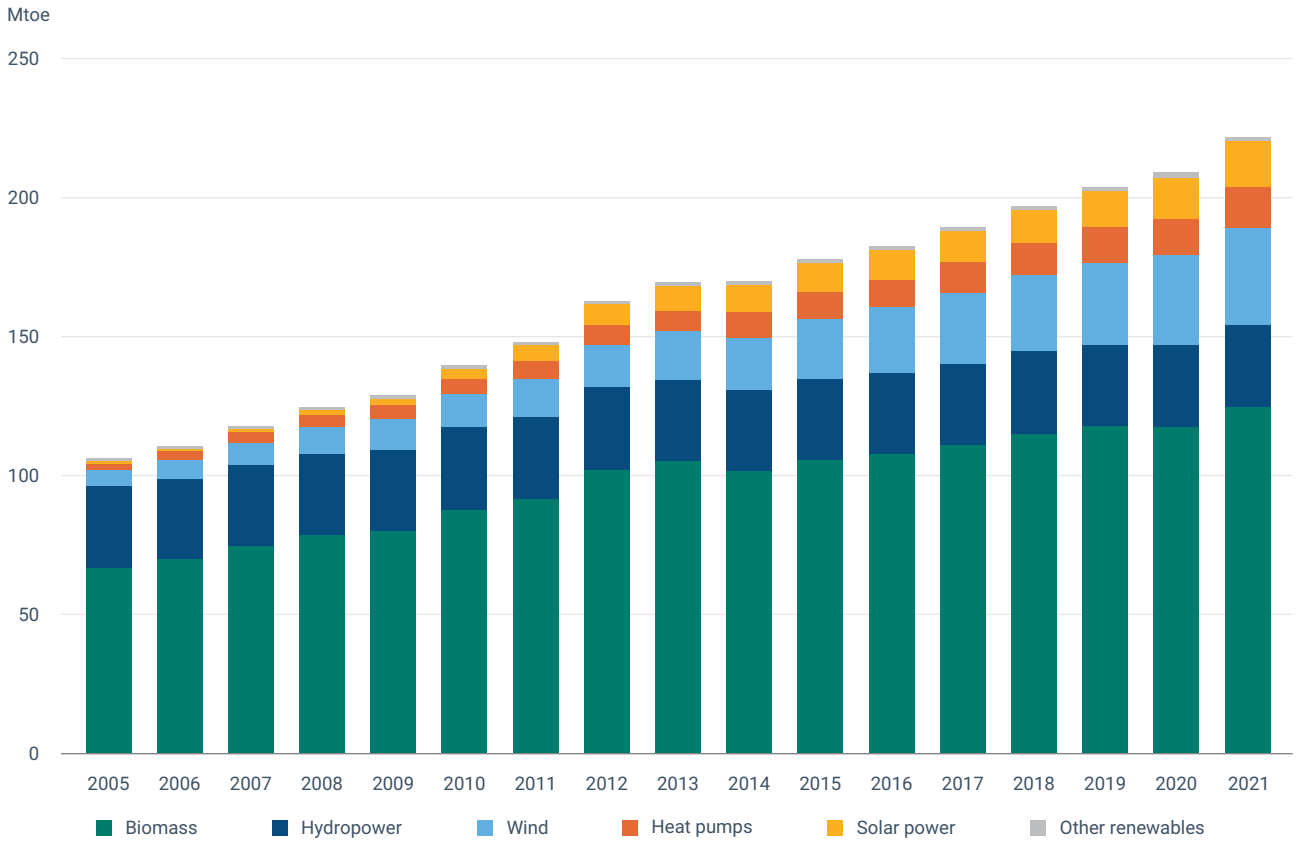
Figure 1.7 Recent growth in RES shares

Notes: The figure illustrates the annual difference in percentage points between the share of renewable energy in year x compared with year x -1, with the value for 2022 based on estimates. The period spans eight years, serving as a comparison base for the trajectory required to meet the objective set for the upcoming eight years leading to the 2030 target. The required annual growth to attain the 2030 target is calculated as the difference between the 42.5% target and the estimated RES share for 2022, divided by 8.

Sources: Eurostat (2023g); EEA (forthcoming f); own calculations.

Technology-wise, the overall renewable energy consumption in the EU remains dominated by biomass over the period 2005-2021. Biomass made up 63% of the overall renewable gross final energy consumption in 2005 and stood at 56% in 2021. Biomass is mostly used for heating and cooling purposes. Hydropower used for generating electricity was the second largest renewable energy source up to 2018, after which wind power overtook its place. Solar power and heat pumps started off as small renewable energy sources in 2005 and have grown in parallel since then, with both standing at 7% of overall renewable energy consumption in 2021.

Figure 1.8 Renewable gross final energy consumption by technology in the EU-27

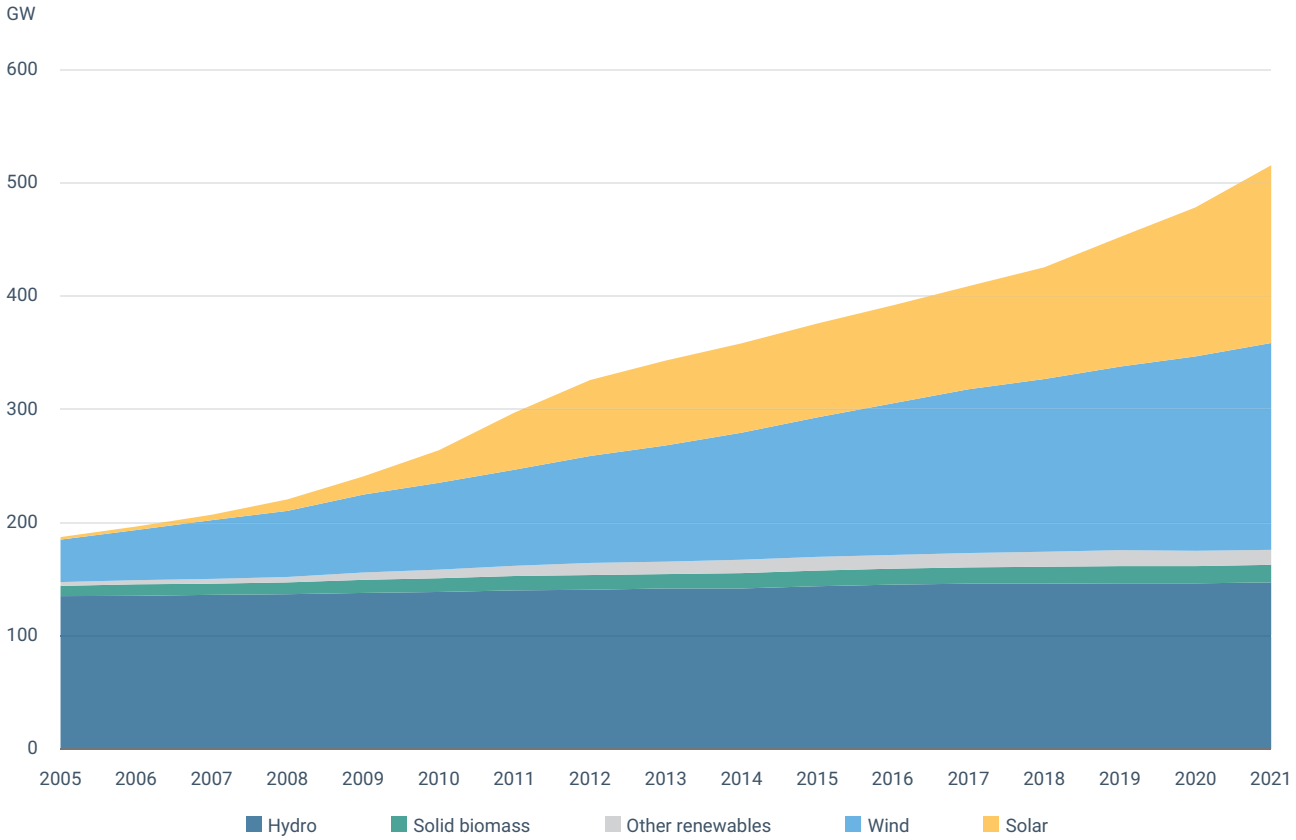


Notes: This figure illustrates the renewable energy consumed per technology in the EU-27. The category of biomass bundles solid biomass (including municipal waste); biodiesel; bio gasoline; other biofuels (complying with RED sustainability criteria); biogas; bioliquids. Solar refers to: concentrated solar power; solar photovoltaic; solar thermal. Hydropower covers normalised hydropower (excluding pumping). Wind refers to normalised onshore and offshore wind. Heat pumps refer to the geothermal/ambient fraction of energy used by the heat pumps. Other renewables include tidal, wave and ocean energy, and geothermal electricity.

Sources: EEA (2022a); Eurostat (2023a).

The rapid progress of certain technologies becomes even more evident when we consider their installed capacities. In the renewable electricity sector, wind and solar capacities have shown strong growth since 2005. Wind power has been increasing at a rate of over 5% annually in recent years, while solar capacity, after a slowdown since 2013, is now experiencing significant growth again, with an annual increase of almost 20% in 2021.

Figure 1.9 RES-E capacities in gigawatts



Notes: This figure depicts the installed capacity of renewable electricity sources in the EU-27, categorised by their respective technologies, from 2005 through 2021.

Source: Eurostat (2023c).

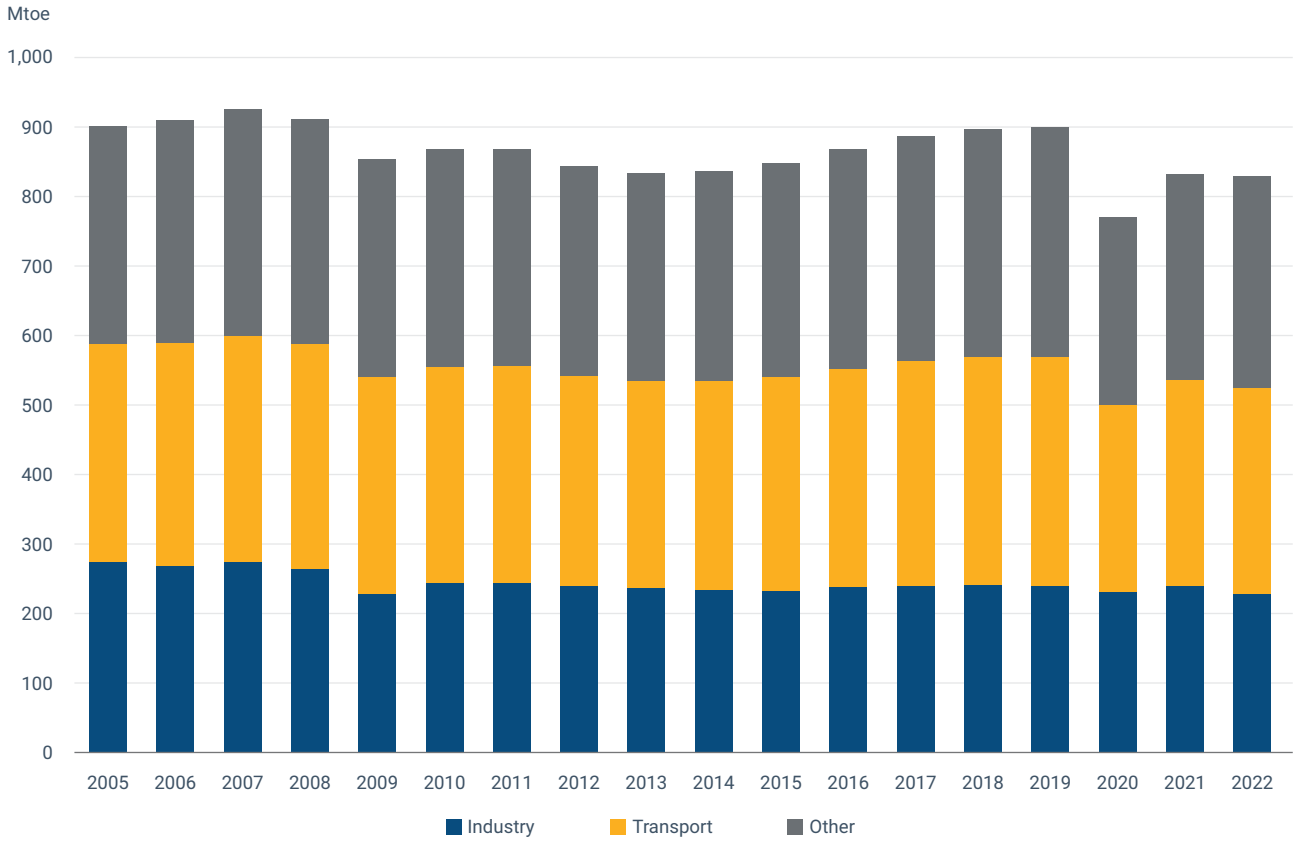
1.5 EU-wide evolutions in energy efficiency

In July 2023, the EU adopted the revised Energy Efficiency Directive (2023/955), which sets out the framework for achieving an 11.7% reduction in EU energy consumption by 2030, compared to the 2020 reference scenario projections. Alongside implementing a range of policy measures targeted at promoting energy savings across diverse economic sectors, with special emphasis on the public sector, the EED outlines a binding final energy consumption target of no more than 763 Mtoe in 2030. For primary energy consumption, an indicative EU primary energy consumption target amounting to no more than 992.5 Mtoe in 2030, is included (EU, 2023b). Member States shall collectively ensure that these EU-wide targets are achieved, by including an updated national contribution in their NECPs. These new 2030 targets require substantial acceleration in energy efficiency: in 2021, the final and primary energy consumption levels in the EU-27 were more than 24% above the newly adopted 2030 targets ([8]).

([8]) This is taking into account the change of definition of the final energy consumption in the new EED: see the notes under Figure 1.11.

Figure 1.10 illustrates the evolution of final energy consumption since 2005, which indicates that only limited progress has been made in this period, with the final energy consumption in 2022 estimated to be 8% lower than in 2005. At the same time, the distribution between sectors has remained relatively constant over this period, with industry accounting for about 25% of the final energy consumption and transport accounting for just over 30%. In recent years, the impact of the COVID-19 pandemic is evident: in 2020, the final energy consumption was reduced by 8% on an annual basis, mainly due to a decline in industry and transport. In 2021, however, the final energy consumption increased by an historic 7%. As a result, the EU achieved its target for final energy consumption in 2020, while in 2021 the target set for the previous year was exceeded. In 2022, the final energy consumption decreased with 1.5% compared to 2021 according to early estimates, in the context of high energy prices. The 2022 estimates indicate that the industry sector showed the strongest decrease of 5% compared to 2021, while transport sector experienced an estimated growth of 3%.

Figure 1.10 Final energy consumption per sector in the EU-27 (2005-2022)

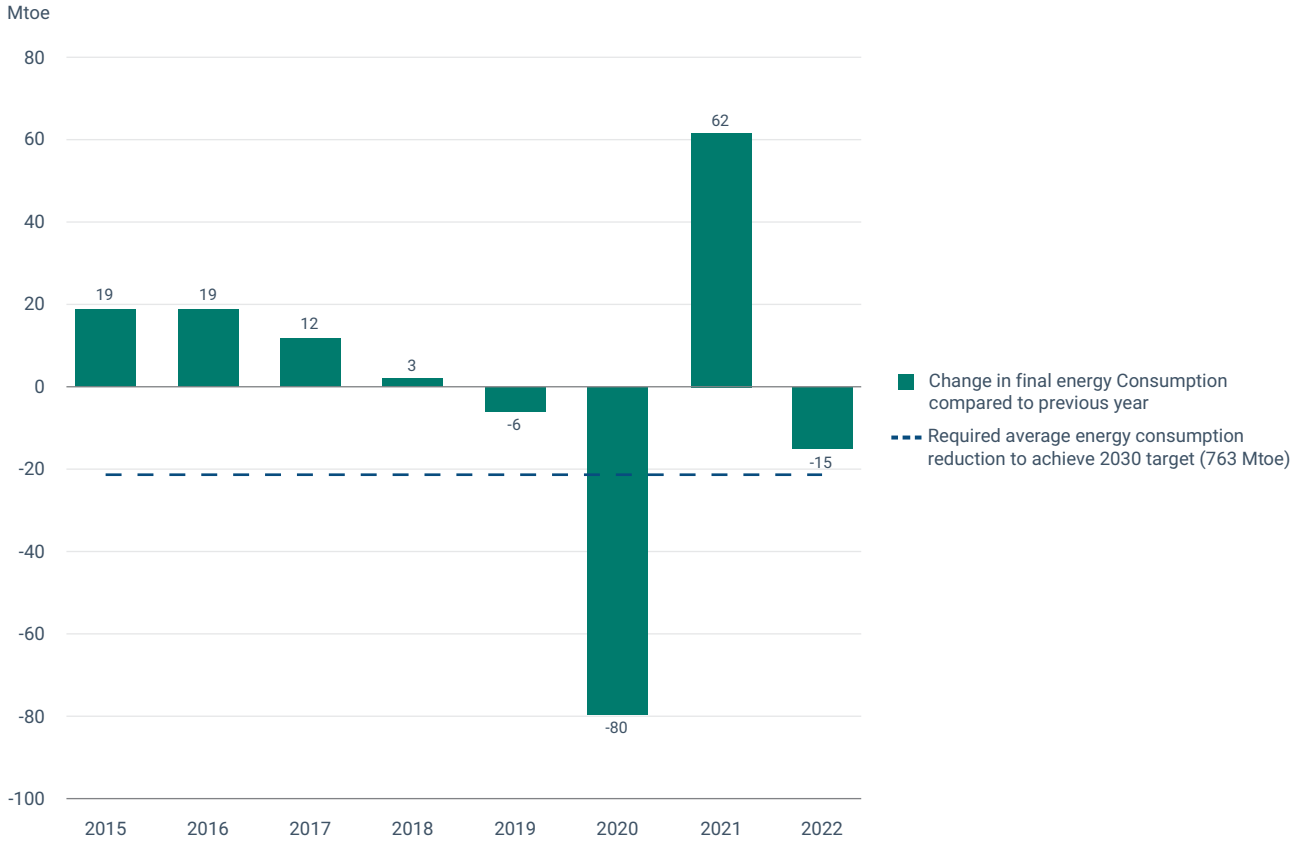


Notes: This figure illustrates the evolution of the final energy consumption in the EU-27 by end-sector. The data for the period 2005-2021 relies on Eurostat (2023a), whereas the 2022 data is based on estimations regarding the primary and final energy consumption by the EEA (EEA, forthcoming e).

Sources: Eurostat (2023a); EEA (forthcoming e).

To achieve the 2030 target, a substantial acceleration in energy savings is necessary for both primary and final energy consumption. Compared with the period since 2005, the average annual absolute energy reduction for primary energy must more than double, while for final energy it should be four times faster to reach the 2030 targets. Figure 1.11 illustrates that, only in the years 2019, 2020 and 2022, significant reductions in final energy consumption were observed in the last eight years.

Figure 1.11 Recent changes in EU-27 final energy consumption



Notes: The figure illustrates the annual difference in the total final energy consumption over the past 8 years. The values used to construct this graph are from Eurostat for the period 2015-2021, and from the EEA's early estimates for 2022. These figures include international aviation, transformation losses and consumption from blast furnaces and exclude ambient energy. However, the 2030 target for final energy consumption, as outlined in the recently adopted Energy Efficiency Directive (EED), deviates in its scope. Notably, this target excludes both transformation losses and consumption from blast furnaces. In the forthcoming methodology for monitoring the EU's progress toward 2030, alignment between the scope of historical values and the specified target definition should be ensured. To illustrate the potential impact, the final energy consumption for the EU-27 in 2021, based on the latest definition, stands at 947 Mtoe, contrasting with the 968 Mtoe calculated under the current monitoring methodology.

Sources: Eurostat (2023d); EEA (forthcoming e).

