The Climate DESK

:FutureCamp

Potential Impact of a

2040 EU *Climate Target* of -90 % on Germany

This report has been commissioned by
the *German Chamber of Commerce and Industry, DIHK,*
and the *German Association of Local Public Utilities, VKU.*

The report has been written by
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with *FutureCamp Climate.*

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Key findings of this study

The proposed 2040 target is achievable only with timely, coordinated and resolute action across all sectors.

The European Commission demonstrates how the proposed 2040 target of a 90% net GHG emissions reduction can be achieved in an economically and ecologically viable way. To achieve it, a comprehensive and challenging set of measures is required. The Commission emphasizes that while the target is demanding, it remains a scientific necessity to mitigate the worst impacts of anthropogenic climate change. Timely and sustained efforts, supported by strong policies and financial investment, are imperative to maintain a realistic trajectory toward this goal.

The potential inability to achieve the 2030 target significantly complicates the prospect of reaching the proposed 2040 target.

The EU member states' projected emissions indicate a looming, significant failure to meet the 2030 target of a 55% net GHG reduction. In the current 2021-2030 period, an average annual emissions reduction of 125 Mt CO_2-eq is required. The proposed 2040 target would already increase this rate by approximately 30 percent to 163 Mt CO_2-eq for the 2031-2040 timeframe. If, on the other hand, emissions reach the level that projections considering the existing measures expect, an average reduction of 209 Mt CO_2 eq per year would be necessary after 2030, exceeding the current value by approximately 67percent. It is therefore necessary to get those sectors on track that are at risk of missing the 2030 target. Otherwise, it could become increasingly difficult to achieve the climate targets for 2040 and 2050.

Effective carbon leakage protection and the successful introduction of ETS II are critical.

With its two emissions trading systems (ETS), the EU has instruments in place that cover and regulate the majority of emissions. Both systems are in critical phases: For ETS I, covering the power sector and industry, the transition from free allocation to a system of carbon leakage protection through CBAM must be successful to avoid jeopardizing industrial production. The introduction of the ETS II, covering transport, buildings and small industries, must also be successful. The system will begin with substantial pressure to reduce emissions. There is a risk of considerable burdens for households, industry, businesses and municipalities. For agriculture, there is currently no resilient reduction path at all.

Efficient, timely and successful deployment of new technologies is critical for achieving the proposed 2040 target.

The proposed 2040 target heavily relies on the rapid development, deployment, and adoption of new technologies such as carbon capture and storage (CCS) and green hydrogen. Achieving this will require significant investments along the whole value chain. Building the necessary infrastructure, securing economic viability, and gaining broad stakeholder support are essential. The reliance on these technologies demands urgent, coordinated efforts to ensure timely and efficient implementation.

Germany's GHG reduction pathways face significant challenges, with critical implications for the EU

Germany faces major challenges in achieving its decarbonization goals. Failure to meet Germany's planned reductions would have a detrimental trickle-down effect on other EU member states. As the EU's largest emitter and economy, Germany's shortfall would raise the overall emissions burden, increasing the difficulty for the EU to meet its proposed 2040 target. The trade-offs could be significant, risking economic imbalance and undermining the collective efforts of the EU's climate strategy.

1 Executive summary

This report evaluates the European Union's (EU) proposed 2040 climate target, which seeks a 90% reduction in net greenhouse gas (GHG) emissions compared to 1990 levels. Focusing on Germany's municipal energy companies and the industrial mid-tier sector, it outlines the key policy, infrastructure, and economic adjustments needed to meet this goal. Commissioned by German industry associations German Chamber of Industry and Commerce (DIHK) and German Association of Local Public Utilities (VKU), it answers two main questions: What adaptations are required to achieve a 90% GHG reduction by 2040? How will these changes affect municipal energy suppliers and the industries they support?

The EU commission has proposed to aim for a 90% GHG reduction target by 2040, compared to 1990 levels.

The target proposes the trajectory to follow on the way to the 2050 net-zero target established by the EU Climate Law. This target is in line with scientific advice from the European Scientific Advisory Board on Climate Change and the Paris Agreement, and it relies on the suggestion put forward by the accompanying impact assessment report.

According to the scenario analysis performed by the impact assessment, a -90% reduction target offers the most effective path to achieve the 2050 net-zero target.