Box 1.3

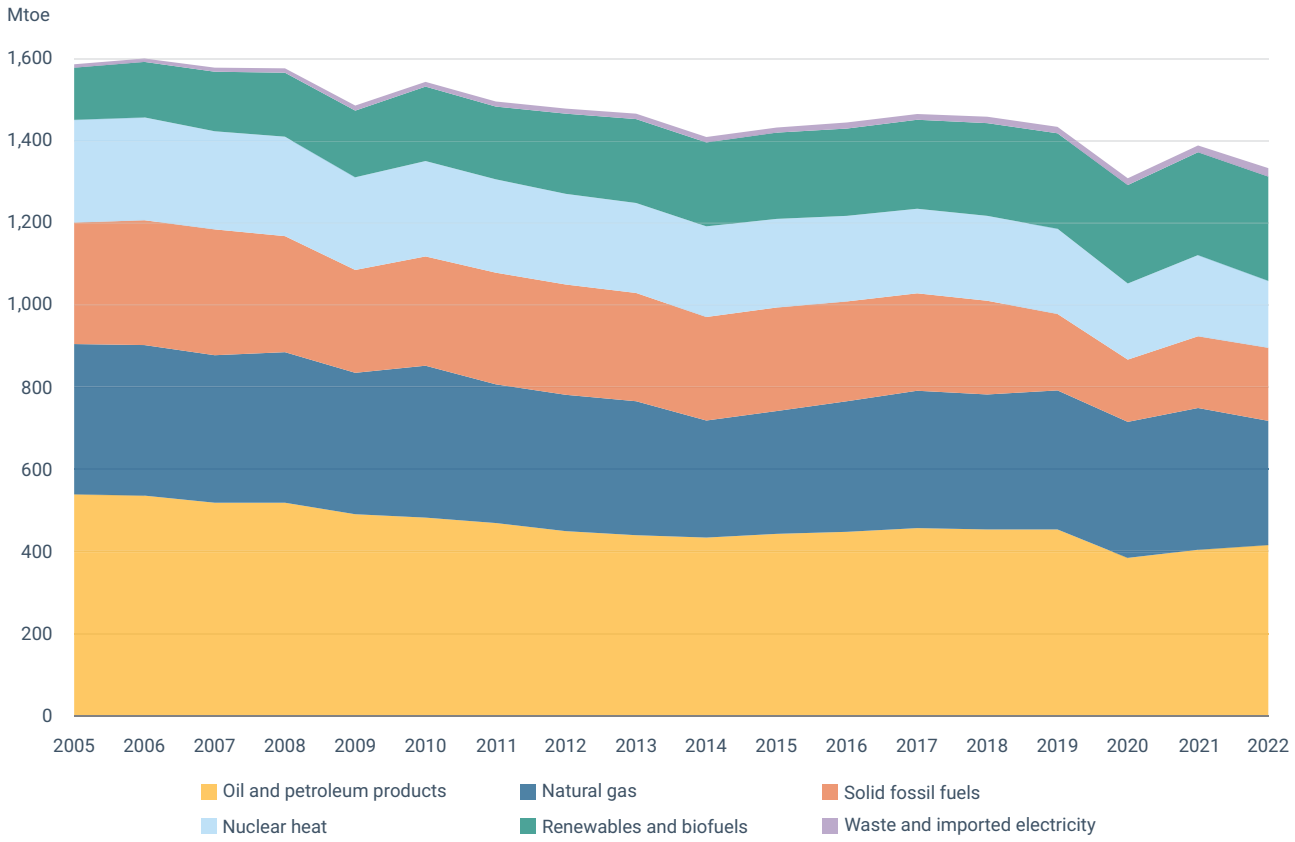
Differences between the evolution of final and primary energy consumption

According to Eurostat (2018), the primary energy consumption measures the total energy demand of a country, including the energy sector, losses during transformation and distribution, and the final consumption by end-users. It does not include energy carriers used for non-energy purposes, such as petroleum for producing plastics. Final energy consumption refers to the total energy consumed by end-users, such as households, industry, and agriculture. It excludes energy used by the energy sector itself, including deliveries and transformation. It also excludes fuel transformed in industrial auto-producers' power stations and coke transformed into blast-furnace gas, unless it is part of overall industrial consumption rather than the transformation sector.

The difference between primary energy consumption and final energy consumption relates to what the energy sector itself requires, and its transformation and distribution losses. The gap between primary and final energy consumption increases when losses in the energy transformation and distribution sector become more significant. Key factors influencing this difference are the proportion of electricity within the final energy demand, and how this electricity is generated. Shifting from fossil fuels to highly efficient renewable sources, such as hydro, solar and wind for electricity generation, can lead to a reduction in primary energy consumption. Conversely, when electricity replaces fossil fuels in final energy demand due to its higher efficiency, final energy consumption decreases.

Primary energy consumption broadly shows the same trend as final energy consumption, although the decrease in primary energy consumption is more pronounced over the later decades due to the fuel mix change. More specifically, Figure 1.12 illustrates the growing prominence of renewable energy in the energy mix, making it the third largest energy source in the EU by 2021, after oil and natural gas. Preliminary estimates for 2022 illustrate notable year-on-year reductions in the consumption of nuclear energy (18%) and natural gas (12%). At the same time, the consumption of solid fossil fuels is estimated to increase for the second year in a row, although at a much slower pace (2%) than in 2021. This evolution explains the higher discrepancy in primary versus final energy consumption. Approximated estimates indicate a decrease of 16% in primary energy consumption compared to 2005, while final energy consumption declined by 8% in the same period.

Figure 1.12: Primary energy consumption per source in EU-27 (2005-2022)



Notes: This figure illustrates the evolution of primary energy consumption (PEC) in the EU-27 since 2005, categorised by energy source. The data for the period 2005-2021 relies on Eurostat (2023a), whereas the 2022 data is based on estimations regarding primary and final energy consumption by the EEA (forthcoming e).

Sources: Eurostat (2023a): EEA (forthcoming e).

2 Greenhouse gas emissions and energy trends at the sectoral level

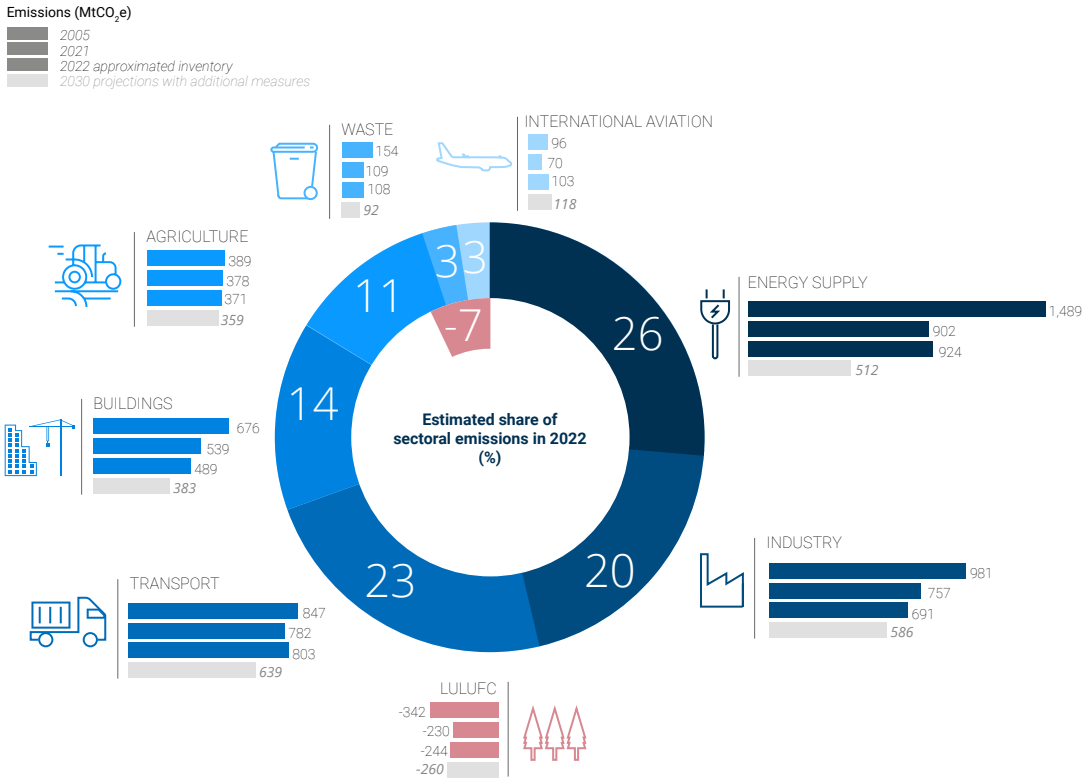
Key messages

- The reduction of greenhouse gas emissions varies widely across the sectors. As of 2021, the energy supply sector has reduced its emissions by almost 40% from 2005 levels. The waste, industry and buildings sectors have also reduced their emissions by more than 20% over this period, while in the transport and agricultural sectors emissions fell by only 11% and 3%, respectively. Compared to 2005, the LULUCF sector's capacity to capture and store CO_2 through land, land use change, and forestry activities decreased significantly through 2021, requiring a complete reversal to meet the 2030 LULUCF target.

- The estimates for 2022 indicate distinct sectoral trends, largely influenced by the energy crisis. The industrial sector recorded an estimated 9% year-on-year reduction in GHG emissions, linked to decreased output driven by higher energy prices. A similar percentage decrease was observed in GHG emissions from the buildings sector. In contrast, the energy supply sector emissions increased by an estimated 3% due to a temporary increase in coal usage, while the transport sector experienced a significant emission increase of 6%. Additionally, the 2022 estimates suggest a rise in CO_2 removals by the LULUCF sector.

- Looking towards 2030, collective efforts will need to intensify across all sectors. Member States' projections indicate substantial expected emission reductions for all sectors in 2030 based on a combination of existing and planned policies. However, all projected 2030 sector emissions fall short of the envisaged scenario reference points of the mix 55-scenario, which are coherent with achieving the overall 55% target. In particular for the buildings sector, the planned policy measures would result in a 2030 emission level that lags considerably behind the mix 55-scenario results.

Figure 2.1 **Sectoral trends and progress towards achieving the 2030 GHG emissions target**



Note: The energy supply sector covers GHG emissions inventory categories 1.A.1 and 1.B; 'industry' covers 1.A.2 and 2; 'transport' covers 1.A.3; 'buildings' covers 1.A.4 +1.A.5; 'agriculture' covers category 3; 'waste' covers category 5; 'international transport', as reported under memo items; 'LULUCF' as reported under category 4.

Sources: EEA (2023b, forthcoming c).

While Chapter 1 presents an overview of the progress made towards achieving the overarching targets for greenhouse gas emissions, renewable energy, and energy efficiency, this chapter delves into the specific pathways that individual sectors can pursue to reach climate neutrality, i.e. energy supply, buildings, transport, industry, agriculture, and LULUCF. Each sector possesses distinct characteristics, along with unique opportunities and challenges to mitigate greenhouse gas emissions effectively. For each of the six sectors, the historical evolution of greenhouse gases is presented together with the factors influencing change over time. In addition, each section looks towards 2030 and beyond, examining the greenhouse gas projections reported by Member States in 2023.

With the exception of LULUCF, no binding climate targets are imposed on individual sectors at the European or national level. However, the mix 55-scenario, as referred to in Chapter 1, includes modelled sector-specific emission results for 2030 that are coherent with an overall GHG emissions reduction of 55% by 2030. In this section, we utilise those sectorial emissions results as reference points to provide insights into each sector's progress towards contributing to the overall 2030 targets.

2.1 Energy supply

Figure 2.2 Key GHG emissions trends and projections for the energy supply sector (CRF 1.A.1 + 1.B)

Notes: GHG emissions of the energy supply sector refer to CRF categories 1.A.1 and 1.B, with the value for 2022 based on the approximated estimates for greenhouse gas emissions. The projections are based on the data submitted by Member States in March 2023. The mix 55-scenario reference point refers to the 2030 emissions as included in the mix 55-scenario for the energy sector where the EEA has mapped the GHG emissions of the PRIMES categories into categories linked to the CRF classification.

Sources: EC (2021b); EEA (2023b, forthcoming c, forthcoming e); own calculations.

The energy supply sector, responsible for the production of heat and electricity, accounted for a quarter of the total EU-27 greenhouse gas emissions in 2021. However, it is also the sector that has made the most substantial contribution to reducing emissions. Since 2005, emissions have been declining at a rapid pace, with multiple annual reductions of more than 5% recorded over the last decade. The replacement of coal by less CO_2-intensive natural gas is an important factor in explaining the emission reduction, but in recent decades the roll-out of renewable energy has been the primary driver. EEA estimates indicate that without the deployment of renewable energy since 2005, greenhouse gas emissions in 2021 would have been almost 50% higher than actual emissions in the energy supply sector (EEA, 2022a).

Contrary to its overall downward trend, greenhouse gas emissions in 2021 increased by 7% compared to 2020, mainly as a result of post-COVID recovery.

Preliminary estimates for 2022 indicate a further 3% increase in GHG emissions for this sector compared to 2021. This increase can be attributed to the low output of hydro and nuclear installations during the summer months of 2022, which was partly accompanied by a 3% increase in fossil fuel-based energy production (EC, 2023k, 2023j). At the same time, the price surge of natural gas made coal relatively cheaper, resulting in a temporary increase in the use of solid fossil fuels.

Looking ahead to 2030, the mix 55-scenario envisions a 69% decrease in GHG emissions from the energy supply sector compared to 2005 levels, which is an additional 30 percentage point reduction compared to 2021. Taking into account the additional policy measures provided by Member States, the sector's GHG emissions are expected to drop by 66% compared to 2005.

2.1.1 A flexible and resilient energy system

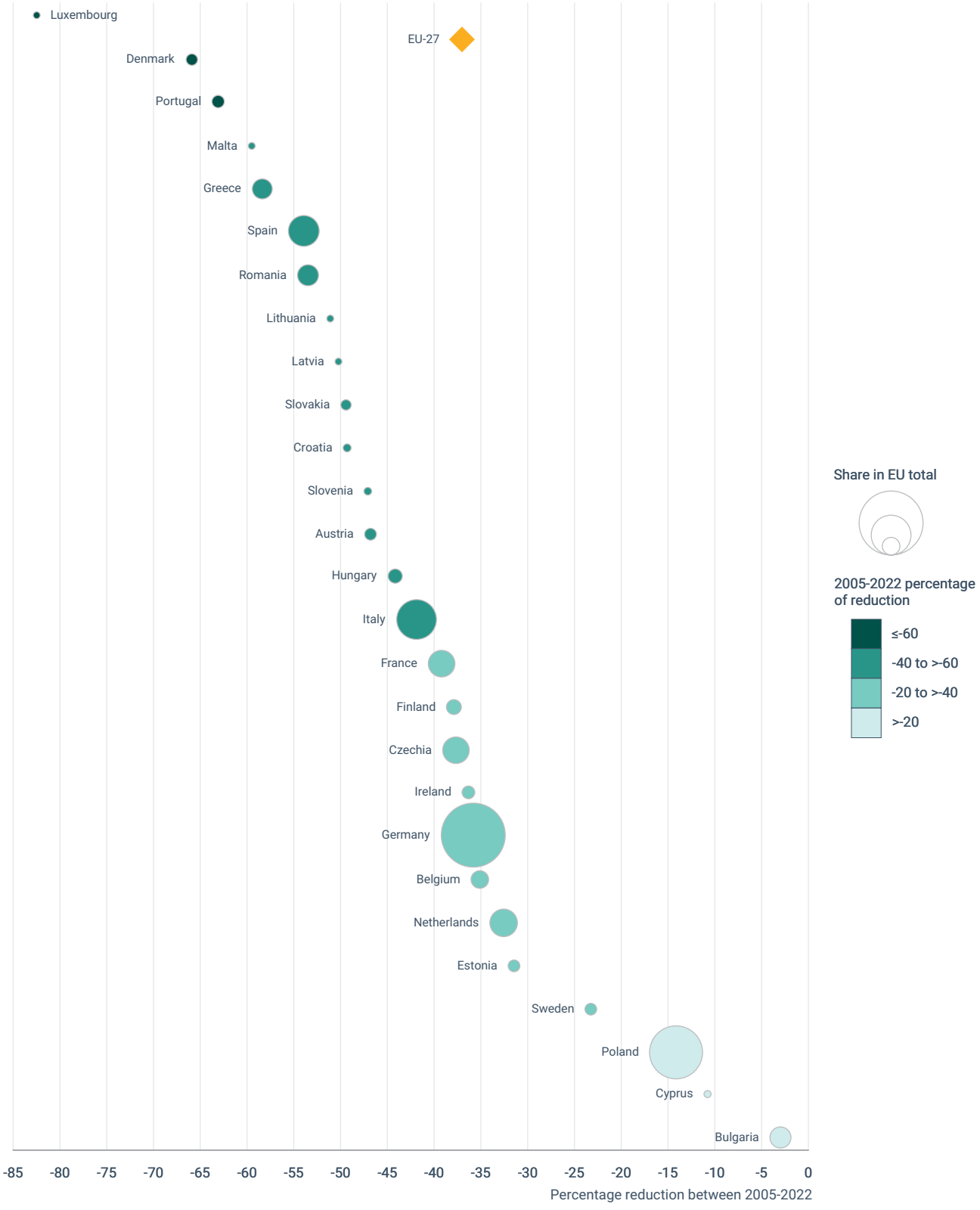
The energy system is undergoing significant and transformative changes. There is a rapid push towards decarbonisation, with renewable electricity seeing remarkable year-on-year growth. One of the main challenges in this transition is ensuring sufficient flexibility within the energy system. As renewable sources gain dominance, i.e. wind and solar, the system is poised to become decentralised and supply-driven. In this regard, demand responses play a crucial role where consumers actively respond to fluctuations in energy availability. Additionally, efforts can be made on the supply side to minimise the variability of renewable energy by utilising storage technologies. The complementary nature of renewable energy production across Europe can be harnessed through cross-border transmission networks (EEA/ACER, 2023). To this effect, the European Commission has proposed a revision of the Electricity Market Design which includes measures to further develop renewable flexibility assets and to promote the role of prosumers (EC, 2023h).

Apart from decarbonisation, the energy system is also increasingly impacted by the effects of ongoing climate change itself. This became clear in the summer of 2022 when severe droughts led to an estimated 18% decrease in production by hydro installations (Eurostat, 2023e). Climate change also has an impact in other areas: in 2022, the Copernicus Climate Change Service found that Europe witnessed its highest amount of surface solar radiation in 40 years, indicating a positive trend and greater potential for energy generation through solar panels. In addition, lower wind speeds were found in usually windy Eastern Europe and Scandinavia (Copernicus Climate Change Service, 2022).

The observations from 2022 reinforce the pressures that climate change places on the European energy system, as previously highlighted by the EEA report on adaptation challenges and opportunities for the European energy system (EEA, 2019). It is vital for both public authorities and market players to prioritise climate resilience when expanding the energy system. By doing so, a balanced and resilient energy system can be shaped for the future.

2.1.2 *Member States' perspective*

Figure 2.3 **Evolution of GHG emissions in the energy supply across Member States: percentage change (2005-2022)**



Notes: The position along the X-axis corresponds to the percentage change specific to the energy supply sector (CRF1.A.1 + 1.B) within the respective countries between 2005 and 2022, with the 2022 values used for the calculation based on estimates. The dimensions of the spheres reflect the proportional contribution of each country within the total EU-wide emissions from the energy supply sector.

Sources: EEA (2023b, forthcoming c).

Since 2005, all EU Member States have reduced emissions from the energy supply sector, with the most pronounced percentage reductions in Luxemburg, Denmark and Portugal. Looking at absolute reductions, Germany has played a key role, accounting for over 30% of the overall EU reductions in the energy supply sector. Spain and Italy have also made significant contributions, with their shares exceeding 10%.

2.1.3 Outlook to 2030 and policy context

Despite the increase of GHG emissions in 2021 and 2022, there are hopeful signs that the strongly declining trend in the energy supply sector can be resumed in the coming years. In addition to the unprecedented capacity growth of renewable energy in 2022 (EC, 2023j), the increase in coal consumption is expected to be temporary. Starting from the fourth quarter of 2022, declining gas prices incentivised a higher deployment of gas installations compared to coal production. Furthermore, assuming a rebound of hydro power in 2023, combined with the expected capacity growths in wind and solar, the need for fossil fuels would be significantly reduced in 2023 and beyond.

At the EU level, a robust supportive policy framework aimed at achieving emission reductions in the energy supply sector already exists. One such policy is the EU ETS, which has been in place since 2005 and provides a financial incentive to reduce emissions in key industrial sectors, including energy supply. While CO_2 prices have historically been volatile and relatively low, recent trends indicate a significant increase, with prices reaching EUR 80 per tonne in 2022 (Ember, 2023). This substantial price level serves as a clear incentive to transition towards less carbon-intensive energy sources and promote the use of renewable energy. Furthermore, the revised ETS directive will further enhance the effectiveness of the system by providing greater certainty for businesses and investors.

Regarding renewable energy, the newly-adopted RED in couples the 2030 renewable energy target of 42.5% (with an additional 2.5% indicative top), with ambitious sector-specific targets in transport, industry, buildings, heating and cooling. Building on the substantial growth witnessed in wind and solar power, this directive aims to significantly reduce reliance on fossil fuels in the energy supply sector by 2030.

Read more and find detailed data about:

- Report on Flexibility solutions to support a decarbonised and secure EU electricity system
- Dashboard – renewable energy in Europe
- Indicator on greenhouse gas emission intensity of electricity generation in Europe

2.2 Buildings

Figure 2.4 Key GHG emission trends and projections in the buildings sector (CRF 1.A.4 and 1.A.5)

Historic Trends	% change **2022 vs 2021**	**-9%**
	% change **2021 vs 2005**	**-20%**
2030 projections and modelling	% change **2030 vs 2005** **WAM** projections	**-43%**
	% change **2030 vs 2005** **Mix 55** scenario	**-61%**

Notes: GHG emissions of the buildings sector refer to CRF categories 1.A.4 and 1.A.5, with the value for 2022 based on the approximated estimates for greenhouse gas emissions. The projections are based on the data submitted by Member States in March 2023, while the mix 55-scenario reference point refers to the 2030 emissions as included in the mix 55-scenario for the buildings sector, where the EEA has mapped the emissions of the PRIMES categories into categories linked to the CRF classification.