To achieve a 90% GHG reduction by 2040, multiple transformations need to happen. The power sector must reach an 81-87% renewable share. Transport electrification is expected to reach 75%, and buildings must reduce energy consumption by 50%. Industry emissions also must reduce with increasing penetration of hydrogen and large-scale deployment of CCS. The estimated amount of investment needed to realize those systemic transformations is estimated to be €3-4.5 trillion.

The existing policy framework provides a solid basis for implementing climate protection targets, but it alone will not guarantee their realization.

The European climate policy framework is solidly embedded in the European Climate Law, with its 2050 net-zero target and operationalized by the Fit for 55 packages with its comprehensive reach. Alongside various sector-specific policy instruments, a large share of EU emissions is and will be covered by carbon pricing under the EU emissions

Figure 1: Annual GHG emission reductions: 2021–2040 and impact of missing 2030 targets

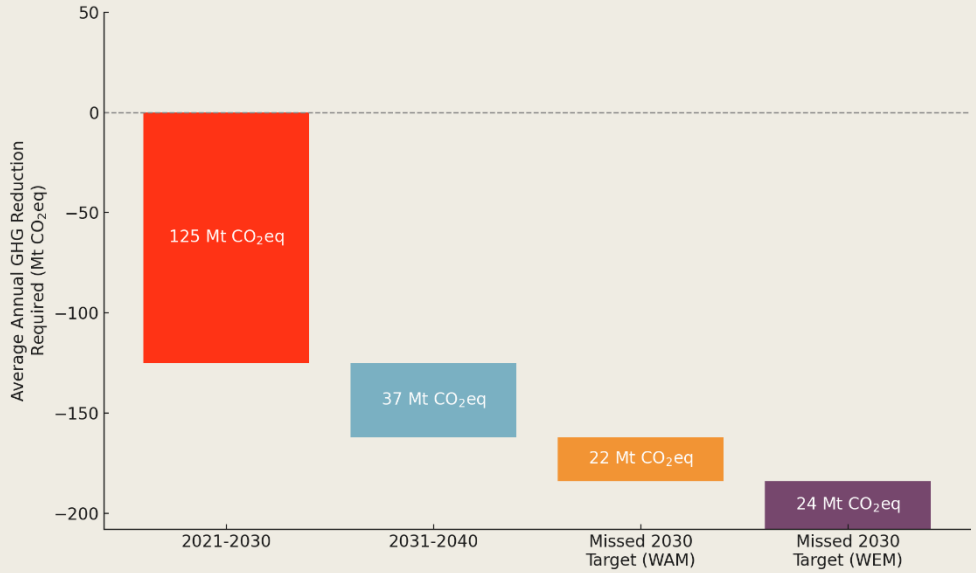
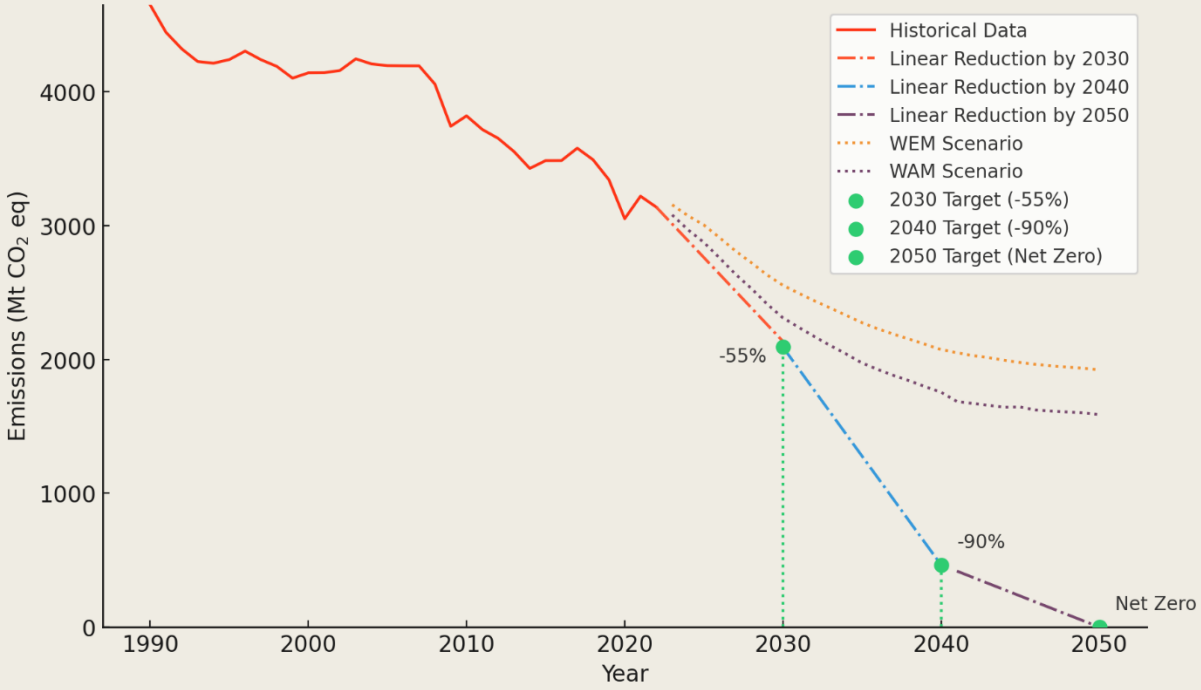