Sources: EC (2021b); EEA (2023b, forthcoming c, forthcoming e); own calculations.

The buildings sector accounted for 14% of the total direct EU GHG emissions in 2021, with emissions from this sector mainly linked to the combustion of fossil fuels for space and water heating. The GHG emissions from this sector exhibit significant annual fluctuations, which can be attributed to annual weather variations and their impact on the heat and energy demand. Nevertheless, the overarching trend in GHG emissions since 2005 has been on a downward trajectory, with an average annual reduction of 1.4%. A key contributing factor to this decline is the significant improvement in the energy performance of buildings through better insulation, coupled with reduced heat demand resulting from more frequent milder winters (Tsemekidi Tzeiranaki et al., 2022). These factors have counterbalanced the upward effect on energy consumption linked to population growth, increase in the number of households, and the construction of larger houses. At the same time, a switch to less CO_2-intensive fuels like biomass and natural gas significantly reduced emissions, and solid and liquid fossil fuel use for homes has decreased.

Preliminary estimates for 2022 indicate an estimated 9% reduction in GHG emissions compared with 2021. This evolution can be attributed in part to a milder winter, leading to an 8% decrease in heating degree days (Eurostat, 2023b) and a subsequent decline in energy demand compared to 2021. In addition, the substantial increase in energy prices, particularly natural gas prices, played a role in the observed trend. Prices more than doubled for typical household customers by September 2022 compared to the previous year, which, coupled with general energy awareness resulting from the energy crisis, contributed to the emissions drop. In addition to the economic impact, households across Europe have embraced behavioural changes to actively reduce energy consumption, supported by national and European awareness-raising campaigns. The November 2022 EU barometer (Ipsos European Public Affairs, 2022) revealed that nearly two-thirds of respondents across all countries agreed that it is essential for everyone to make conscious efforts to reduce energy usage during peak hours. In addition to immediate behavioural changes, more structural adjustments are also visible, with the sale of heat pumps growing rapidly in 2022. According to figures from the European Heat Pump Association, 3 million heat pumps were sold in Europe in 2022, an increase of 39% compared to 2021 (EHPA, 2023). If the same growth rate is maintained, the EU-27 would be on track to achieve the planned roll-out of 10 million more heat pumps by 2027 (Lyons *et al.*, 2022).

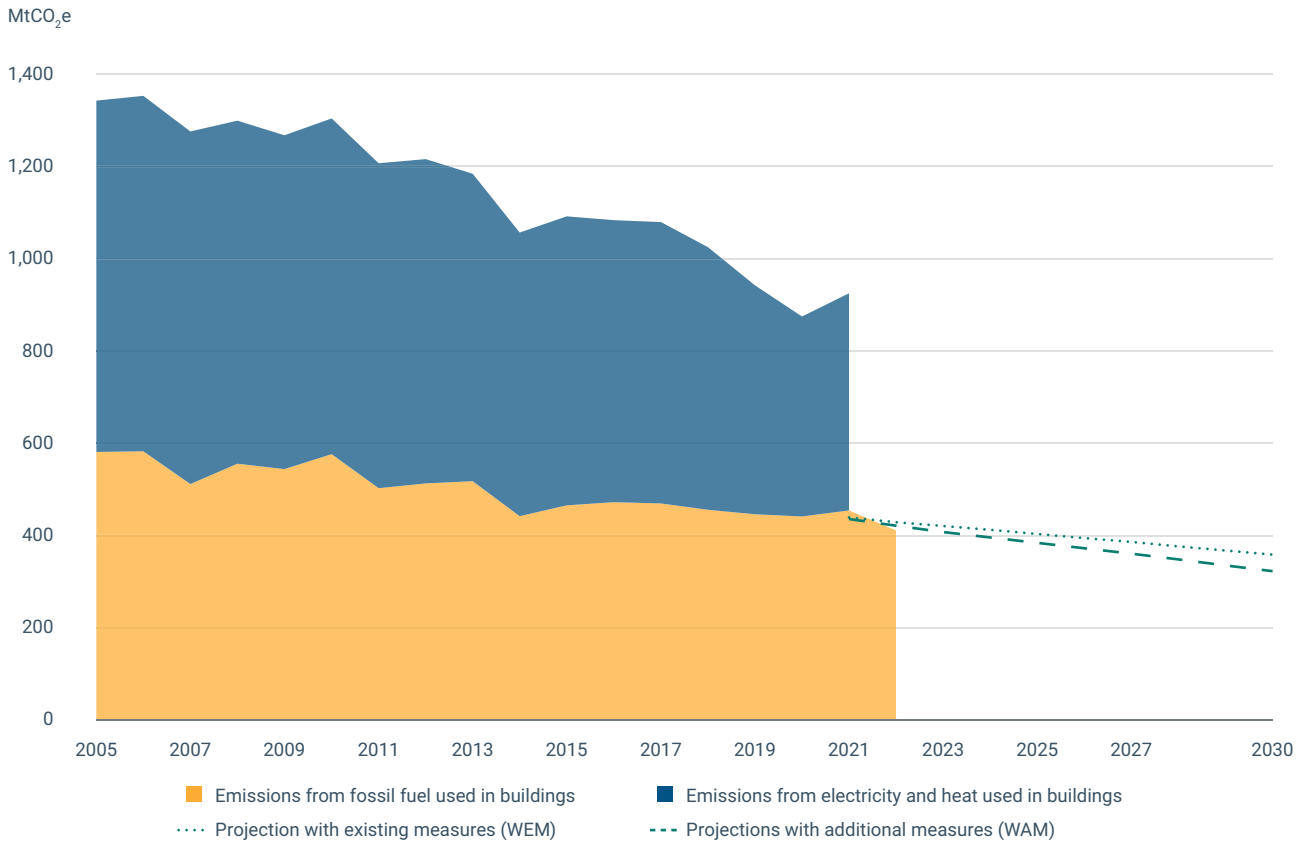
The mix 55-scenario outlines a contribution for the buildings sector to reduce emissions by 61% by 2030, relative to 2005 levels. Member States' projections significantly lag behind the required rate of reduction, as the current WAM projections indicate an emission reduction of 43%, considerably lower than what is necessary to meet the mix 55-scenario reference point.

© Bruno Coelho, My City /EEA

2.2.1 The role of electrification and district heating

In addition to direct fuel consumption in buildings – reflected in the direct greenhouse gas emissions attributed to the sector, an important part of the energy consumption in buildings is linked to electricity consumption and collective heating systems. If these are based on fossil fuels, this does not affect CO_2 emissions of the buildings sector but credits to the emissions from the energy supply sector. An EEA indicator illustrates the indirect emissions of energy consumption linked to heating. The cumulation of direct and indirect emissions represents 35% of energy-related EU emissions in 2021, demonstrating that indirect emissions in the buildings sector are critical to be taken into account. The indicator also reveals that there are more pronounced emission reductions if these two categories are taken together, thus reflecting the ongoing decarbonisation of the electricity and heating and cooling sector.

Figure 2.5 **Direct and indirect greenhouse gas emissions from energy use in buildings in the EU (1.A.4.a and 1.A.4.b)**

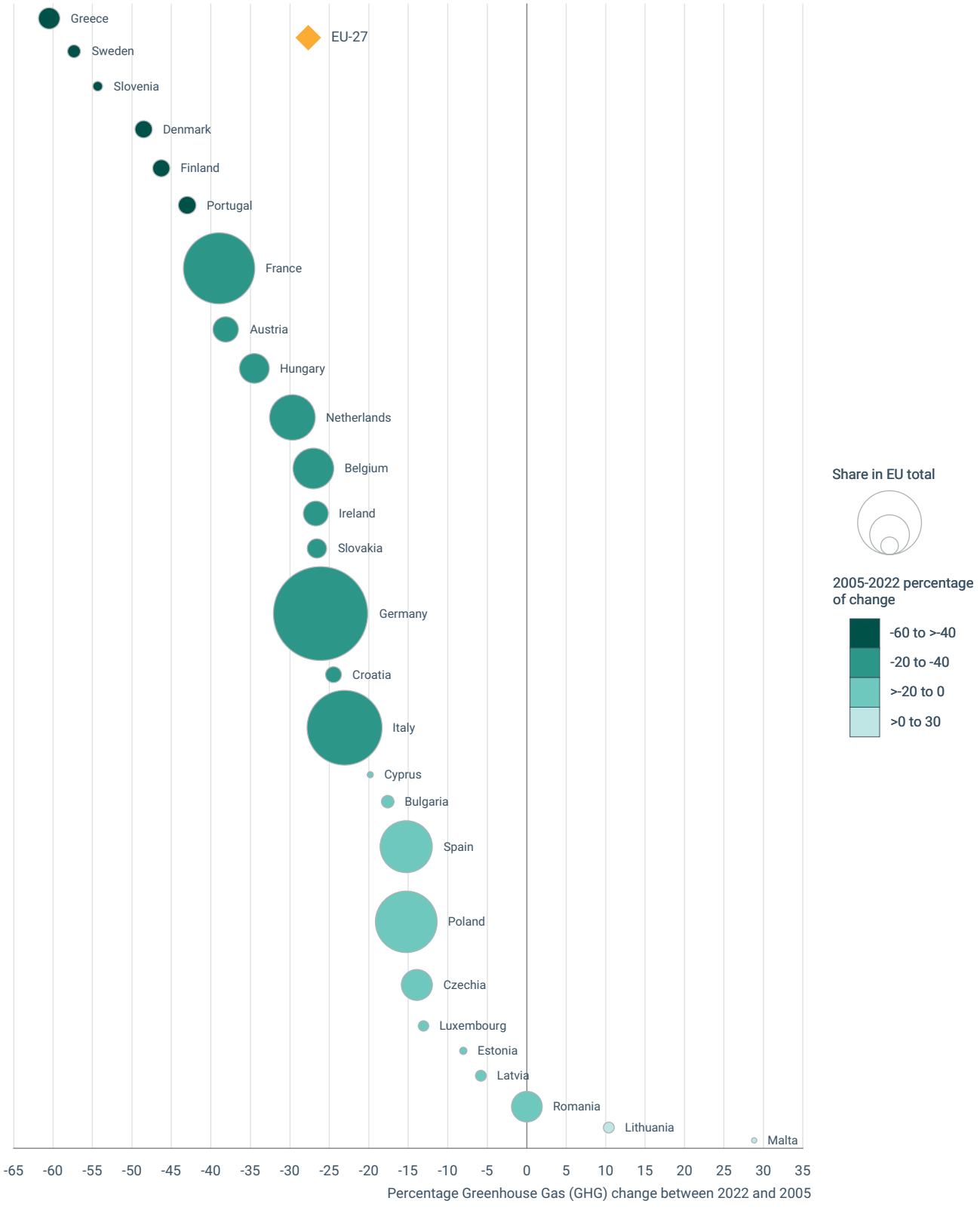


Notes: The comprehensive methodology outlining the framework for developing this indicator can be accessed on the dedicated EEA indicator page (EEA, 2023d).

Sources: EEA (2023b, forthcoming c, forthcoming e); own calculations.

2.2.2 *Member States' perspective*

Figure 2.6 **Evolution of GHG emissions in the buildings sector across Member States: percentage change (2005-2022)**



Notes: The position along the X-axis corresponds to the percentage change specific to the buildings sector (CRF1.A.4 + 1.A.5) within the respective countries between 2022 and 2005, with the 2022 values used for the calculation based on estimates. The dimensions of the spheres reflect the proportional contribution of each country within the total EU-wide emissions from the buildings sector.

Sources: EEA (2023b, forthcoming c).

Looking at the evolution since 2005, emissions from the buildings sector have decreased in most Member States, with the exception of Malta and Lithuania. The country-specific evolution can be explained by various parameters, such as population growth, economic development, and specific building energy efficiency policies. An important part of the notable emission reductions implemented in the Nordic countries runs parallel to an increase in the use of district heating, in which biomass is often used.

2.2.3 Outlook to 2030 and policy context

The buildings sector is projected to play a pivotal role in achieving the European climate targets. This ambition aligns with the goals of the RePowerEU initiative, which strives to install 10 million heat pumps by 2027, enhance the renovation rate, and increase the utilisation of renewable energy sources within buildings. Several policy instruments have been set up to support these goals, ranging from various national incentive schemes to the new ETS-2 system that will cover GHG emissions from the buildings sector from 2027 onwards. Furthermore, with the proposed recast of the Energy Performance of Buildings Directive (EC, 2021c), non-economic barriers are addressed to accelerate the renovation of buildings. At the same time, it is crucial to strike a balance between these challenging aspirations and the maintenance of a reliable and affordable energy supply, which remains a key priority.

While there is promising potential for substantial emissions reductions through advancements like heat pumps, it is crucial to acknowledge that there is no one-size-fits-all solution for the buildings sector. Encouraging individual homeowners to take action is vital, particularly in Member States where individual heating systems dominate. Additionally, some countries rely on collective district heating systems, necessitating the modernisation of existing, sometimes outdated infrastructures, such as integrating waste heat and renewable heat systems (EEA, 2023, 2023d).

Read more and find detailed data about:

- Briefing on accelerating the energy efficiency renovation of residential buildings — a behavioural approach
- Briefing on decarbonising heating and cooling — a climate imperative
- Briefing on cooling buildings sustainably in Europe: exploring the links between climate change mitigation and adaptation, and their social impacts
- Indicator on greenhouse gas emissions from energy use in buildings

2.3 Transport

Figure 2.7 Key GHG emission trends and projections in the transport sector, including international transport

Notes: GHG emissions of the transport sector, including fuels used for international aviation and maritime transport, refer to CRF categories 1.A.3, and international shipping and international aviation as reported under memo items, with the value for 2022 based on the approximated estimates for greenhouse gas emissions. The projections are based on the data submitted by Member States in March 2023, while the mix 55-scenario reference point refers to the 2030 emissions as included in the mix 55-scenario for the transport sector (including international transport), where the EEA has mapped the emissions of the PRIMES categories into categories linked to the CRF classification.

Sources: EC (2021b); EEA (2023b, forthcoming c, forthcoming e); own calculations.

The transport sector is a significant source of greenhouse gas emissions, accounting for almost a quarter of the total emissions in the EU-27 in 2021. More than 75% of the sector emissions are linked to emissions from road transport, although international aviation and international navigation are also significant contributors in this sector. Unlike other sectors, the transport sector's greenhouse gas emissions have substantially increased since 1990. There was a continuous rise in emissions until 2007, and there has not been a significant decrease since then. However, over the last years, the emissions fell sharply in 2020 due to the COVID-19 pandemic, after which they rose again in 2021, albeit to a lower level than before the pandemic. In 2022, the estimated emissions of the sector have increased by 6% compared to 2021.

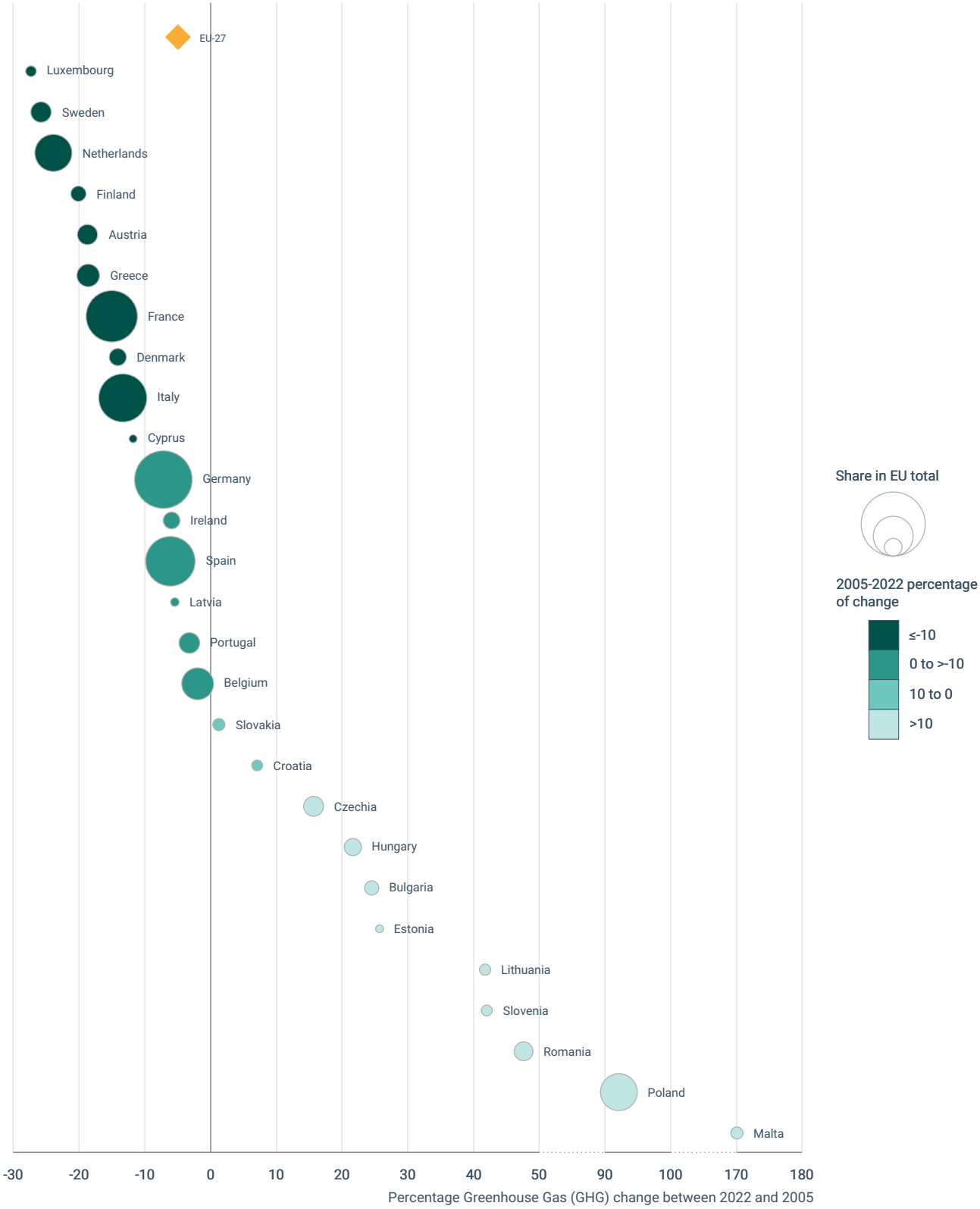
To achieve the climate target of 55% reduction in 2030, a 23% reduction in greenhouse gas emissions from the transport sector in 2030, compared to 2005, has been modelled in the mix 55-scenario, requiring a further decrease of 12 percentage points in the GHG emissions in the period 2022-2030. Member states' current projections, which include additional measures, would result in an emission reduction of 18% by 2030, meaning further transport measures would have to be introduced, or reductions from other sectors would have to become proportionately greater than indicated in the scenario.

The evolution of greenhouse gas emissions in road transport is tied to the substantial growth in both passenger and freight kilometres travelled (EEA, 2023f), as well as rising car ownership rates. Consequently, the transport sector accounts for more than half of the domestic oil product consumption in the EU-27. However, there has been a significant positive change observed in recent years, with a shift towards more environmentally friendly car technologies. The CO_2 emissions of newly registered cars are substantially decreasing, with noteworthy year-on-year declines of 12% for both 2020 and 2021. This remarkable improvement can largely be attributed to the rapid rollout of electric vehicles, which have no tailpipe CO_2 emissions and are becoming increasingly popular in the EU. In 2022, almost 22% of new car registrations were for electric vehicles, with fully electric cars making up more than half of these registrations. While this illustrates that electric cars start taking up a significant share of new sales, they still make up only 2% of the total passenger car fleet in 2022 (EC, 2023g). The speed of decarbonising road transport will therefore depend, to a large extent, on the renewal of the vehicle fleet. At the same time, a modal shift to sustainable transport modes, i.e. new forms of urban mobility, the use of inland waterway transport and rail transport, can also accelerate decarbonisation.

The total emissions from international aviation, as reported in GHG emissions inventories, encompass the emissions generated by flights departing from one EU Member State and arriving in any other EU or non-EU country. Over the years, these emissions have exhibited significant growth. Between 1990 and 2005, the emissions related to international aviation nearly doubled, and from 2005 to 2019, they experienced an additional increase of 39%. Aviation was particularly affected by the COVID-19 pandemic, witnessing GHG emissions in 2020 that were less than half of the record levels recorded in 2019. In 2021, there was a substantial year-on-year emissions growth of 24%. Estimates for 2022 suggest almost a 50% increase in emissions growth compared to the previous year. Despite this notable rise, GHG emissions of international aviation still remain significantly below the record levels of 2019.