Figure 2: EU historical GHG emissions, climate targets, WEM and WAM projections (1990-2040)



trading system (ETS). EU ETS I is critical to reduce emissions in power, heat, and industry. The main challenge here is the transition to an effective carbon leakage protection through the carbon border adjustment mechanism (CBAM) and the transition to production processes that are compatible with net-zero. ETS II will play a critical role in fostering the transition towards renewables in transport and in the building sector but will start with a high pressure to implement mitigation measures fast.

Historical emissions of the EU reflect early policy efforts.

Through improvements in energy efficiency and a large roll out of renewable energy in the power sector, the EU has reduced its emissions by a third since 1990. Among the countries with the highest emissions in Europe —Germany, France, Italy, Poland, and Spain— Germany has reduced its emissions at the fastest rate despite its historical reliance on coal in the power sector. Nonetheless, all major emitters face the challenge of decarbonizing their large industrial bases and reach higher levels of renewables penetration.

The current emission trajectory of the EU and the individual member states is not in line with its ambitious targets.

While the emission reduction in the EU has been substantial in the past, country's projections show that the current pace is inadequate to meet the 2030 and the proposed 2040 target. The sectors covered by EU ETS I have reduced their emission by a total of 47% compared to 2005. However, faster emissions reductions are needed to meet the 2030 target of – 64% in the sectors covered by ETS I. Similarly, sectors outside ETS I are projected to miss their 2030 targets set in the Effort Sharing Regulation (ESR) by more than 13 percentage points. The rate of emissions reduction will have to increase significantly to meet those targets.

Meeting EU's medium and long-term mitigation targets is critical to avoid dangerous climate change impacts, but it can only happen if existing policies are made to work and complemented with needed new policies.

EU ETS I, has proved to be a successful and cost-effective instrument to drive down emissions in the power sector. The main challenge ahead lies in decarbonizing the industry sector. For a deep decarbonization of heavy industry, ETS I will have to move to a new phase where free allowances are progressively removed and substituted with CBAM to ensure carbon leakage protection. An effective implementation of CBAM is an important prerequisite to avoid increased mitigation objectives in the EU, which are simply outweighed by increased emissions abroad, i.e. carbon leakage. At the same time, the right policy framework needs to be designed to direct investments towards key technologies like CCS and hydrogen. ETS II is expected to become the main driver of emission reductions in transport and the building sector. However, challenges such as the potential considerable burden on households, industry, businesses and municipalities must be addressed for it to be successful. Furthermore, the interaction between ETS II and the ESR can create inefficiencies.

The policy changes necessary to meet the targets will reverberate on the legal landscape in Germany.

Germany must undertake substantial reforms in its legal and regulatory frameworks to meet the EU's 2040 climate targets. Existing policies, such as the Renewable Energy Sources Act and the Building Energy Act, need updates to accelerate renewable energy growth, decarbonize heating systems, and expand essential infrastructure. Key challenges will have to be addressed in all sectors. To achieve 80-100% renewable electricity by 2040 the necessary policies and incentives must be put in place to stimulate investments in grid infrastructure and energy storage. The building sector must be equipped with the necessary finance and support to reach a 3-4% annual rate of energy-efficient retrofits. Charging infrastructure for electric vehicles must be scaled up to increase adoption rates. Consistent and wide scoped carbon pricing, higher public investments and policies incentivizing investments will all have to be targeted by German policymakers to avoid missing its 2030 and proposed 2040 target.

Municipal energy companies will play a key role in shaping Germany's mitigation efforts.