2.3.1 *Member states' perspective*

Figure 2.8 **Evolution of GHG emissions in the transport sector across Member States: percentage change (2005-2022)**



Notes: The position along the X-axis corresponds to the percentage change specific to the transport sector (CRF1.A.3 + international aviation and international maritime reported as memo-items) within the respective countries between 2022 and 2005, with the 2022 values used for the calculation based on estimates. The dimensions of the spheres reflect the proportional contribution of each country in the total EU-wide emissions from the transport sector.

Sources: EEA (2023b, forthcoming c).

Examining the distribution per Member State reveals varying trends in different countries. While Malta and Poland experienced an increase of more than 50% since 2005, transport-related greenhouse gas emissions in Sweden, Luxemburg, the Netherlands, Finland and Greece decreased substantially. In particular for Greece, this is related to a reduction in greenhouse gas emissions of their international maritime sector. Sweden set ambitious targets for the transport sector and have implemented a carbon tax on fuels since 1991, with exemptions for sustainable biofuels. Luxembourg introduced a CO_2 tax on fossil fuels in 2021 and invested significantly in public transport, while the Netherlands, among other measures, established ambitious targets and actively stimulated the development of a charging infrastructure to foster the adoption of zero-emission vehicles.

2.3.2 Outlook to 2030 and policy context

With the approval of the Fit-for-55 package, there is full focus on further emission reductions in the transport sector. In addition to the policies stimulating energy efficiency and the uptake of renewable energy, various new policy instruments have been introduced:

- From 2027 onwards, greenhouse gas emissions of the road transport sector will be covered by the new emission trading system (ETS-2). The new system will apply to distributors that supply fuels to the buildings, road transport and certain other sectors.

- CO_2 standards have been tightened for new cars and vans for the period 2030-2034 and a target is set at 55% CO_2 emission reductions for new cars and 50% for new vans (both compared to 2021 levels). A 100% CO_2 emission reduction target for both new cars and vans is set from 2035 onwards (EU, 2023d).

- Heavy-duty vehicles, lorries, buses, and coaches generate around 28% of all CO_2 emissions from road transport and contribute over 6% to the total EU greenhouse gas emissions. Existing CO_2 standards require manufacturers to reduce the CO_2 emissions of new heavy trucks by 15% by 2025 and 30% by 2030, compared to 2019 levels. The European Commission proposed, in February 2023, to extend the scope to other new lorries as well as to new buses, coaches and trailers, thus tightening the existing 2030 target of 30-45%, and setting new reduction targets for 2035 at 65% and 90% from 2040. The proposal also sets a 100% zero-emission target for new urban buses from 2030, which currently generate around 5% of CO_2 emissions in the heavy-duty transport sector and meaningful air pollution in urban areas.

- The Alternative Fuel Infrastructure Regulation aims to ensure that there is a sufficient infrastructure network for recharging or refuelling road vehicles or ships with alternative fuels. It includes specific deployment targets for infrastructure that will have to be met in 2025, or 2030 (Council of the European Union, 2023a).

- With the ReFuelEU aviation initiative, the Council and the European Parliament reached a provisional political agreement on a proposal aimed at decarbonising the aviation sector and creating a level playing field for sustainable air transport.

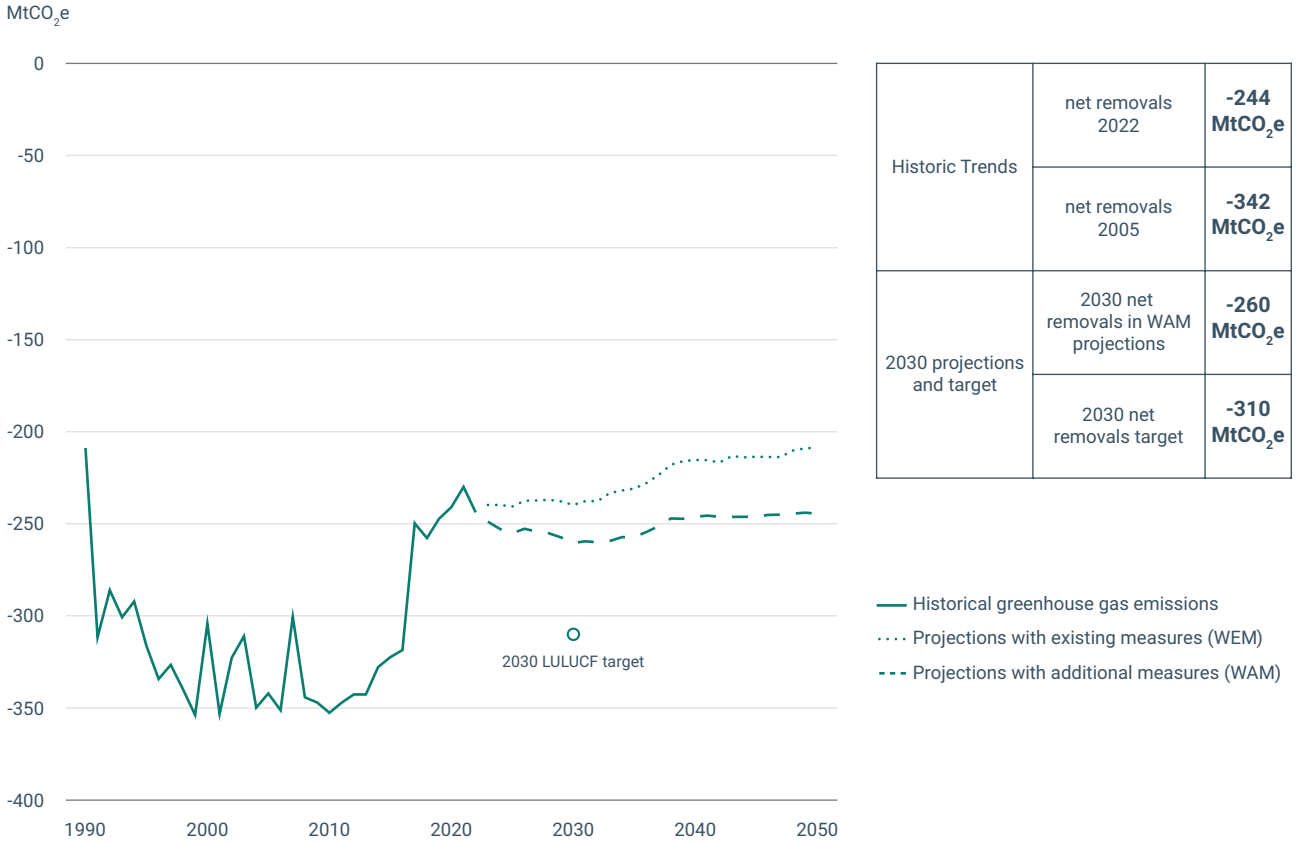
- With the FuelEU maritime initiative, a new law to decarbonise the maritime sector has been adopted, including measures to ensure a gradual reduction of the greenhouse gas intensity of fuels used by the shipping sector from 2025 (Council of the European Union, 2023c). Furthermore, from 2024, the EU ETS will be extended to cover CO_2 emissions from all large ships entering EU ports, regardless of the flag they fly. From 2026, the EU ETS will further cover methane and nitrous oxide emissions from the maritime sector.

Read more and find detailed data about:

- Indicator on greenhouse gas emission transport sector
- Indicator on renewable energy use in transport sector
- Indicator on CO_2 performance of new passenger cars in Europe
- New registrations of electric vehicles
- Transport and Environment Report 2022

2.4 LULUCF

Figure 2.9 Key GHG emissions trends and projections in the LULUCF sector



Notes: The GHG emissions of the LULUCF sector refer to the GHG emissions reported under CRF category 4, with the 2022 values based on estimates. The projections are based on the most recent data submitted by Member States. The 2030 target refers to the 310 $MtCO_2e$ reduction target as included in the LULUCF Regulation (EU) 2018/841 amended by (EU) 2023/839. The values in both the chart and the table refer to the net removals of the LULUCF sector. The negative values signify that the removals at the EU level for the LULUCF sector exceeded its emissions.

Sources: EC (2021b); EEA (2023b, forthcoming c, forthcoming e); own calculations.

The land use, land use change and forestry (LULUCF) sectors cover anthropogenic GHG emissions and CO_2 removals that relate to land use and land use conversions. It includes activities that release greenhouse gases, such as the conversion of forest to other land uses (deforestation) and draining wetlands for agricultural or other purposes. On the other hand, the LULUCF sector also covers activities that remove CO_2 from the atmosphere and store it as carbon in biomass and soils.

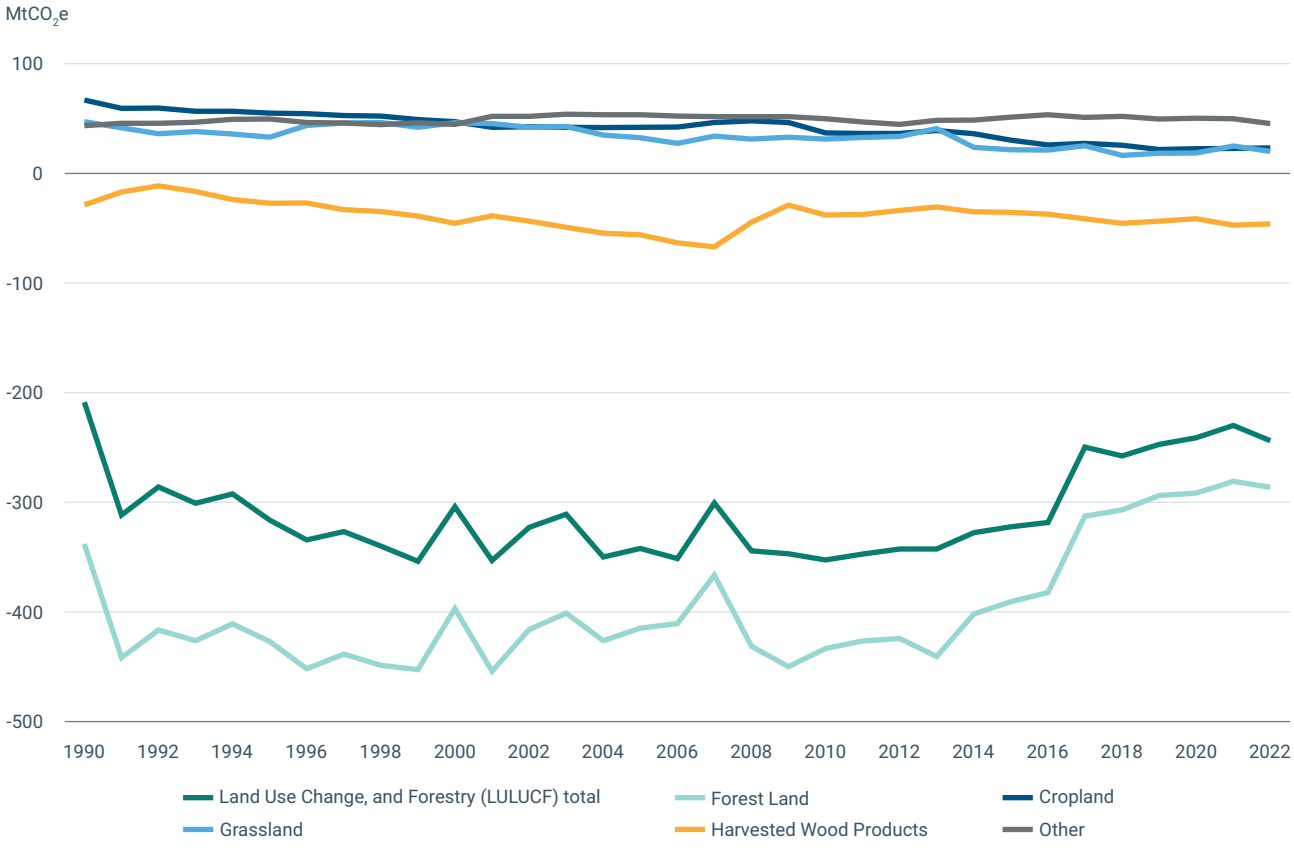
Overall, the LULUCF sector has acted as a net CO_2 sink for the EU since 1990, removing more CO_2 from the atmosphere than it has emitted, thanks to the ability of trees and plants to absorb CO_2 from the atmosphere. However, in the past decade, the sink capacity of the LULUCF sector has significantly declined, with the net removals shrinking from 342 $MtCO_2e$ in 2005 to 229 $MtCO_2e$ as of 2021. In 2022, the reported LULUCF estimates indicate the net removal is estimated to account for 244 $MtCO_2e$, implying an increase of the sink compared to 2021. The new LULUCF regulation has set the target for 2030 at a net removal of 310 $MtCO_2e$. To achieve this target, over the next eight years the net removals should increase by an additional total of 66 $MtCO_2e$. However, the aggregated Member State projections, taking into account additional measures, fall short of achieving this required increase in net removals.

2.4.1 Crucial role of forests to remove CO_2

Within the LULUCF sector, the removals and GHG emissions related to different types of land uses are aggregated. While croplands, wetlands, settlements and grassland are net emitters of greenhouse gases, forest land is the largest contributor to GHG emissions removals, with a CO_2 capture of 288 Mto in 2021, or about 8% of the total greenhouse gas emissions emitted in the EU.

When looking at the different land use categories in Figure 2.10 it becomes evident that forests play a crucial role in comprehending the dynamics of LULUCF GHG emissions. In the EU, there has been a consistent upward trend in forest coverage over the years. The proportion of land covered by forests has steadily risen from 35% in 1990 to 39% of the total land area by 2020 (Eurostat, 2021). Despite this increase in forest coverage, the amount of CO_2 sequestered in forests has witnessed a decline in recent times, caused by a combination of a decrease in the net growth of the forests, an increase in harvest, and natural disturbances (Korosuo et al., 2023).

Figure 2.10 Historical evolution of LULUCF GHG emissions



Source: EEA (2023b, forthcoming c)

An important underlying cause is the relatively old age of the trees in many forests across Europe. As forests age, the capacity of the forest to absorb CO_2 per unit area (ha) decreases (Korosuo et al., 2023), resulting in a reduced carbon sink potential compared to forests with trees in the fastest period of growth. Furthermore, in forests that reach maturity, the harvested volume increases. Although young trees are typically planted to replace the harvested ones, it takes a considerable amount of time for these trees to reach their optimal growth phase, during which they perform maximum CO_2 sequestration and contribute to biomass production (Korosuo et al., 2023). In addition, it is important to distinguish between afforestation and deforestation in terms of the immediate effects on the net emissions balance. While the conversion of a forest to a 'new use type' and its harvesting leads to an immediate release of greenhouse gas emissions, afforestation in the first years, only manages a small additional removal of emissions. A third factor to take into account is the impact of climate change: in recent years the negative impacts have been intensely obvious in the form of forest fires and insect infestation in forests, which caused the loss of carbon and thus an increase in emissions (EEA, forthcoming d). The causes of the ongoing trend of the EU forest sink are further discussed by Korosuo et al., (2023).

The LULUCF sector comprises different categories and management practices. Some measures with additional mitigation potential are increased afforestation, decreased deforestation, improved forest management, fallowing of histosols, improved crop rotation and improved grassland management. However, for many of the measures, there is a challenge with the time lag between the time a mitigation measure is implemented and the time the results are visible. Reducing forest harvest and minimizing deforestation are actions with immediate results. The former also affects biomass availability and may hold implications for adaptation efforts, which in some cases require additional harvest (EC, 2021a).

2.4.2 Member States' perspectives

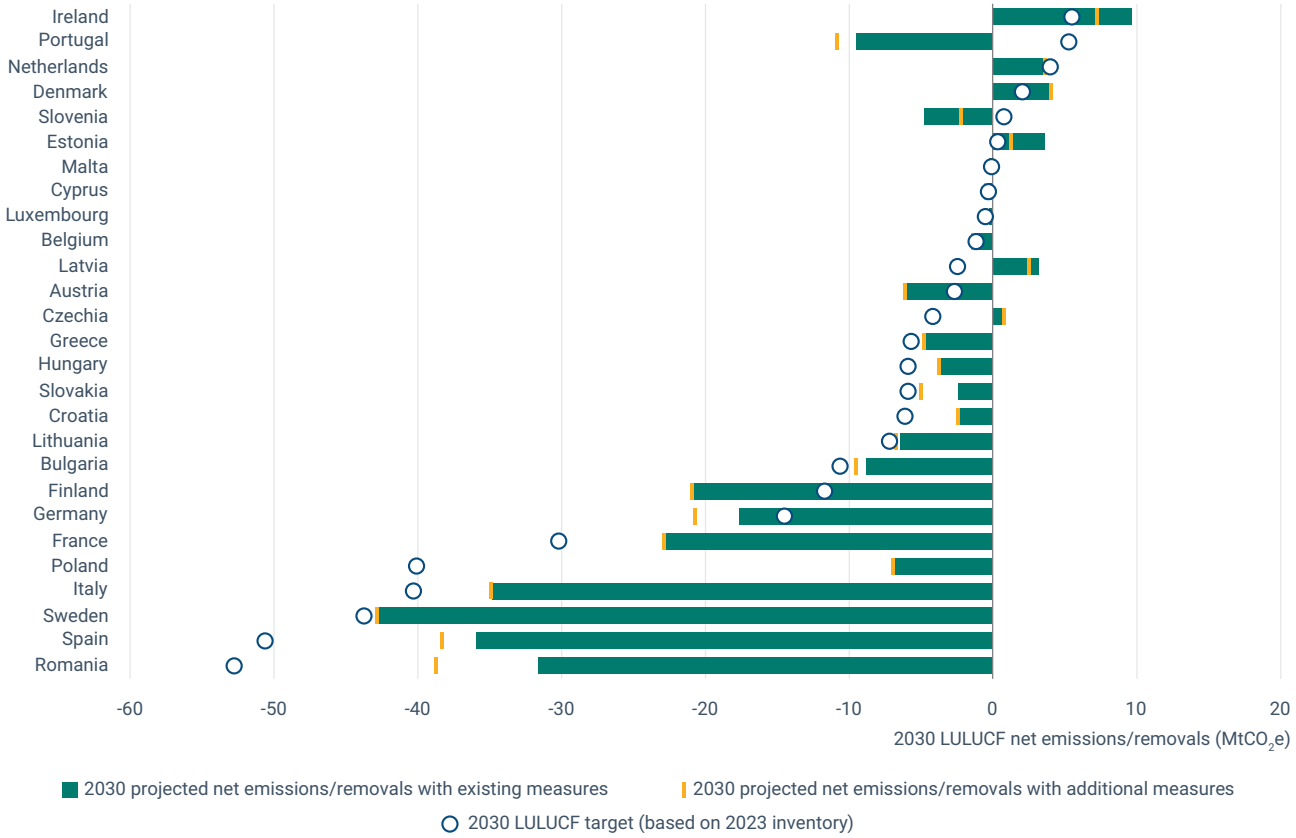
While the EU, on the whole, had a surplus in LULUCF GHG removals compared to emissions, this is not true for all Member States. In 2021, nine Member States (Czechia, Denmark, Estonia, Finland, Germany, Ireland, Latvia, Malta and the Netherlands), had a LULUCF sector that was a net source of GHG emissions.

With the revision of the LULUCF regulation in 2023, the governance framework is divided into two phases. In the first period 2021-2025, Member States should ensure that accounted emissions from land use are compensated by at least an equivalent amount of accounted removals. For the 2026-2030 phase, the compliance rules will be simplified by moving from accounting benchmarks to reported emissions and removals and the governance framework will be aimed at achieving the EU-wide target of 310 $MtCO_2e$ net removals by 2030.

Member State targets for net emissions and removals for the year 2030 are included in the revised LULUCF regulation. These targets are defined as increased removals to the average 2016 to 2018 net inventory results for the LULUCF sector in each Member State. The targets as outlined in the Annex to the LULUCF Regulation are based on the GHG inventory submitted in 2020 and total an EU-wide net removal of 310 $MtCO_2e$ by 2030. However, the final 2030 targets will be established using the inventory submitted in 2032. Considering the latest GHG emissions inventory of 2023, the sum of the Member States' reduction targets would amount to 318 $MtCO_2e$, because the average removal in the years 2016-2018 increased by 8 $MtCO_2e$ compared to the 2020 inventory. In addition to the 2030 targets, national net removal 'budgets' will be defined for the years 2026-2029. For compliance of both elements, flexibilities can be used.

In Figure 2.11, LULUCF projections by Member States are shown in relation to their 2030 target, calculated with the 2023 GHG emissions inventory. For some Member States, the 2030 target would end up in a source instead of a removal target (Denmark, Estonia, Ireland, the Netherlands, Portugal and Slovenia).Projections including additional policies and measures, suggest that only nine Member States would achieve their 2030 target when applying the 2023 GHG emissions inventory to the target framework.

Figure 2.11 LULUCF 2030 projections by each Member State in relation to their 2030 target



Note: Final target numbers for compliance under the LULUCF regulation will be calculated with the 2032 GHG emissions inventory.

Sources: EEA (2023b, forthcoming c).

Read more and find detailed data about:

- Indicator on LULUCF emissions
- The European biomass puzzle — Challenges, opportunities and trade-offs, around biomass production and use in the EU (forthcoming)

2.5 Agriculture

Figure 2.12 Key GHG emissions trends and projections in the agriculture sector

Notes: GHG emissions of the agriculture sector refer to CRF category 3. The projections are based on the most recent data submitted by Member States, while the mix 55-scenario reference point refers to the 2030 emissions as included in the mix 55-scenario for the agriculture sector, where the EEA has mapped the emissions of the PRIMES categories into categories linked to the CRF classification.

Sources: EC (2021b); EEA (2023b, forthcoming c, forthcoming e); own calculations.

In 2021, greenhouse gas emissions from the EU agriculture sector, as reported under CRF category 3, accounted for approximately 11% of the total greenhouse gas emissions in the EU. While agricultural emissions witnessed a 20% decline in the period 1990-2005, emission reductions have remained relatively stagnant during 2005-2021. Estimates for 2022 indicate that this trend persists.

The primary source of emissions in the agriculture sector stems from livestock, with methane released from enteric fermentation accounting for almost half of the total greenhouse gas emissions in the sector. In addition, N_2O emissions from soil associated with fertiliser application (31%), and the management of manure (16%), are also significant sources of GHG emissions in this sector.

Over the last decades, efficiency improvements have resulted in a decrease in the greenhouse gas intensity per unit of production in the agriculture sector. For instance, between 2000 and 2019, the level of enteric fermentation per litre of milk decreased by 17% due to changes in dairy cattle management practices. These efficiency improvements have played a crucial role in mitigating emissions from the agriculture sector. However, overall, the improvements in GHG emissions intensity per unit of product are offset by increases in production, hence the emission reductions have stagnated since 2005 (EEA, 2022b).

Looking ahead to 2030, the mix 55-scenario supporting the climate target plan envisages a 12% reduction in emissions from the agriculture sector compared to the levels recorded in 2005, requiring a year-on-year decrease of 1% for the next eight years. Based on Member State projections, the emission reduction in 2030 would amount to 8% compared to 2005, in the scenario taking into account additional measures.

2.5.1 Opportunities for implementing measures to reduce GHG emissions from farm to fork

The current approach to reducing greenhouse gas emissions in the agricultural sector, as outlined in the 2020 climate target plan and national policies, primarily focuses on existing technological solutions at the farmer level (EC, 2020b). While measures, such as optimising fertiliser use, improving livestock health and implementing anaerobic digestion, are important steps, further exploration of additional strategies across the entire food production and consumption chain is needed.

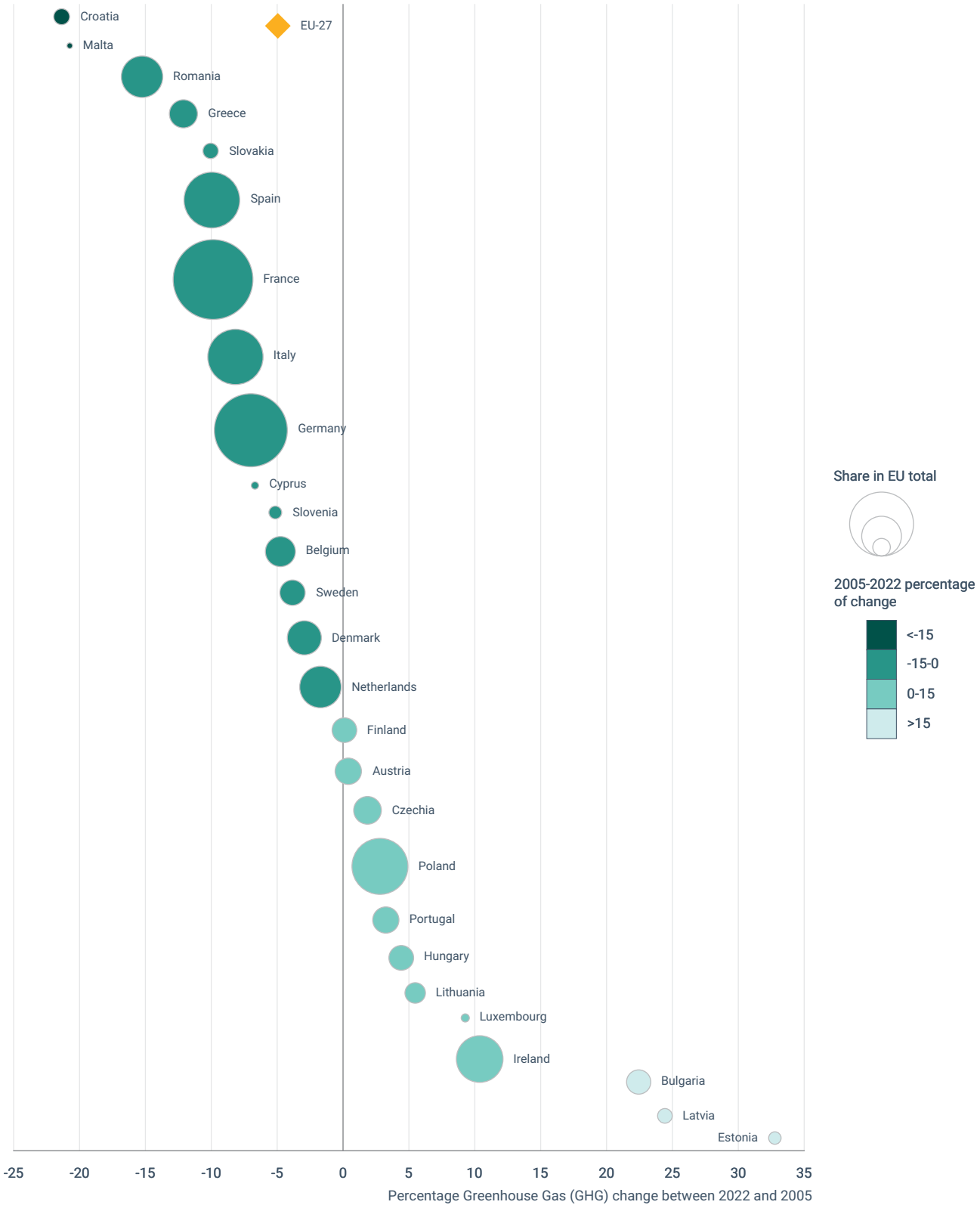
There is significant untapped potential for more diverse measures beyond the existing scope. Policymakers could consider stronger incentives or obligations for methane-reducing practices and technologies in livestock production, or adopt stronger incentives for precision farming techniques to decrease nitrogen use, as these practices are not yet widely adopted. Additionally, the use of carbon auditing tools presents an opportunity for further emission reductions (EEA, 2022b).

Particularly promising opportunities lie within the broader agri-food system, where effective GHG emission reductions and carbon sequestration can be achieved. The key to success is a comprehensive approach that includes reducing overall resource demand, preventing waste generation, and promoting circular and sustainable resource utilisation. To make this happen, collaboration among multiple stakeholders is crucial, involving consumers, processors, retailers, and policymakers, each playing a part in reducing emissions within their respective domains.

One impactful measure that stands out is adjusting dietary choices. This approach can reduce greenhouse gas emissions and offer health benefits to the population. The potential emission reduction impact of dietary changes could be equivalent to the technical reduction potentials of the agriculture sector (EC, 2020c).

2.5.2 *Member states' perspectives*

Figure 2.13 **Evolution of GHG emissions in the agriculture sector across Member States: percentage change (2005-2022)**



Notes: The position along the X-axis corresponds to the percentage change specific to the agricultural sector (CRF 3) within the respective countries between 2022 and 2005, with the 2022 values used for the calculation based on estimates. The dimensions of the spheres reflect the proportional contribution of each country within the total EU-wide emissions from the agriculture sector.

Sources: EEA (2023b, forthcoming c).

At the Member State level, France is the primary emitter with 18% of the EU's total agricultural emissions. Since 2005, progress in reducing emissions varied across different Member States, with Estonia, Latvia and Bulgaria witnessing significant increases in agriculture emissions, while the highest reductions were achieved in Croatia and Malta.

Read more and find detailed data about:

- Briefing on progress and prospects for decarbonisation in the agriculture sector and beyond
- Circular Agrifood: Potential of circular economy actions to reduce greenhouse gas emissions
- Indicator on greenhouse gas emissions from agriculture

2.6 Industry sector

Figure 2.14 Key GHG emissions trends and projections in the industry sector

Historic Trends	% change **2022 vs 2021**	**-9%**
	% change **2021 vs 2005**	**-23%**
2030 projections and modelling	% change **2030 vs 2005 in WAM** projections	**-40%**
	% change **2030 vs 2005 in Mix 55** scenario	**-46%**

Notes: GHG emissions of the industry sector refer to CRF categories 1.A.2 and 2, with the value for 2022 based on estimates. The projections are based on the most recent data submitted by Member States, while the mix 55-scenario reference point refers to the 2030 emissions as included in the mix 55-scenario for the industry sector, where the EEA has mapped the emissions of the PRIMES categories into categories linked to the CRF classification.

Sources: EC (2021b); EEA (2023b, forthcoming c, forthcoming e); own calculations.

In 2021, the industrial sector contributed 21% of the EU's total greenhouse gas emissions. Over the years, there has been a consistent decline in emissions from this sector, with a substantial 35% reduction observed by 2021 compared to 1990 levels. The emission reduction progress was most rapid during 1990-2000 and 2000-2010, while the decrease in emissions since then has been relatively slower. The decline in emissions can be attributed to several factors, including the restructuring of the European economy, significant reductions in process-related emissions, and improved energy efficiency (EEA, 2020).

The year-after-year variations in the emissions of the industry sector are strongly correlated to production volumes, with the economic crises in 2008-2009 and 2020 significantly impacting emissions figures. Simultaneously, improvements in specific emissions, driven by factors such as enhanced energy efficiency and increased utilisation of biomass and waste as energy sources, have been observed across all sectors, with the rate of improvement varying among them (EC, 2021d).

This same trend is also visible in 2022, with the estimated GHG emission levels showing a decrease of 9% compared to 2021. In particular, the fertilisers, metals and cement sectors reported significant emissions reductions in 2022, related to the reduced output due to the higher energy prices (EC, 2023k).

Looking ahead to 2030, the industry sector is modelled to achieve a further reduction in emissions by 46% in the mix 55-scenario of the climate target plan, with projections from Member States suggesting a decline of 40%.

2.6.1 Outlook to 2030 and policy context

Since 2005, the European Union has implemented the EU ETS, which covers most energy-intensive industries and the electricity sector, as one of the cornerstones of the EU climate policy. The ETS prices carbon emissions, incentivising companies to actively reduce their emissions. To maintain competitiveness, certain industries considered to be at risk of carbon leakage (the relocation of industry to countries with less stringent emission regulations), receive a free portion of emission allowances based on the emission levels of the most efficient installations. Overall, GHG emissions covered by the EU ETS have reduced considerably since 2005, although the reduction in some large energy-intensive industrial sectors such as the cement and chemical industries have been more modest, in particular in the period 2013-2021. This may be due to the higher costs for reducing GHG emissions in industrial processes compared with other sectors, while these industrial sectors also had fewer readily-deployable large-scale zero-carbon technologies at their disposal (EEA, 2022c).

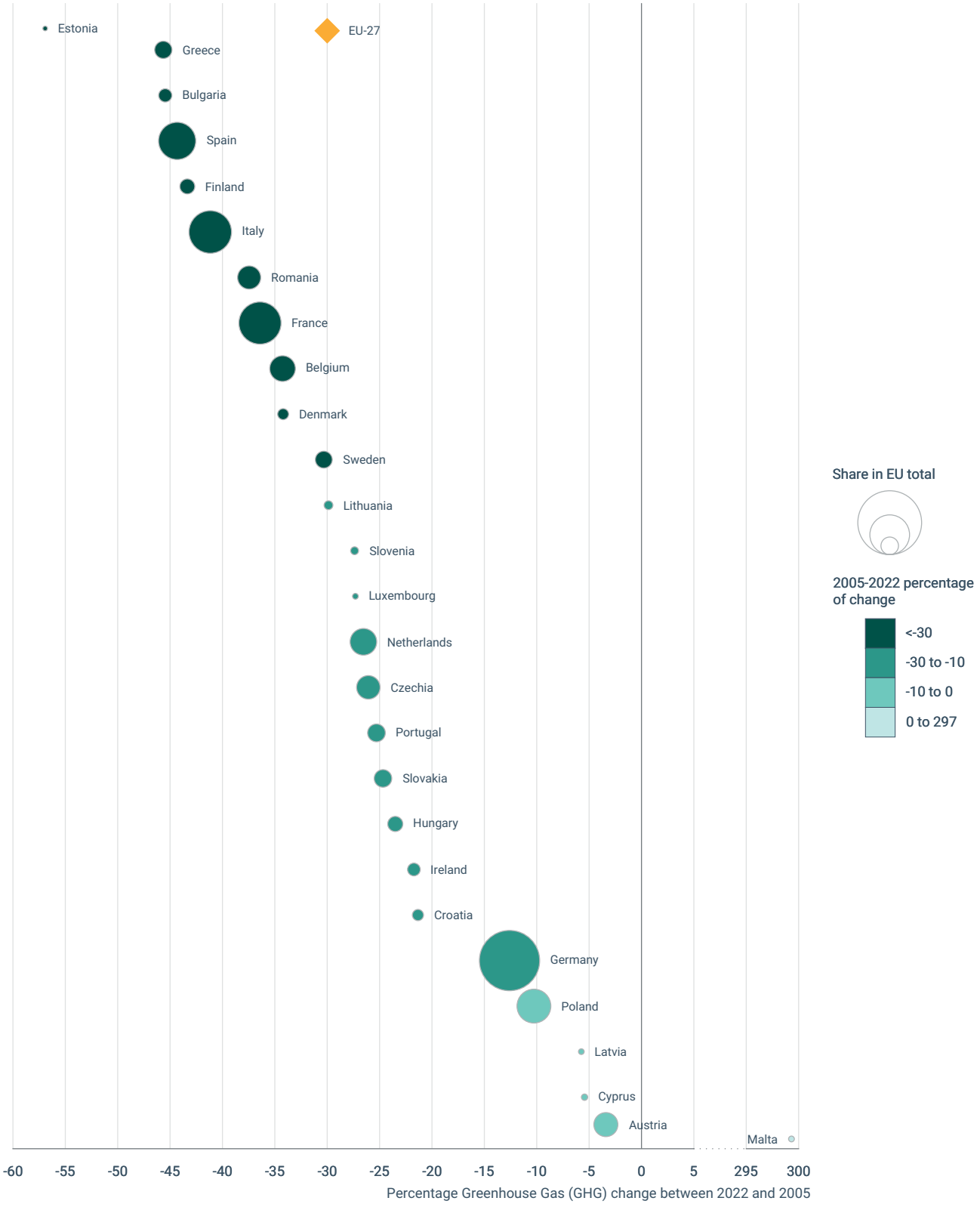
The increasing prices of CO_2 have made investments in low-carbon technologies more attractive over the last years. However, additional incentives are necessary to encourage investments in green industries. Major reinvestments in the transformation of industrial processes, such as the electrification of processes, the usage of carbon-neutral fuels like hydrogen, the scale-up of technologies like carbon-capture-utilisation and storage, increased energy efficiency and circular economy, are needed to reach the ambitious climate goals and address hard-to-abate emissions. Additionally, investments in net-zero technologies, such as the deployment of batteries, heat pumps, solar panels, electrolysers, fuel cells and wind turbines, are needed. The introduction of these investments needs to be combined with circular economy initiatives to optimise material flows and move to less energy-intensive secondary raw materials, where possible. To promote the necessary investments, several measures have been incorporated into the Fit-for-55 package. These measures include the expansion of renewable sources and the prioritisation of the energy efficiency first principle in the EED. Furthermore, substantial resources have been allocated through the EU Innovation Fund and REPowerEU, supporting the necessary investments in green technologies.

In synergy with the Fit-for-55 legislation, other policy initiatives are also being taken under the European Green Deal, which accelerate the transition to a green industry. For example, the Zero Pollution Action Plan (EC, 2021b) contains key 2030 targets to speed up pollution reductions at source, by mainstreaming pollution prevention in all relevant EU policies. This is made concrete in the chemical strategy for sustainability. In addition, the revision of the Industrial Emissions Directive (EC, 2022c), for which the European Commission has tabled a proposal in April 2022, will also include measures aiming to improve energy efficiency in industrial sectors.

In March 2023, the European Commission introduced the Green Deal Industrial Plan (EC, 2023e) with particular focus on accelerating the transition in the industrial sector. This plan, and the associated proposal for a Net Zero Industry Act (EC, 2023i), aims to create a favourable environment for net-zero investments by providing support for industrial manufacturing and strategic cross-country projects involving net-zero products. Additionally, the Critical Raw Materials Act ensures access to vital materials, such as rare earths, which play a significant role in manufacturing net-zero technologies and products.

2.6.2 *Member states' perspectives*

Figure 2.15 **Evolution of GHG emissions in the industry sector across Member States: percentage change (2005-2022)**



Notes: The position along the X-axis corresponds to the percentage change specific to the Industry sector (CRF1.A.2 and 2) within the respective countries between 2022 and 2005. The dimensions of the spheres reflect the proportional contribution of each country within the total EU-wide emissions from the industry sector.

Sources: EEA (2023b, forthcoming c).

Since 2005, greenhouse gas emissions from industry decreased in most EU-27 countries except Malta, that saw a sharp rise due to refrigeration and air-conditioning equipment emissions. Estonia, Greece, and Bulgaria had the largest percentage decline.

Read more and find detailed data about:

- Trends and projections in the EU ETS in 2022

3 Greenhouse gas emissions and energy trends in European countries

Key messages

- In 2021, Europe saw emissions bounce back after the COVID-19 pandemic. The use of renewable energy increased, compared to 2020, but due to higher absolute energy consumption, the share of renewable energy sources remained roughly the same as in 2020. This trend was also evident in individual Member States, which generally made modest progress towards their 2030 targets and contributions.

- In 2021, the greenhouse gas emissions in the effort sharing sectors were below Member States' AEAs for all except five Member States (Austria, Cyprus, Denmark, Ireland and Italy). For 2022, approximated emissions show that nine Member States had effort sharing emissions above their AEAs (Croatia, Cyprus, Denmark, Hungary, Ireland, Italy, Lithuania, Malta and Romania).

- In 2021, the total RES shares in Europe ranged from 12% in Luxembourg, to 63% in Sweden, while total RES shares in France, Ireland, the Netherlands and Romania were below their 2020 target. Preliminary estimates for 2022 suggest that the RES share increased in most Member States compared to 2021, but not for Cyprus, Estonia, Hungary, Italy, Romania and Slovenia. Total final and primary energy consumption increased across all Member States in 2021, rebounding from the extraordinary drop observed in 2020. Preliminary estimates for 2022 indicate that eighteen countries have reduced their final energy consumption compared to 2021, while fifteen countries show a similar reduction trend in primary energy consumption.

- Looking towards 2030, three Member States (Greece, Portugal and Sweden) project that their existing measures will be sufficient to stay below their 2030 effort sharing emission limits. When additional measures are factored in, a total of six Member States project to stay below their 2030 effort sharing emission limits, namely Croatia, Greece, Luxembourg, Portugal, Spain and Sweden.

The EU-27 has committed to achieve climate neutrality by 2050. For 2030, intermediate targets are set for the reduction of greenhouse gas emissions, the increase of renewable energy and the improvement of energy efficiency. To achieve these EU-wide targets, a strict governance framework is established for Member States.

As of the publication of this report, national targets for the reduction of GHG emissions in effort sharing sectors under the amended Effort Sharing Regulation have been brought in line with the net 55% greenhouse gas target. Regarding renewable energy and energy efficiency, countries are in the process of updating their contributions for 2030 through updates to their NECPs. Therefore, until the final NECPs are in place in 2024, for these latter dimensions, the national contributions as established in the 2019 NECPs persist.

This section shows the progress towards the national 2030 ambitions for the EU-27 Member States ([9]). In addition, the chapter also describes progress in the EEA member countries that are not members of the EU-27, namely Iceland, Liechtenstein, Norway, Switzerland and Türkiye, and in the contracting parties to the Energy Community.