Municipal companies are placed at the core of the transition as they manage critical aspects such as district heating, waste, and public transport. As such, they are well positioned to drive the energy transition from the bottom up. However, how the German and European policy frameworks will develop over the course of the next decade will have significant repercussions on them. District heating will be directly impacted by CO_2 costs from ETS plants (e.g., industrial waste heat) that feed into their networks. Furthermore, the planned inclusion of thermal waste incineration facilities under EU ETS I would result in additional costs for district heating networks. Yet mitigation options in the sector are limited. Therefore, regulations for addressing difficult or unavoidable residual emissions will be necessary. A careful policy design can create the needed market-based incentives to invest in CO_2 removal technologies.

2 Introduction

This report provides an in-depth analysis of the potential impact of the EU proposed 2040 climate target of a 90% GHG emission reduction at the EU level and on Germany, with particular attention to the industrial mid-tier sector and municipal energy companies. The primary objective is to examine the direct and indirect effects of the proposed 2040 climate target on key sectors within EU and Germany, focusing on potential legal framework adjustments, infrastructure needs, and the economic implications for local energy suppliers and industries. In doing so, the report aims to answer two main research questions: (1) What are the necessary policy changes and sector-specific adaptations required to achieve the proposed 90% reduction in net GHG emissions by 2040 and (2) How will these changes affect municipal energy suppliers and the industries they support?

The report is structured to guide the reader through a series of logical steps, starting with an overview of the EU's proposed 2040 climate target, followed by an analysis of the current EU and German policy frameworks. It then delves into historical and projected emissions trends, which provide context for the evaluation of progress toward climate goals. A detailed assessment of the required policy changes at both EU and national Member State levels is presented, with a specific focus on energy, transport, waste management, and industry. The discussion also highlights the interplay between the EU ETS I and ETS II and the ESR, alongside key national policies. The report concludes with an evaluation of the implications for municipal energy companies and the industries they serve, outlining both the challenges and opportunities arising from the proposed 90% GHG reduction target.

For the analysis, historical emissions data from 1990 to 2022[1] and projections from the 2023 EU-wide report[2] by the European Environment Agency (EEA) are used. GHG emission projections are based on data from EU Member States and reflect anticipated outcomes under current ("with existing measures", WEM) and planned ("with additional measures", WAM) policies and measures; it is important to note these are projections, not actual emission levels, and are subject to change based on future developments. Given the recent availability of Germany's updated 2024 projection report, German-specific data has been updated wherever relevant and useful to provide a more accurate picture. All emissions data refer to GHG emissions expressed in CO_2 equivalent (CO_2 eq) terms. Full references are provided in the footnotes throughout the report to ensure transparency and traceability of the data sources used. The sectors discussed in this report follow the IPCC classification and are outlined in the info box at the end of this chapter.

This report was commissioned by the German industry associations DIHK and VKU and produced by The Climate Desk in collaboration with FutureCamp Climate. It is based on comprehensive quantitative and qualitative analyses that have been carried out carefully and conscientiously.

[1] European Environment Agency. (2024). *National emissions reported to the EEA*. Europa. https://www.europa.eu/webdav/datastore/public/eea_t_national-emissions-reported_p_2024_v01_r00/EXCEL

[2] European Environment Agency. (2023). *Metadata on national emissions data*. Europa. https://sdi.eea.europa.eu/catalogue/srv/eng/catalog.search#/metadata/14ffb69b-9c55-49f3-8477-3460aca891c4

3 The EU Commission's proposal for the 2040 climate target

This chapter provides a detailed analysis of the EU's proposed 2040 climate target, as presented in the communication[3] from the EU Commission on 6 February 2024, and the accompanying impact assessment report[4]: "Securing our future - Europe's 2040 climate target and path to climate neutrality by 2050, building a sustainable, just, and prosperous society." While the EU communication proposes a mitigation target for 2040, the impact assessment substantiates the target by determining an indicative 2030-2050 GHG budget. This budget should represent a feasible, fair, and effective contribution to implementing the Paris Agreement.