3.1 Effort sharing legislation emissions

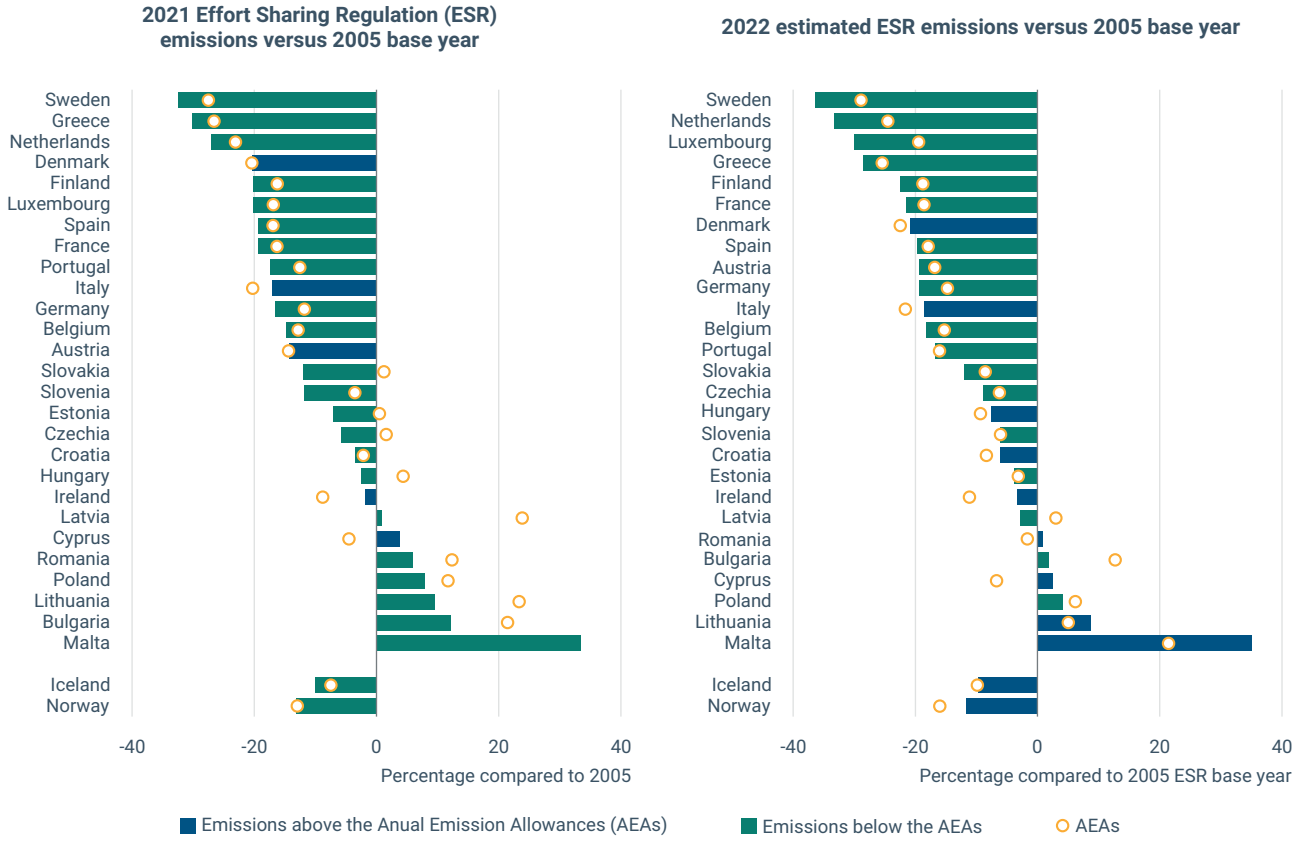
The Effort Sharing Regulation (ESR) sets binding national emission reduction targets to reduce emissions, by 2030, from domestic transport (excluding CO_2 emissions from aviation), buildings, agriculture, small industry and waste. The national 2030 reduction targets are expressed as a percentage change from 2005 emission levels and range from 10-50% ([10]).

The 2030 national emission reduction targets are translated into annual emission allocations (AEAs) for each year in the period 2021-2030, based on a defined trajectory comprising of binding annual emission limits for each Member State. Member States can use a number of flexibilities to comply with these binding annual targets. Following the amendment of the ESR in 2023, national emission reduction targets for 2030 have been raised, with a simultaneous increase in the emission limits set for the years 2023-2029. For the years 2021 and 2022, annual emission allocations have not changed.

In 2021, emissions in the effort sharing sectors were lower than Member States' AEAs for all except five Member States (Austria, Cyprus, Denmark, Ireland and Italy). For some specific Member States, the AEAs are relatively high in 2021, due to a single-year adjustment of their AEAs in 2021 ([11]). Sweden, Greece and the Netherlands were the three Member States with the largest emissions reduction in 2021 compared to 2005. Preliminary estimates for 2022 indicate that all but nine Member States (Denmark, Italy, Hungary, Croatia, Ireland, Romania, Cyprus, Lithuania and Malta) had effort sharing emissions lower than their AEA prior to the use of flexibilities. Effort sharing emissions for both Norway and Iceland remained below their AEAs in 2021. However, preliminary estimates indicate that this would not be the case for 2022 in either country.

([9]) This analysis does not take into account the possible use of flexibilities, as provided for in the European regulatory framework.
([10]) This is different from the national targets for 2020 set under the Effort Sharing Decision (ESD), where some Member States had positive targets and could then increase their effort sharing emissions in 2020 compared to 2005. At EU level, the ESD emission reduction target amounted to a 10% reduction in the Effort Sharing sectors by 2020.
([11]) See Regulation (EU) 2018/842. These Member States are Bulgaria, Croatia, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Malta, Poland, Portugal, Romania, Slovenia and Slovakia.

Figure 3.1 **Emissions in the effort sharing sectors in 2021 and 2022 compared to the annual emission allocations**



Notes: Malta's 2021 AEAs stand at 102% compared to the 2005 base year and are, thus, not depicted in the figure. AEAs of Iceland and Norway are currently not yet adapted to the revised Effort Sharing reduction target of 40%.

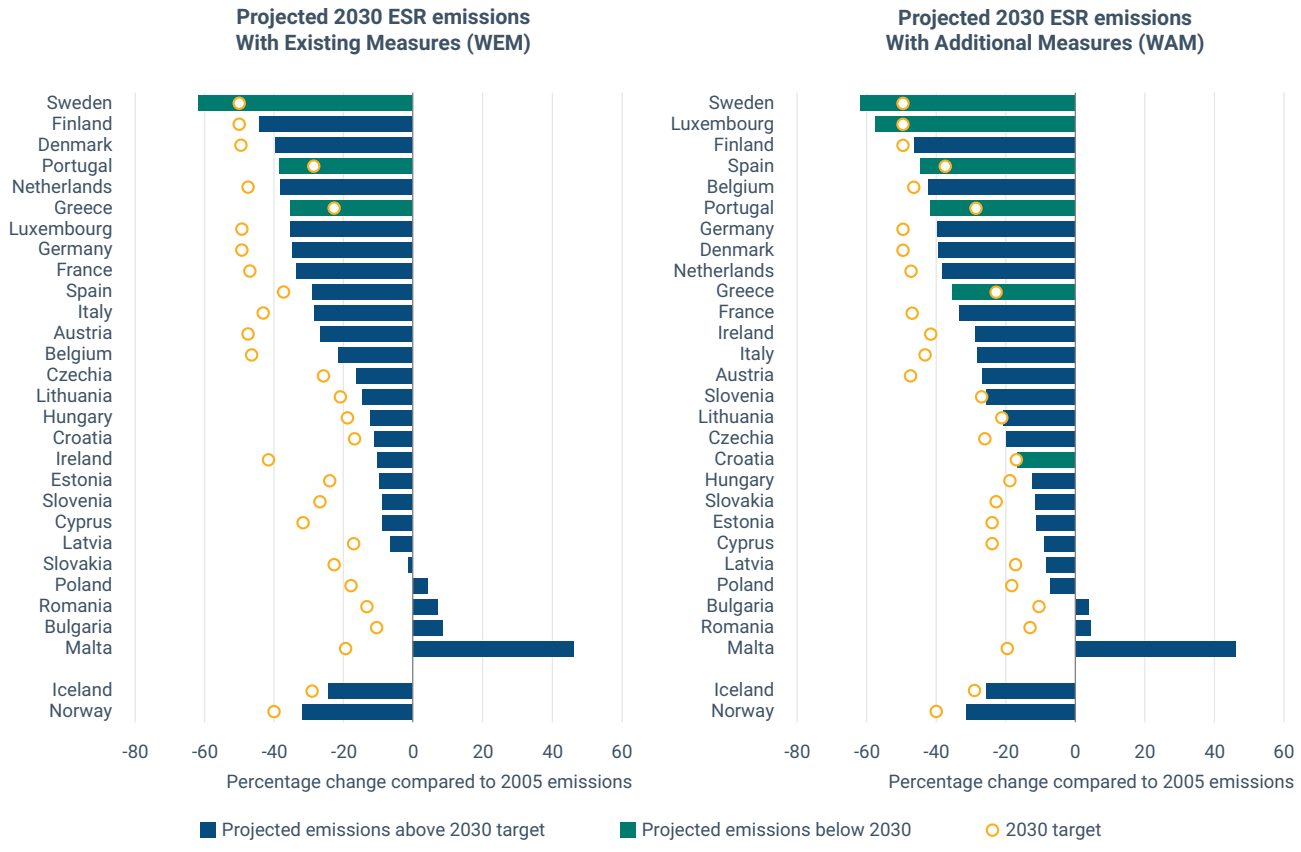
Sources: EEA (2023e, forthcoming a); EU (2023e).

Based on the projections submitted in March 2023, three Member States (Greece, Portugal and Sweden) project that their effort sharing emissions will stay below their 2030 effort sharing targets based on their existing measures (WEM). All other Member States show considerable gaps between their projected effort sharing emissions and their 2030 targets, and they would have to revert to the use of flexibilities under the ESR to close the gap. Malta has the largest gap of 65 percentage points. The second highest gap is shown in Ireland with a difference of 32 percentage points between WEM emissions as a percentage of 2005 base-year emissions and their target. By summing up all the Member States' projected ESR emissions based on existing measures for 2030, the EU-wide ESR emission reduction projection is 27%. This is 13 percentage points away from the overall target of a reduction of 40%. When adding the effects of additional planned measures, the list of Member States that project emissions in the effort sharing sectors below their effort sharing targets, extends to a total of six: Croatia, Greece, Luxembourg, Portugal, Spain and Sweden. The difference is very small for Lithuania (Figure 3.2). The EU-wide scenario with additional measures is a conservative scenario, because not all Member States submitted a scenario with additional measures. For nine Member States a scenario with additional measures has not been submitted in 2023 (Austria, Cyprus, Denmark, France, Greece, Hungary, Italy, Malta and Sweden). For these Member States, the scenario with existing measures is shown.

By summing up all projected ESR emissions under 'with additional measures' for 2030, the EU-wide Effort Sharing emission reduction is 32%. This is still 8 percentage points away from the overall target of a reduction of 40%.

In most scenarios submitted by Member States, emissions until 2030 are projected to decline more in the Effort Sharing sectors than under the EU ETS. This reflects Member States' commitments to achieve their national targets under the ESR. In the EU ETS, in some Member States (Bulgaria, Czechia and the Netherlands), emissions in the scenario that takes additional planned measures into account, are higher than in the scenario that relies on the existing measures. This is assumingly due to electrification trends in other sectors that are not covered up by the respective increase of renewable energy capacity growth. Only in Poland and Slovakia, until 2030, emissions are set to decrease more under the EU ETS than under the ESR.

Figure 3.2 **Projected emissions in the effort sharing sectors in 2030 compared to Member States' national targets**



Sources: EEA (2023e, forthcoming b); EU (2023e).

3.2 Renewable energy

The newly-adopted Renewable Energy Directive raises the European target of a renewable energy share in 2030 from the current 32% to 42.5%, with a top-up of 2.5%. In order to achieve this objective, the existing governance framework is adhered to. This means that all EU Member States determine in their NECPs their individual contribution to the EU's overall 2030 renewable target, expressed as the share of gross final energy consumption. To do so, they have to put forward a value for 2030 (the contribution) and set an indicative trajectory until then. Draft updated NECPs were due at the end of June 2023 and will be assessed by the European Commission by the end of 2023. Taking into account the recommendations of the Commission, Member States will submit final updated NECPs by the end of June 2024.

During this ongoing process, the existing 2030 contributions and trajectories that were established by Member States in 2019 remain in effect. Furthermore, in alignment with the Governance Regulation, the annual share of renewable energy starting from 2021 should not fall below the binding Member State target established for the year 2020.

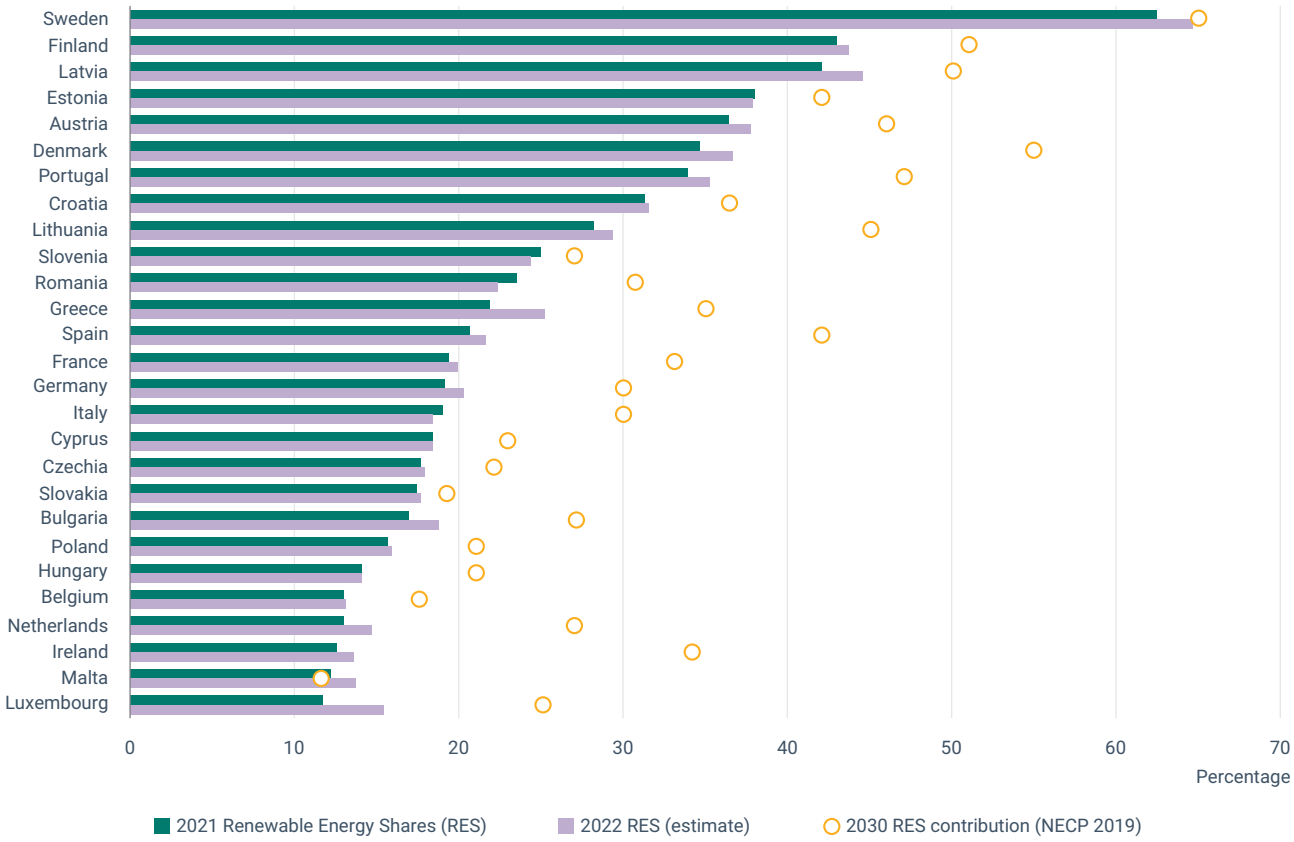
In 2021, total renewable energy shares in Europe ranged from 12% in Luxembourg to 63% in Sweden. France, Ireland, the Netherlands and Romania had total RES shares that were below their individual 2020 target. This means that, within one year, these Member States will have to take additional measures to cover the gap within the duration of a further year.

For 2022, preliminary estimates indicate that the total RES shares ranged from 14 in Malta to 65% in Sweden. Twenty-one of the EU-27 Member States saw an increase in their renewable energy shares between 2021 and 2022. Luxembourg and Greece topped the list, having increased their RES shares by more than 3 percentage points in 2022. In contrast, the RES shares of Romania, Slovenia and Italy decreased by more than 0.5 percentage points compared to 2021.

Member States' 2030 RES share contributions, according to their NECPs submitted in 2019 (EC, 2020e), range from 11.5% (Malta) to 65% (Sweden). The contributions would have been sufficient to achieve the overall former EU target share of 32%, as the collective contribution from the 2019 NECPs was estimated to be 33.1-33.7% (EC, 2020e, 2020a). There is a substantial gap to the revised target of 42.5-45%.

Among the Member States, by 2022, Malta had already exceeded its national contribution level for 2030 by 1 percentage point. Meanwhile, Spain was 20 percentage points away from its 2030 contribution level in 2022. On average, the current distance to the national 2030 contribution is 8 percentage points.

Figure 3.3 National progress towards 2030 RES contributions



Sources: EC (2020e); EEA (forthcoming f); EU (2018); own calculation.

3.3 Energy efficiency

The newly-adopted Energy Efficiency Directive represents a substantial increase in European ambition. Under this new directive, the EU's 2030 target for primary energy consumption has been revised from 1,128 Mtoe to 992 Mtoe, while the binding target for final energy consumption has been lowered from 846 Mtoe to 763 Mtoe. Member States contribute to the realisation of the European targets by providing indicative national 2030 contributions based on both final and primary energy consumption, accompanied by indicative trajectories for each.

The recently adopted directive offers a comprehensive list of factors and national characteristics that Member States can consider when calculating their contributions. Importantly, they can use a formula designed to enable Member States to determine their contributions in a fair and feasible way (Annex 1 of the EED). When establishing their indicative contributions, each Member State must guarantee that the ambition level of their contribution does not surpass the formula-derived value by more than 2.5%. A gap-filling mechanism is defined to make sure that all Member States' contributions add up to the EU's 11.7% target.

Member States are currently updating their NECPs to incorporate the new European targets for energy efficiency. Therefore, this assessment is based on the energy efficiency 2030 contributions outlined in the Member States' 2019 NECPs. See Figure 3.4 and Figure 3.5 for final and primary energy consumption.

As described above, the EU reduced its final energy consumption by 7% between 2005 and 2021. Looking at Member State level, final energy consumption decreased in 18 EU countries. The strongest decreases in final energy consumption can be observed in Greece, Italy, Portugal and Spain. However, nine countries experienced an increase in final energy consumption: Bulgaria, Czechia, Hungary, Latvia, Romania and Slovakia recorded a limited increase of final energy consumption, while the increase was more outspoken in Poland (+28%), Malta (+28%) and Lithuania (+21%), (see Figure 3.5). The significant increases in Poland and Lithuania are largely driven by the transport sector, which has seen massive increases of 92% and 54% respectively.

In contrast to final energy consumption, primary energy consumption increased only in Poland by 2021 (18% compared to 2005 levels), while in all other countries the consumption levels decreased. Greece (-33%), Italy (-20%) and Portugal (-21%) showed the strongest decline in primary energy consumption over this period (see Figure 3.5).

According to 2022 preliminary estimates, eighteen Member States saw a decrease in final energy consumption between 2021 and 2022, with the Netherlands, France and Austria reducing their final energy the most. Portugal, Malta and Poland saw the highest increase in final energy consumption in the same time period, though their growth remained under 4%. Similarly, the Netherlands and France experienced the strongest drop in primary energy consumption. In contrast, twelve Member States saw an increase in their primary energy for 2022, with Malta, Ireland, Greece, Cyprus, Bulgaria and Estonia experiencing growth of more than 5%.

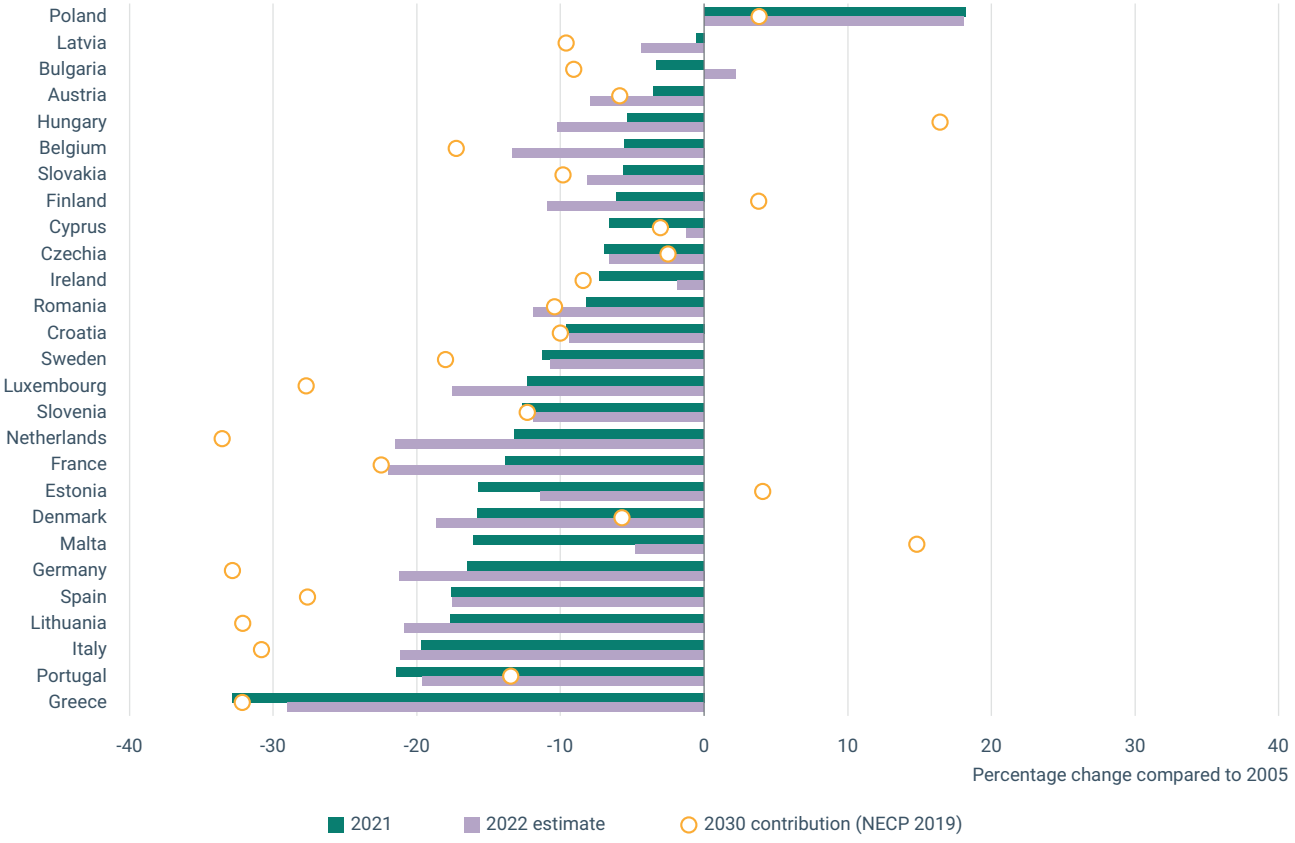
Figure 3.4 National progress towards 2030 Final energy consumption contributions

Note: To ensure comparability with energy efficiency targets, this indicator follows the Eurostat methodology for final energy consumption (Europe 2020-2030, FEC2020-2030) and primary energy consumption (Europe 2020-2030, PEC2020-2030).

Sources: EC (2020e); EEA (forthcoming e); Eurostat (2023d).

The accumulated 2030 contributions, included in the 2019 NECPs, result in a primary energy consumption of 1,176 Mtoe and a final energy consumption of 885 Mtoe, which are well above the new targets as agreed at EU level. Nineteen Member States intend to reduce their national final energy consumption levels by 2030 compared with 2005, ranging from a reduction of 1.1% (Finland) to a reduction of 31.7% (Luxembourg). In 2021, eight Member States already had final energy consumption levels below their intended contributions to final energy consumption in 2030 (Bulgaria, Cyprus, Denmark, Estonia, Hungary, Malta, Poland and Romania). With regard to primary energy consumption, achieving the intended 2030 contributions will require consumption decreases in 22 Member States, ranging from 2.5% (Czechia) to 33.6% (Netherlands), compared with their 2022 energy consumption. At the same time, ten Member States already had primary energy consumption levels in 2021 that were below their respective 2030 primary energy contributions.

Figure 3.5 **National progress towards 2030 PEC contributions**



Notes: To ensure comparability with energy efficiency targets, this indicator follows the Eurostat methodology for final energy consumption (Europe 2020-2030, FEC2020-2030) and primary energy consumption (Europe 2020-2030, PEC2020-2030).

Sources: EC (2020e); EEA (forthcoming e); Eurostat (2023d).

3.4 Energy and climate trends and projections in other EEA countries

The previous sections mainly describe progress among EU Member States, but it is important to note that reporting on progress to climate and energy targets, and membership or cooperation in the European Environment Agency and the European Environment Information and Observation Network (Eionet), includes a number of countries that are not members of the EU. Where available, information on greenhouse gas emissions, renewable energy and energy consumption is shown in the following sections for Iceland, Liechtenstein, Norway, Switzerland and Türkiye. In addition, all nine Contracting Parties to the Energy Community – Albania, Bosnia Herzegovina, Kosovo ([12]), Georgia, North Macedonia, Moldova, Montenegro, Serbia and Ukraine, are considered if data is available.

Box 3.1

Energy Community

The Energy Community is an international organisation bringing together the nine Contracting Parties and the EU to create an integrated pan-European energy market. The key objective is to extend the EU internal energy market rules and principles to the Western Balkans and the Black Sea region. This is done through adapting and adopting the EU legislation pertinent to the energy market, extending the stable regulatory and market framework of the EU internal energy market. This includes the Governance Regulation, which has been adapted to specify the reporting obligations of the Contracting Parties of the Energy Community. The reporting obligations range across the dimensions of the Energy Union, covering matters of, for example, decarbonisation, energy efficiency, and energy security. 2023 is the first year that the Contracting Parties are required to report according to the adapted Governance Regulation. These data are not yet available. Consequently, the data utilised for the Contracting Parties in this report is from different sources.

3.4.1 Greenhouse gas emissions

Since 1990, GHG emissions, including LULUCF and international aviation, in Iceland, Liechtenstein, Norway, Switzerland and Türkiye, exhibited different trends.

Iceland seeks to achieve climate neutrality before 2040 and plans to reduce GHG emissions by 40% by 2030, compared to 1990 (Iceland, 2023). The country updated its nationally determined contribution (NDC) in 2021. It aims at reducing net greenhouse gas emissions by 55% in 2030, 'to be achieved by acting jointly with the European Union and its Member States and Norway' (Iceland, 2021). In 2021, Iceland's emissions were 7% higher than in 1990.

Norway updated its 2030 target in its NDC. It aims to reduce GHG emissions by at least 55% by 2030, compared to 1990 levels, in cooperation with the European Union and its Member States, and with Iceland. In its Climate Change Act and for 2050, Norway set a 90-95% emission reduction target compared to 1990. According to this act, climate targets are to be reviewed every five years (Norway, 2017). In 2021, Norway's GHG emissions were 19% lower than in 1990: without LULUCF they were 9% lower than in 1990.

([12]) This designation is without prejudice to positions on status and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.

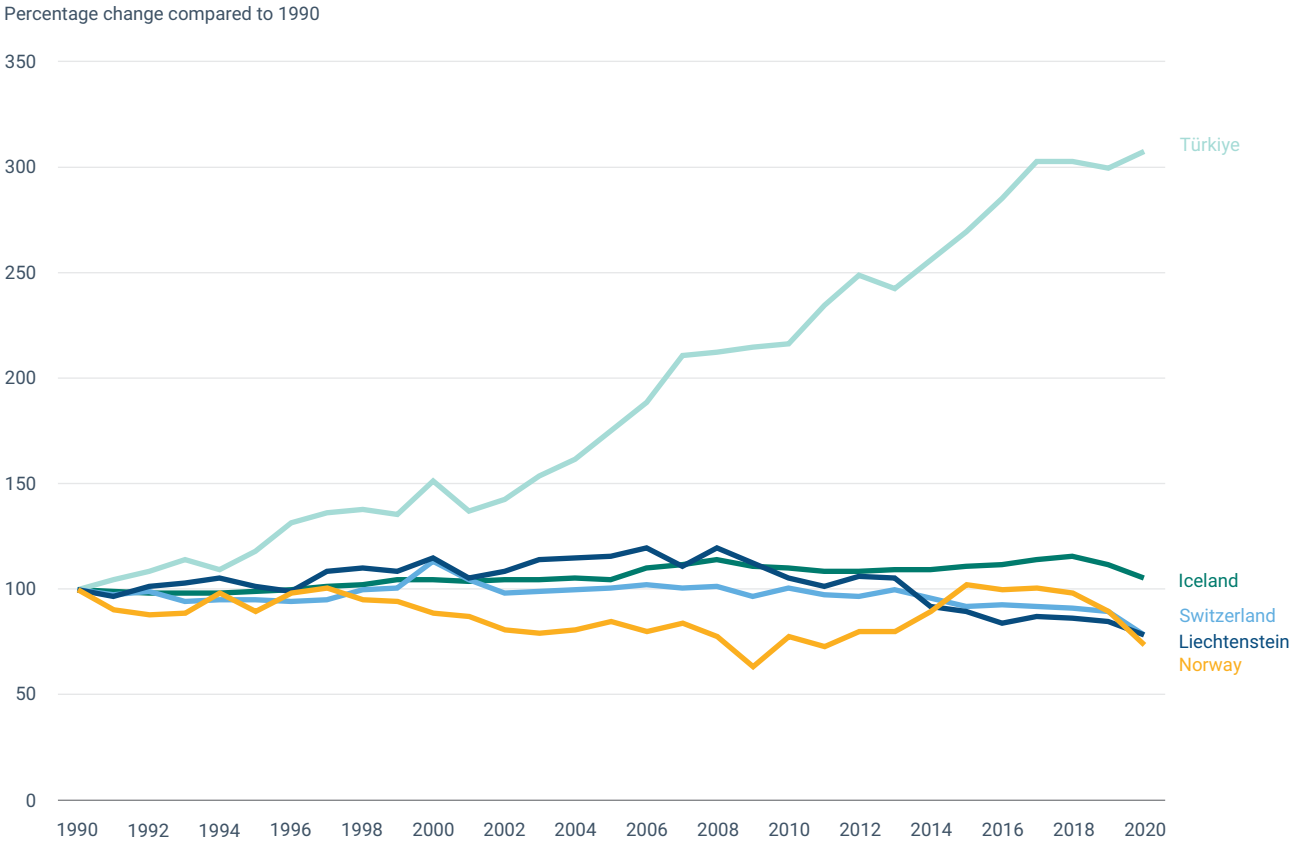
Liechtenstein aims to attain at least a 40% reduction in GHG emissions in 2030 compared with 1990 levels (Liechtenstein, 2015), including emission removals from LULUCF. Liechtenstein's Climate Strategy was adopted in 2022 and aims at climate neutrality by 2050. Since the energy sector plays an important role in Liechtenstein, it is planned to reduce that sector's emissions by 50% by 2030. Liechtenstein plans to update its NDC before the UNFCCC Conference of the Parties (COP) in 2023 (Liechtenstein, 2022). In 2020, GHG emissions in Liechtenstein were 22% lower than in 1990.

Switzerland updated its NDC in 2022 and adjusted the intention to reduce emissions 'from minus 50 percent by 2030 to at least minus 50 percent by 2030'. Switzerland also increased its indicative goal for 2050 to reaching net zero GHG emissions reductions, from the former goal of 70% to 85% (Switzerland, 2021). In 2021, Switzerland had reduced the overall GHG emissions by 19%.

Türkiye updated its first NDC in 2023 and now aims at reducing GHG emissions in 2030 by 41%, (it was 21% in its previous NDC), compared to the business-as-usual scenario provided in its NDC in which 2012 is considered the base year.

Türkiye intends emissions to peak by 2038 and to achieve a net zero emissions target in 2053 (Türkiye, 2023). In 2021, Türkiye's GHG emissions were 242% higher than in 1990 and 37% higher than in Türkiye's base-year of 2012. This increase is mainly related to the relatively high increase in population and energy consumption as a developing country and growing economy.

Figure 3.6 **Total GHG emission trends and projections, including LULUCF and international aviation, in Iceland, Liechtenstein, Norway, Switzerland, Türkiye**

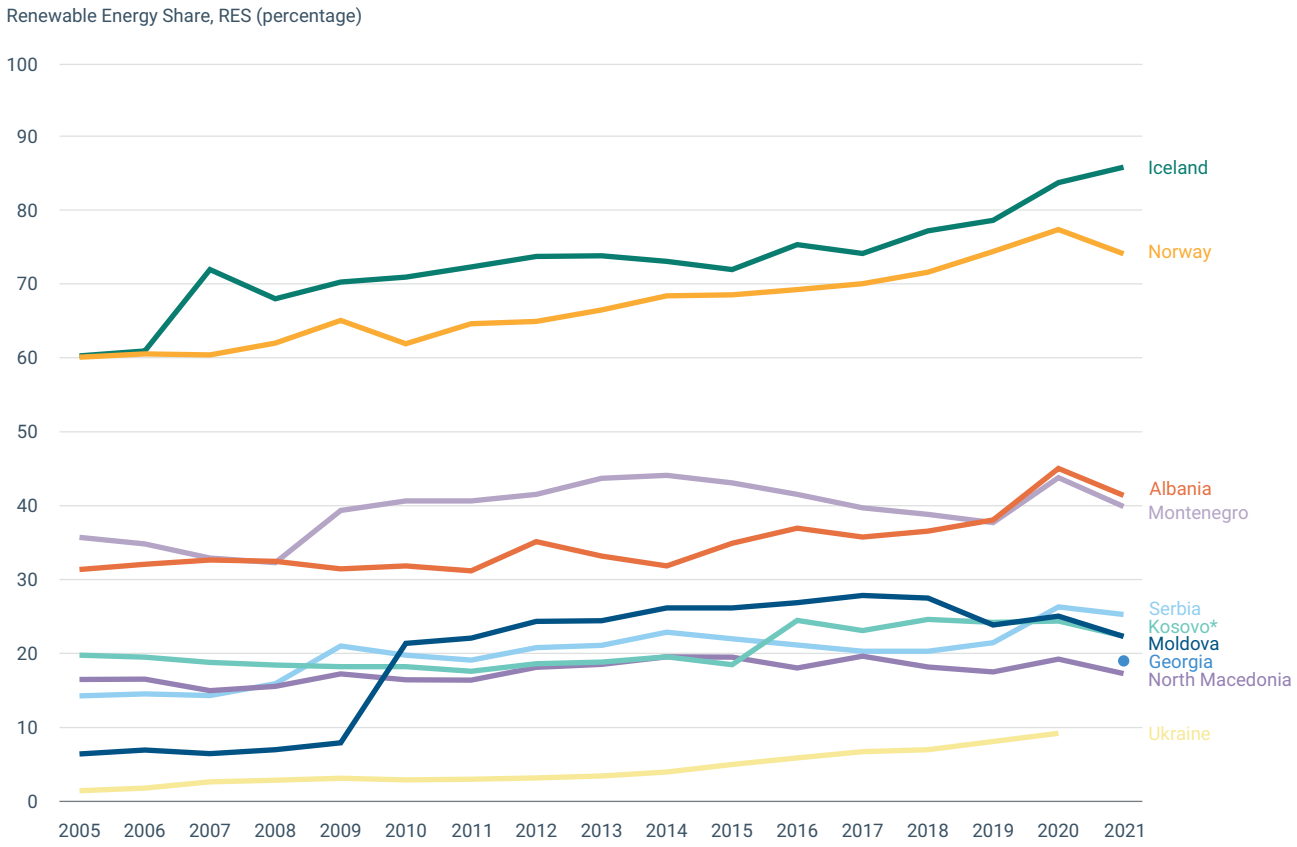


Source: UNFCCC (2023).

3.4.2 Renewable energy

Information on RES shares is available for Iceland and Norway and seven of the nine Energy Community Contracting Parties (Figure 3.7). Iceland and Norway exhibit high levels of renewable energy use throughout the period 2005-2021, compared to those in Energy Community Contracting Parties and EU Member States. RES shares in all countries but Iceland 'topped' in 2020 during the COVID-19 pandemic and fell to a lower share in 2021. Iceland utilises significant levels of derived heat (geothermal) for heating and cooling purposes — a source that was unaffected by the COVID-19 pandemic.

Figure 3.7 **Total RES shares in non-EU member countries and Energy Community countries**



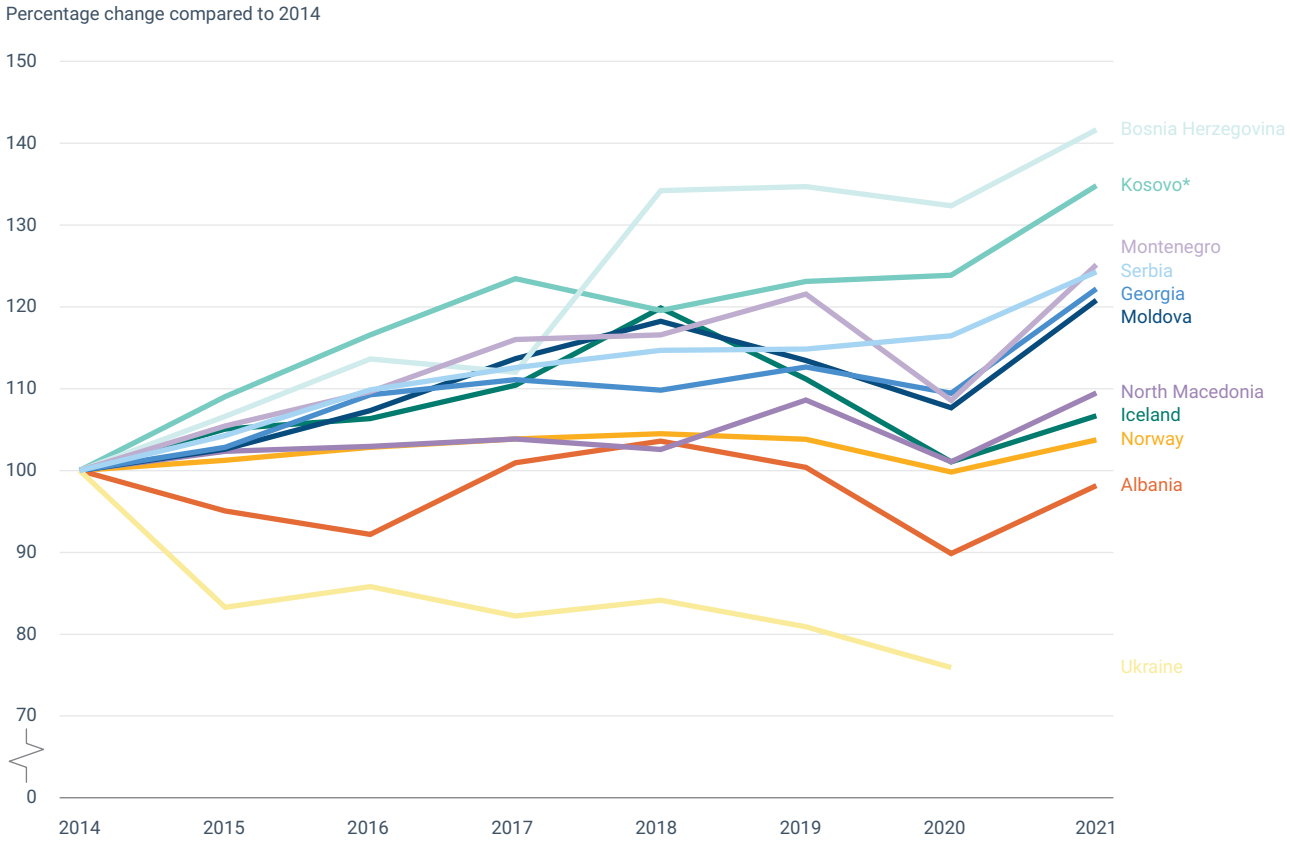
Notes: * The Kosovo designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence

Source: Eurostat (2023g).

3.4.3 Energy efficiency

Information on final energy consumption is available for Iceland and Norway from 1990. For the nine Energy Community countries, the first available year is variable. Figure 3.8 therefore compares the development in all these countries starting in 2014, as this is the first year with available data for all . In all countries, apart from Ukraine with missing data for 2021, the final energy consumption shows a more or less pronounced decrease in the pandemic year 2020, followed by an increase in 2021. The highest increase of final energy consumption since 2014 is visible in Bosnia Herzegovina, while a considerable and close-to-steady decrease took place in Ukraine.

Figure 3.8 Final energy consumption compared to 2014 for non-EU member countries and Energy Community Contracting Parties



Notes: * The Kosovo designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence

Source: Eurostat (2023a).

4 Conclusions and future directions

As shown in this report, Europe has made substantial progress in reducing greenhouse gas emissions, fostering renewable energy and improving the energy efficiency of the economy. The EU has successfully reduced its net emissions by 31% since 1990, according to 2022 estimates, while at the same time prosperity increased sharply. The headline climate and energy targets in 2020 were amply achieved, and the roll-out of renewable energy is going faster than ever.