3.1 Overview of the communication of the proposed 2040 target

The EU's communication proposing the 2040 target aims to start a political debate and guide the development of the post-2030 climate framework, recommending a 90% reduction in net GHG emissions from 1990 levels by 2040. This target aligns with the recommendations of the European Scientific Advisory Board on Climate Change (ESABCC) [5] and the Paris Agreement. The ESABCC report[6] emphasizes the need for urgent action, particularly in sectors like LULUCF, where GHG emissions reductions are lagging. The recommendations identify policy gaps and inconsistencies, such as the need to revise the Energy Taxation Directive and phasing out fossil fuel subsidies, to create a coherent and robust policy framework. They also guide the implementation of key measures like the "Fit for 55" package, ensuring that short-term actions align with long-term goals to avoid carbon lock-in. While many recommendations have been adopted, their full impact depends on timely and robust implementation, with some key legislative actions still pending and the need for stronger enforcement mechanisms to ensure compliance across all EU Member States. To achieve this, the EU's GHG emissions should be reduced to less than 850 million tons of carbon dioxide equivalent (Mt CO_2 eq), excluding Land Use, Land-use Change, and Forestry (LULUCF), by 2040, with carbon removals reaching up to 400 Mt CO_2 eq.

The EU's communication outlines several key conditions necessary for achieving these goals and ensuring a successful transition to climate neutrality by 2050. Full implementation of the 2030 climate and energy framework is essential. The EU must maintain global competitiveness in its industries by fostering innovation, ensuring access to finance, and creating a level playing field with international competitors. A just and inclusive transition is critical, requiring support for vulnerable communities, workers, and regions most impacted by the shift to a low-carbon economy. The EU also needs to engage in international dialogues to ensure that its climate policies do not disadvantage European industries. Strategic dialogue with key stakeholders, including industry, agriculture, and social partners, is essential for shaping the post-2030 climate policy framework. Significant investments are required in energy and transport infrastructure and in deploying low-carbon technologies, including upgrades to power grids, expansion of renewable energy capacity, and development of CCS technologies. Mobilizing public and private sector investments is crucial, leveraging EU funds and creating favorable conditions for private sector participation. The "Energy Efficiency First" principle is emphasized as central

[3] European Commission. (2024). *Securing our future: Europe's 2040 climate target and path to climate neutrality by 2050 – Building a sustainable, just, and prosperous society* (COM(2024) 63 final). European Union.

[4] European Commission. (2024). *Impact assessment report accompanying the communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Securing our future: Europe's 2040 climate target and path to climate neutrality by 2050 – Building a sustainable, just, and prosperous society* (SWD(2024) 63 final, Parts 1–5). European Union.

[5] ESABCC is an advisory body established under the European Climate Law (EU) 2021/1119 recital 24 „ to serve as a point of reference on scientific knowledge relating to climate change by virtue of its independence and scientific and technical expertise "

[6] ESABCC. (2023). *Scientific advice for the determination of an EU-wide 2040 climate target and a GHG budget for 2030–2050.* https://doi.org/10.2800/609405

to reducing consumption and costs, ensuring affordable energy prices for households and industries. Continuous investment in research, innovation, and skills development is necessary to support new technologies and prepare the workforce for a decarbonized economy. The EU aims to achieve sustainable economic growth by decoupling it from GHG emissions. Between 1990 and 2022, the EU's economy grew by 67%, while net GHG emissions dropped by 32.5%, demonstrating the feasibility of economic growth alongside significant emissions reductions. Material productivity, referring to economic value generated per unit of material used, particularly in metals like steel and aluminum and construction materials such as cement and concrete, increased by 37.5% between 2000 and 2022, further indicating progress in resource efficiency. The communication emphasizes the need for a fully decarbonized power system by 2040, which requires rapidly deploying renewable and low-carbon energy technologies, including solar, wind, nuclear, and other net-zero technologies. The share of electricity in final energy consumption (FEC) is expected to double, reaching about 50%, by 2040, with over 90% of electricity generated from renewable and nuclear sources. Fossil fuel consumption is projected to decrease by approximately 80% by 2040 compared to 2021.

Transport sector GHG emissions are expected to decrease by nearly 80% by 2040 compared to 2015. The share of battery-electric and other zero-emission vehicles is projected to exceed 60% for cars, 40% for vans, and 40% for heavy-duty vehicles by 2040. Electrification and the use of renewable fuels are priorities, particularly in aviation and maritime transport. Significant investments are required in refueling and recharging infrastructure, as well as in zero-emission vehicles and aircraft, to meet the proposed 2040 target.

The agricultural sector is crucial for achieving the proposed 2040 target. The focus will be on adopting sustainable practices, enhancing carbon removals, and contributing to the bioeconomy. Precision farming and carbon farming approaches are highlighted as key strategies for reducing GHG emissions and enhancing carbon removals in agriculture.

In the building sector sustainably sourced bio-based materials, like wood in construction, can store carbon long-term, replace fossil-based materials, and support decarbonization.

The EU's communication proposes a comprehensive investment agenda that emphasizes the need for both public and private investments to meet the demands of the climate transition. Significant financial resources must be mobilized, leveraging public and private investments through innovative financial instruments. The European Investment Bank (EIB) plays a crucial role in financing the transition, particularly in de-risking projects and attracting private sector investment through mechanisms like counter-guarantees. For example, the EIB provides guarantees through the European Fund for Strategic Investments (EFSI) and the InvestEU program to attract private investment in high-risk areas like renewable energy and energy efficiency projects; the recent €5 billion counter-guarantee from EIB for wind energy projects, for instance, is expected to generate €80 billion in investment, illustrating the potential of these innovative EU finance tools to de-risk strategic investments in a technology-neutral manner. Deepening the Capital Markets Union is identified as essential for unlocking an estimated €470 billion in annual private funding necessary for achieving the EU's sustainability objectives.

Energy system investments (excluding transport) are estimated at around €660 billion per year from 2031 to 2050, representing about 3.2% of the EU's GDP, which is a significant increase compared to the 1.5% of GDP invested annually in the energy system during 2011-2020[7]. The EU will focus on establishing a framework that supports the decarbonization of energy-intensive industries, particularly those that are difficult to decarbonize. Carbon capture, utilization, and storage (CCUS) technologies are prioritized, especially in sectors with limited alternatives. The circular economy is also highlighted as a strategy with the potential to reduce energy system investment needs by 7% and

[7] "A period during which overall investment levels in the EU were historically low. It is also comparable to the level of investment that will be needed in the current decade to achieve the objectives of the Fit-for-55 package." (Impact Assessment Report)

transport spending by 9% over 2031-2050. Small modular reactors (SMRs) are considered crucial for decarbonizing hard-to-abate sectors, with the first projects expected by early 2030.

Transport sector investments are expected to require ca. €870 billion annually, or 4.2% of GDP. Public sector investments are essential for early-stage low-carbon projects, infrastructure development, and de-risking large-scale projects, while the private sector is expected to contribute significantly, particularly in renewable energy, smart grids, and clean transportation infrastructure.

To mobilize private investments, the Capital Markets Union and Strategic Technologies for Europe Platform (STEP) are key. The Innovation Fund is anticipated to reach €40 billion by 2030 to support low-carbon technologies. The Social Climate Fund aims to mobilize €87 billion to support vulnerable households and micro-enterprises. The InvestEU program is expected to mobilize more than €110 billion in green investments. In 2022, the EU contributed €28.5 billion in public climate finance to developing economies, with an additional €11.9 billion mobilized from private finance. Continued support from the Just Transition Fund is vital for regions most affected by the transition. The Innovation Fund will drive clean technology deployment, while the Social Climate Fund, with €87 billion, will address social impacts.

The communication emphasizes critical policies necessary for achieving climate goals. The European Green Deal must evolve into an industrial decarbonization deal, integrating employment, skills, and social aspects. The European Climate Law introduces a 2040 target to ensure the EU remains on course for 2050 climate neutrality. The ETS remains central to GHG emissions reduction targets. The gradual implementation of the CBAM will align global carbon pricing.

The EU's communication calls for increased ambition in National Energy and Climate Plans (NECPs) by 2024 and highlights the Technical Support Instrument, which offer tailored technical expertise to EU Member States for implementing reforms, especially for the 2030 policy framework, with support covering areas like the green transition, economic recovery, and digital transformation, all provided on a demand-driven basis without requiring co-financing. New initiatives like the EU Solar PV Alliance and Wind Charter will accelerate renewable energy. Key actions include a roadmap for industrial carbon management, the launch of the Industrial Alliance on SMRs, and the EU Grid Action Plan. The Critical Raw Materials Act and Ecodesign for Sustainable Products Regulation will secure resources and promote a circular economy. The Net Zero Industry Act and Green Deal Industrial Plan are crucial for deploying net-zero technologies. Hydrogen Valleys will support industrial decarbonization, and the Circular Economy Action Plan will reduce resource use and GHG emissions. The Strategic Dialogue on the Future of Agriculture and the EU Fisheries and Oceans Pact are essential for achieving climate neutrality in these sectors. The Sustainable Carbon Cycles Communication and the regulation establishing a Union certification framework for carbon removal (CRCF) to incentivize innovative carbon removal technologies and carbon farming are important for meeting the proposed 2040 target.