Alongside this progress, an acceleration in effort is still needed to achieve climate neutrality by 2050, meaning Europe needs to continue developing both the scale of the efforts and the approach that is taken. National projections included in this report show that current efforts are not yet sufficient to achieve climate neutrality, or to achieve the at least 55% net emission reduction target in 2030 – even when planned future policies are taken into account. This applies to the whole of the EU, while diverse challenges face the different sectors:

- For the energy sector, reducing dependency on fossil fuels is the 'red thread' in reducing greenhouse gas emissions, and it is not just good for the climate. By putting energy efficiency and renewable energy first, energy security and air quality can be enhanced, while the impact of volatile and high fossil fuel prices on household budgets could potentially be decreased.

- Europe's aging building system requires a much-needed substantial renovation wave. Upgrading existing buildings across villages and cities in Europe plays a pivotal role in making them more energy-efficient and resilient to climate change.

- Transitioning to a sustainable food system in Europe necessitates significant changes in food production and consumption. Ambitious policies, innovation, and the phase-out of harmful practices are among the key ingredients needed to achieve this transition, resulting in a better agri-food system from farm to fork. Furthermore, restoring and increasing the carbon sink, the ability to absorb CO_2 by the natural environment, is crucial to reach climate neutrality.

- Shifting gears in the transport sector to sustainable solutions can effectively move people and goods while benefiting the climate, reducing air pollution, and minimising noise. Electrification, collective transport, and sustainable urban transport options offer promising avenues for this transition. It is crucial to take action at both the regional and international levels to curb the fast-growing emissions of international aviation and navigation.

Undoubtedly, the societal transition required to achieve these goals will present challenges. It will require substantial investments of both time and money and is likely to have broad social implications, which should be addressed in the policies and measures.

When comparing the progress made up to this point, with the annual efforts needed towards 2030, it is evident that a transformative shift will become imperative. Yet, beneath the overarching figures, encouraging indicators come into view. While wind and solar held a modest presence in the 2005 electricity sector, their estimated share in electricity production has surpassed 20% in 2022, with those technologies redefining the energy supply sector for the coming years. Other sectors, too, have witnessed noteworthy acceleration, exemplified by the soaring sales of heat pumps and electric vehicles.

At the national level, promising signs also emerge. A retrospective examination reveals significant discrepancies in sector-specific reduction efforts across countries, indicating unexplored potential for greenhouse gas reduction throughout the majority of Member States. The updated framework of the Effort Sharing Regulation sets ambitious GHG emissions reduction targets for all Member States, and the projections indicate that national governments are indeed working to accelerate the reductions in these sectors.

Europe has taken decisive steps with the European Green Deal, providing clear direction and urging countries, the public, and companies to reduce their greenhouse emissions. The European Parliament and the Council have agreed on collective binding targets for both emissions reductions and increased GHG emissions removals in the LULUCF sector, and resources have been allocated accordingly. Now it is up to the Member States to deliver on the targets and realise the transformation in practice. Thousands of national policies and measures are helping to reduce net GHG emissions across Europe, and better information on effective policy mixes, effects, costs and benefits are needed. The latest Member States submissions in 2023 reported more than 3,000 GHG emissions policies and measures. Together, these thousands of policies and measures will bring us closer to climate neutrality, but more will need to be initiated and launched.

The impacts of climate change are becoming increasingly evident every day, with record temperatures and extreme weather events occurring in rapid succession. However, there is an active opportunity to mitigate this impact. Each tonne of CO_2 that is not emitted contributes to limiting the consequences of climate change. In recent decades, the groundwork for ongoing mitigation has been set. Now, the crucial challenge is to make an exponential shift in the climate transition in the coming years. If this trend, already evident in specific technologies, becomes mainstream across all sectors of society, the path to climate neutrality opens up.

Abbreviations

AEA	Annual emission allocation
AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change
CO_2	Carbon dioxide
EC	European Commission
ECL	European Climate Law
EED	Energy Efficiency Directive
EEA	European Environment Agency
ESR	Effort Sharing Regulation
ETC CM	European Topic Centre on Climate Change Mitigation
ETS	Emissions Trading System
EU	European Union
EU-27	27 Member States of the European Union (post-Brexit)
FEC	Final energy consumption
GHG	Greenhouse gas
GW	Gigawatt
GWP	Global warming potential
ktoe	Kilotonnes of oil equivalent
LNG	Liquified natural gas
LULUCF	Land use, land use change and forestry
$MtCO_2e$	Megatonnes of CO_2 equivalent
Mtoe	Million tonnes of oil equivalent
NECP	National energy and climate plan
NREAP	National renewable energy action plan
PEC	Primary energy consumption
RED	Renewable Energy Directive
RED II	Recast Renewable Energy Directive
RES	Renewable energy source
WAM	With additional measures
WEM	With existing measures

References

Copernicus Climate Change Service, 2022, *European State of the Climate 2022*, European Centre for Medium range Weather Forecasts (https://climate.copernicus.eu/esotc/2022/temperature).

Council of the European Union, 2023a, *Alternative fuels infrastructure: Council adopts new law for more recharging and refuelling stations across Europe* (https://www.consilium.europa.eu/en/press/press-releases/2023/07/25/alternative-fuels-infrastructure-council-adopts-new-law-for-more-recharging-and-refuelling-stations-across-europe) accessed 8 November 2023.

Council of the European Union, 2023b, *Council and Parliament reach provisional deal on renewable energy directive* (https://www.consilium.europa.eu/en/press/press-releases/2023/03/30/council-and-parliament-reach-provisional-deal-on-renewable-energy-directive) accessed 8 September 2023.

Council of the European Union, 2023c, *FuelEU maritime initiative: Council adopts new law to decarbonise the maritime sector* (https://www.consilium.europa.eu/en/press/press-releases/2023/07/25/fueleu-maritime-initiative-council-adopts-new-law-to-decarbonise-the-maritime-sector) accessed 8 November 2023.

EC, 2018, *In-depth analysis in support of the Commission Communication COM(2018) 773: a clean planet for all — a European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy* (https://knowledge4policy.ec.europa.eu/publication/depth-analysis-support-com2018-773-clean-planet-all-european-strategic-long-term-vision_en) accessed 16 September 2022.

EC, 2020a, *An EU-wide assessment of National Energy and Climate Plans*, *EUR-Lex - 52020DC0564 - EN - EUR-Lex* (https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1600339518571&uri=COM:2020:564:FIN) accessed 12 May 2021.

EC, 2020b, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'Stepping up Europe's 2030 climate ambition: investing in a climate-neutral future for the benefit of our people' (COM(2020) 562 final) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562) accessed 27 June 2023.

EC, 2020c, Impact Assessment accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions + Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people (SWD(2020)176 Final) (https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=SWD:2020:176:FIN) accessed 28 November 2022.

EC, 2020d, *Impact of Covid-19 on Carbon Emissions* (https://ec.europa.eu/newsroom/rtd/items/691508/en) accessed 8 September 2023.

EC, 2020e, *National energy and climate plans — EU countries' 10-year national energy and climate plans for 2021-2030*, *National energy and climate plans* (https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en#national-energy-and-climate-plans-2021-2030) accessed 8 December 2023.

EC, 2021a, Commission Staff Working Document Impact Assessment Report Accompanying the document Proposal for a Regulation of the European Parliament and 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 (SWD/2021/609 final) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021SC0609) accessed 8 September 2023.

EC, 2021b, *Excel files for MIX scenario*, Energy (https://energy.ec.europa.eu/publications/excel-files-mix-scenario_en) accessed 8 September 2021.

EC, 2021c, Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast) (COM/2021/802 final) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52021PC0802).

EC, 2021d, *Update of benchmark values for the years 2021 – 2025 of phase 4 of the EU ETS - Benchmark curves and key parameters* (https://climate.ec.europa.eu/system/files/2021-10/policy_ets_allowances_bm_curve_factsheets_en.pdf) accessed 8 December 2023.

EC, 2022a, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions EU 'save energy' (COM(2022) 240 final) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A240%3AFIN).

EC, 2022b, 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 (COM/2022/230 final) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483) accessed 16 September 2022.

EC, 2023a, *2023 Strategic Foresight Report: sustainability and wellbeing at the heart of Europe's Open Strategic Autonomy*, *European Commission - Press release*, (https://ec.europa.eu/commission/presscorner/api/files/document/print/%20de/ip_23_3623/IP_23_3623_EN.pdf) accessed 8 September 2023.

EC, 2023b, *AMECO Database — EEA and European Commission 2022 Autumn Forecasts*, *Economy and Finance* (https://economy-finance.ec.europa.eu/economic-research-and-databases/economic-databases/ameco-database_en) accessed 8 November 2023.

EC, 2023c, *Amending the Regulation on greenhouse gas emissions and removals from land use, land use change and forestry*, *Legislative Train Schedule* (https://www.europarl.europa.eu/legislative-train/package-fit-for-55/file-lulucf-revision) accessed 8 November 2023.

EC, 2023d, Communication from the Commission to the European Parliament and the Council - Sustainability and people's wellbeing at the heart of Europe's Open Strategic Autonomy (COM(2023) 376 final) (https://commission.europa.eu/system/files/2023-07/SFR-23_en.pdf) accessed 8 October 2023.

EC, 2023e, 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 'A Green Deal Industrial Plan for the Net-Zero Age' (COM(2023) 62 final) (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) accessed 8 October 2023.

EC, 2023f, *EU Emissions Trading System (EU ETS)*, (https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en) accessed 8 September 2023.

EC, 2023g, *European Alternative Fuels Observatory,* (https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27) accessed 8 October 2023.

EC, 2023h, 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 (COM/2023/148 final) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023PC0148).

EC, 2023i, Proposal for a Regulation of the European Parliament and of the Council on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act) (COM(2023) 161 final) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023PC0161) accessed 8 October 2023.

EC, 2023j, *Quarterly report - On European electricity markets*, Market Observatory for Energy 15 (https://energy.ec.europa.eu/system/files/2023-05/Quarterly%20Report%20on%20European%20Electricity%20Markets%20Q4%202022%20v2C_0.pdf) accessed 8 September 2023.

EC, 2023k, *Slight upturn in 2022 ETS emissions due to energy crisis and rebound in aviation – but declining trend maintained*, *Climate Action* (https://climate.ec.europa.eu/news-your-voice/news/slight-upturn-2022-ets-emissions-due-energy-crisis-and-rebound-aviation-declining-trend-maintained-2023-04-24_en) accessed 8 September 2023.

EEA, 2019, *Adaptation challenges and opportunities for the European energy system*, EEA Report No 1/2019, European Environment Agency (https://www.eea.europa.eu/publications/adaptation-in-energy-system) accessed 19 March 2023.

EEA, 2020, *Trends and drivers of EU greenhouse gas emissions*, EEA Report 3/2020, European Environment Agency (https://www.eea.europa.eu/publications/trends-and-drivers-of-EU-GHG) accessed 5 October 2021.

EEA, 2022a, 'Dashboard – Renewable energy in Europe 2022', European Environment Agency (https://www.eea.europa.eu/themes/energy/renewable-energy/renewable-energy-in-europe-2022) accessed 8 September 2023.

EEA, 2022b, 'Progress and prospects for decarbonisation in the agriculture sector and beyond', European Environment Agency (https://www.eea.europa.eu/publications/Progress-and-prospects-for-decarbonisation) accessed 8 October 2023.

EEA, 2022c, *Trends and projections in Europe 2022*, EEA Report No 10/2022, European Environment Agency (https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2022) accessed 8 October 2023.

EEA, 2023a, 'Climate change impacts, risks and adaptation', European Environment Agency (https://www.eea.europa.eu/en/topics/in-depth/climate-change-impacts-risks-and-adaptation?activeAccordion=dd2e16ef-4d34-48ae-bd38-31258544004d).

EEA, 2023b, 'EEA greenhouse gas — data viewer', European Environment Agency (https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer) accessed 8 October 2023.

EEA, 2023c, 'EU Emissions Trading System (ETS) data viewer', European Environment Agency (http://www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer) accessed: 8 October 2023.

EEA, 2023d, '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, 2023e, 'Greenhouse gas emissions under the Effort Sharing Decision (ESD)', European Environment Agency (https://www.eea.europa.eu/en/datahub/datahubitem-view/e9ce7eb8-8439-4f2f-96f8-279a36c5fa7a) accessed 16 August 2023.

EEA, 2023f, *Transport and environment report 2022*, EEA Report No 07/2022, European Environment Agency (https://www.eea.europa.eu/publications/transport-and-environment-report-2022/transport-and-environment-report/view) accessed 8 October 2023.

EEA, forthcoming a, *Approximated estimates for the primary and final consumption of energy in 2022,* European Environment Agency.

EEA, forthcoming b, *Approximated estimates for the share of gross final consumption of renewable energy sources for 2022*, European Environment Agency.

EEA, forthcoming c, *Approximated EU GHG inventory: proxy GHG estimates for 2022*, European Environment Agency.

EEA, forthcoming d, *The European biomass puzzle Trade-offs, opportunities, and challenges around biomass production and use in the EU,* European Environment Agency.

EEA, forthcoming e, *Member States' greenhouse gas (GHG) emission projections' for 2022,* European Environment Agency.

EEA/ACER, 2023, *Flexibility solutions to support a decarbonised and secure EU Electricity System,* European Environment Agency.

EHPA, 2023, 'Heat pumps: Europe's buildings avoid more emissions than ever' (https://www.ehpa.org/market-report-2023).

Ember, 2023, 'Carbon Price Tracker — The latest data on EU and UK ETS carbon prices', Data Tools (https://ember-climate.org/data/data-tools/carbon-price-viewer) accessed 8 October 2023.

EU, 2018, 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, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (OJ L 328, 21.12.2018 p. 1-77) (http://data.europa.eu/eli/reg/2018/1999/oj/eng) accessed 23 March 2023.

EU, 2021, Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) no 401/2009 and (EU) 2018/1999 'European Climate Law' (OJ L 243/1, 9.7.2021) (http://data.europa.eu/eli/reg/2021/1119/oj/eng) accessed 8 March 2023.

EU, 2023a, Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2023:231:FULL).

EU, 2023b, Directive of the European Parliament and of the Council on energy efficiency and amending Regulation (EU) 2023/955 (recast) (2021/0203 (COD)) (https://data.consilium.europa.eu/doc/document/PE-15-2023-INIT/en/pdf).

EU, 2023c, Regulation (EU) 2023/839 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/841 as regards the scope, simplifying the reporting and compliance rules, and setting out the targets of the Member States for 2030, and Regulation (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review (https://eur-lex.europa.eu/eli/reg/2023/839/oj) accessed 4 June 2023.

EU, 2023d, Regulation (EU) 2023/851 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2019/631 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition (OJ L 110, 25.4.2023, p. 5–20) (https://eur-lex.europa.eu/eli/reg/2023/851) accessed 8 October 2023.

EU, 2023e, Regulation (EU) 2023/857 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, and Regulation (EU) 2018/1999 (OJ L 111, 26.4.2023, p. 1–14) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R0857) accessed 16 August 2023.

EU, 2023f, Regulation (EU) 2023/955 of the European Parliament and of the Council of 10 May 2023 establishing a Social Climate Fund and amending Regulation (EU) 2021/1060 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R0955&qid=1692622985398).

Eurostat, 2018, 'Glossary: Primary energy consumption' (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Primary_energy_consumption#:~:text=Primary%20energy%20consumption%20measures%20the,final%20consumption%20by%20end%20users) accessed 8 September 2023.

Eurostat, 2021, '39% of the EU is covered with forests' (https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20210321-1).

Eurostat, 2023a, 'Complete energy balances - NRG_BAL_C, Data Browser' (https://ec.europa.eu/eurostat/databrowser/view/NRG_BAL_C__custom_7132602/default/table?lang=en) accessed 8 October 2023.

Eurostat, 2023b, 'Cooling and heating degree days by NUTS 3 regions - annual data - NRG_CHDDR2_A, Data Browser' (https://ec.europa.eu/eurostat/databrowser/view/nrg_chddr2_a/default/table?lang=en) accessed 8 October 2023.

Eurostat, 2023c, 'Electricity production capacities by main fuel groups and operator - NRG_INF_EPC, Data Browser' (https://ec.europa.eu/eurostat/databrowser/view/NRG_INF_EPC/default/table?lang=en) accessed 8 October 2023.

Eurostat, 2023d, 'Energy efficiency - NRG_IND_EFF, Data Browser' (https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_eff/default/table?lang=en) accessed 8 October 2023.

Eurostat, 2023e, 'Gross production of electricity and derived heat from non-combustible fuels by type of plant and operator - NRG_IND_PEHNF, Data Browser' (https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_pehnf/default/table?lang=en) accessed: 8 October 2023.

Eurostat, 2023f, 'Population change - Demographic balance and crude rates at national level' (https://ec.europa.eu/eurostat/databrowser/view/demo_gind/default/table?lang=en).

Eurostat, 2023g, 'SHARES up to 2020 and 2021, Additional data' (https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20(SHARES))accessed 8 October 2023.

EUSABCC, 2023, *Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050*, European Scientific Advisory Board on Climate Change (https://climate-advisory-board.europa.eu/reports-and-publications/scientific-advice-for-the-determination-of-an-eu-wide-2040/scientific-advice-for-the-determination-of-an-eu-wide-2040-climate-target-and-a-greenhouse-gas-budget-for-2030-2050.pdf/@@display-file/file) accessed 8 September 2023.

Iceland, 2021, 'Update of the Nationally Determined Contribution of Iceland' (https://unfccc.int/sites/default/files/NDC/2022-06/Iceland_updated_NDC_Submission_Feb_2021.pdf) accessed 8 October 2023.

Iceland, 2023, 'Governmental Climate Change Website, Government of Iceland' (https://www.government.is/topics/environment-climate-and-nature-protection/climate-change) accessed 8 October 2023.

IPCC, et al., 2014, *Climate change 2014: mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press (https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/drafts/fgd/ipcc_wg3_ar5_summary-for-policymakers_may-version.pdf) accessed 28 August 2015.

Ipsos European Public Affairs, 2022, *Flash Eurobarometer 514 - EU's response to the energy challenges* (https://webgate.ec.europa.eu/ebsm/api/public/deliverable/download?doc=true&deliverableId=85115) accessed 8 October 2023.

Kaya, Y., 1990, *Impact of carbon dioxide emission control on GNP growth: Interpretation of proposed scenarios*.

Korosuo, A., et al., 2023, 'The role of forests in the EU climate policy: are we on the right track?', *Carbon Balance and Management* 18 (15) (https://doi.org/10.1186/s13021-023-00234-0).

Liechtenstein, 2015, 'Liechtenstein's intended nationally determined contribution (INDC)' (https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Liechtenstein%20First/150422_INDC_FL.pdf) accessed 3 July 2019.

Liechtenstein, 2022, *Liechtenstein's Eighth National Communication - Submission of December 2022 under the United Nations Framework Convention on Climate Change and the Kyoto Protocol* (https://unfccc.int/sites/default/files/resource/NC8_BR5_LIE_2022.pdf) accessed 8 October 2023.

Lyons, L., et al., 2022a, *Heat Pumps in the European Union – 2022 Status Report on Technology Development, Trends, Value Chains and Markets*, Joint Research Centre JRC130874 (https://publications.jrc.ec.europa.eu/repository/bitstream/JRC130874/kjna31268enn.pdf).

Meyer-Ohlendorf, Nils, et al., 2023, *Designing the EU 2040 Climate Target - Political context, level of ambition, implications for Member States and sector* (https://www.ecologic.eu/19359) accessed 8 September 2023.

Norway, 2017, 'Act relating to Norway's climate targets (Climate Change Act)' (https://lovdata.no/dokument/NLE/lov/2017-06-16-60) accessed 3 July 2019.

Romania, 2022, *Romania. 2022 National Inventory Report (NIR)*, NIR (https://unfccc.int/documents/461892) accessed 8 September 2023.

Switzerland, 2021, 'Switzerland's information necessary for clarity, transparency and understanding in accordance with decision 1/CP.21 of its updated and enhanced nationally determined contribution (NDC) under the Paris Agreement (2021 – 2030)' (https://unfccc.int/sites/default/files/NDC/2022-06/Swiss%20NDC%202021-2030%20incl%20ICTU_December%202021.pdf) accessed 8 September 2023.

Tsemekidi Tzeiranaki, S., *et al.*, 2022, *Energy Consumption and Energy Efficiency trends in the EU, 2000-2020*, JRC Science for Policy Report JRC130732, (https://publications.jrc.ec.europa.eu/repository/bitstream/JRC130732/JRC130732_01.pdf) accessed 8 September 2023.

Türkiye, 2023, *Republic of Türkiye Updated First Nationally Determined Contribution* (https://unfccc.int/sites/default/files/NDC/2023-04/T%C3%9CRK%C4%B0YE_UPDATED%201st%20NDC_EN.pdf) accessed 8 October 2023.

European Environment Agency

Trends and projections in Europe 2023
2023 — 83 pp. — 21 x 29.7 cm

ISBN 978-92-9480-606-2
DOI 10.2800/595102

European Environment Agency

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark
Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

Publications Office
of the European Union

TH-AL-23-006-EN-N
DOI: 10.2800/595102