The Recovery and Resilience Facility (RRF) will support sustainable investments. The roles of the Agency for the Cooperation of Energy Regulators (ACER), the Digitalisation of the Energy System Action Plan, and ongoing dialogues such as the Structured and Systematic Dialogue with Social Partners and Clean Transition Dialogues are also crucial. The FuelEU Maritime and ReFuelEU Aviation Regulations are key to cutting emissions in maritime and aviation sectors. The increased use of biomass, biofuels, BECCS technologies, and bio-based products should be guided by clear sustainability rules that account for impacts on the natural carbon sink in the LULUCF sector.

3.2 Overview of the impact assessment report

The impact assessment report, which supplements the communication of the proposed 2040 target, discusses four scenarios. This report focuses on Scenario S3, which the European Commission recommends as the optimal pathway to achieve climate neutrality by 2050. Scenario S3 advocates for

transformative change, focusing on innovation, systemic shifts, and equitable growth, offering the most effective path to meet the proposed 2040 target and ensuring long-term sustainability, equity, and resilience. It is recommended for its comprehensive approach, long-term viability, and focus on equity, making it the best option for achieving sustainable development. This section of the analysis covers key aspects such as objectives, scope, GHG budget, key impacts, underlying assumptions, feasibility, achievability, as well as the associated risks and challenges.

3.2.1 Objectives

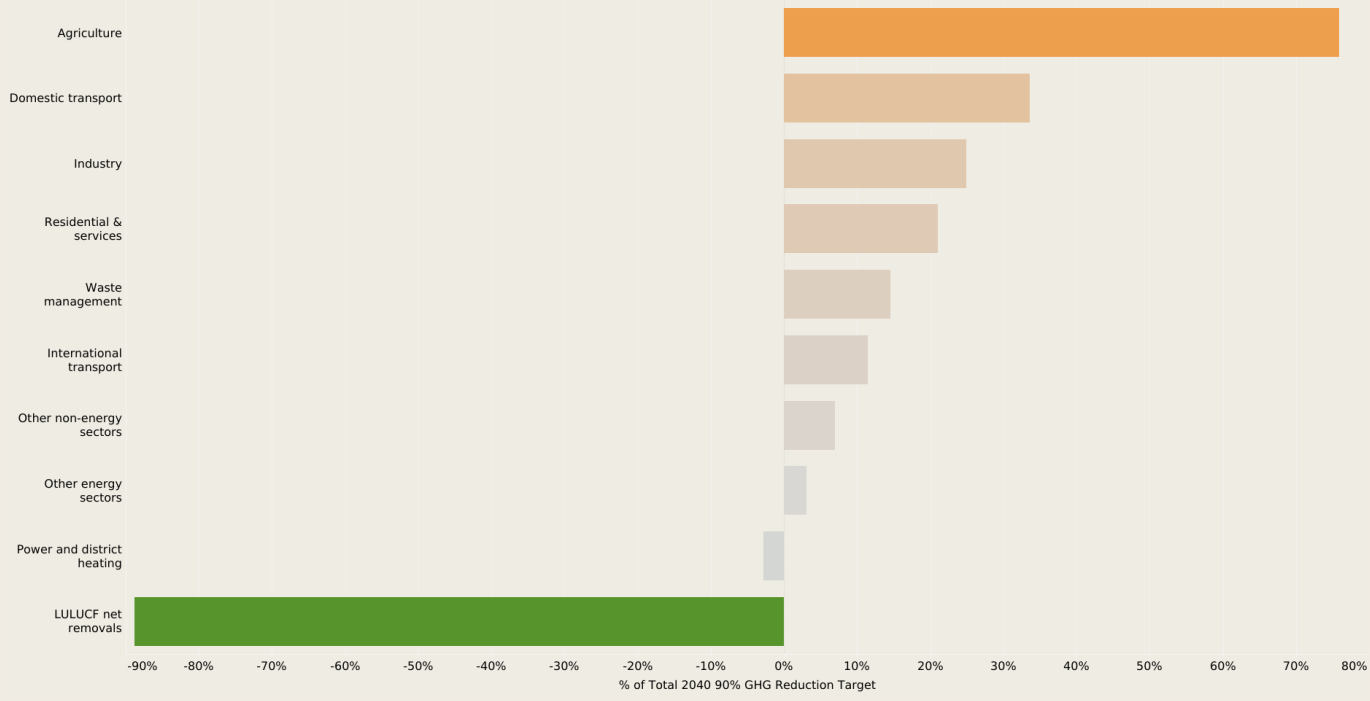
The primary objective of the EU's 2040 climate target is to ensure that the EU remains on a steadfast trajectory toward achieving climate neutrality by 2050, as mandated by the European Climate Law. The proposed 2040 target specifies a 90% reduction in net GHG emissions by 2040 compared to 1990 levels. This involves setting comprehensive, economy-wide GHG reduction goals for 2040, alongside specific pathways tailored for individual sectors. The distribution is illustrated in Figure 1.

The energy sector's GHG reduction pathway anticipates near-complete decarbonization by 2040, achieving up to a 95% reduction in GHG emissions compared to 1990, driven by a significant increase in renewable energy, which is expected to cover 81% to 87% of electricity generation by 2040, compared to 40% in 2021. Nuclear power generation is projected to decrease from 730 TWh in 2021 to around 495 TWh in 2040, reducing its share to approximately 10-11% of total electricity generation.

GHG Emissions in the industry sector are anticipated to be reduced by 56-84% compared to 2015 through electrification, process innovations, new manufacturing technologies, alternative materials and sources, and cleaner supply chains. Hydrogen and carbon capture contribute to these reductions, with carbon capture expected to reach 350 Mt CO_2/year and an injection rate for storage of 240 Mt CO_2/year. This sector also prioritizes the decarbonization of energy-intensive industries such as iron and steel, aluminum, paper and pulp, cement, chemicals, and glass through the extensive adoption of low-carbon technologies.

For the transport sector, the anticipated pathway for 2040 includes electrifying 75% of road transport, with approximately 60 million electric vehicles operational by 2040. Significant GHG emission reductions are also expected in aviation and maritime transport by adopting sustainable

Figure 1: Distribution of sectoral GHG reduction targets for 2040



aviation fuels (SAF) and stringent maritime GHG intensity targets.

The buildings sector is anticipated to achieve a 50% reduction in energy consumption through extensive energy efficiency measures and widespread adoption of heat pump technologies. The agricultural sector is expected to reduce methane emissions by 30% through advanced livestock management and innovative manure treatment technologies. In waste management, the goals include attaining an 80% recycling rate and reducing landfill usage to below 10% by 2040.

3.2.2 Scope

The scope of the 2040 climate target encompasses all domestic net emissions within the EU, including those arising from LULUCF. It also incorporates emissions from international intra-EU aviation and maritime transport, as well as 50% of international extra-EU maritime emissions. The gases covered under these targets include CO_2, methane, and other non-CO_2 gases, consistent with previous targets, ensuring comprehensive coverage across all sectors. The scope systematically addresses all major sources of GHG emissions within the EU, aligning with the requirements outlined in the European Climate Law. Additionally, the proposed GHG reduction pathway is strategically applied across different sectors, targeting large industrial emitters, vehicle manufacturers, fuel providers, building codes, agricultural practices, and waste management to ensure effective control and reduction of GHG emissions at their source.

3.2.3 Rationale

The rationale behind the proposed 2040 climate target is grounded in the EU's legal obligation to contribute an equitable share to global climate action under the Paris Agreement. The targets are strategically designed to align with the international goal of limiting global temperature rise to well below 2 degrees Celsius, and preferably to 1.5 degrees Celsius above pre-industrial levels. The chosen S3 for the 2040 EU climate target aligns with the advice provided by the ESABCC in June 2023. The ESABCC recommended keeping the EU's cumulative GHG emissions within the range of 11-14 giga tonnes of carbon dioxide equivalent (Gt CO_2 eq) between 2030 and 2050, and achieving a reduction of 90-95% in GHG emissions by 2040 relative to 1990 levels.

The recommended 2040 target achieves the lowest cumulative GHG emissions, ranging between 11 to 14 Gt CO_2 eq. This is essential for adhering to the global warming limits stipulated by international climate agreements. The additional costs for achieving climate neutrality in S3 are small compared to the baseline (S1), with only a 1.5% increase in 2031-2040 and 0.8% over 2031-2050. Hence, the cost-benefit analysis favors S3 over other scenarios. These figures indicate a positive economic outcome, even when considering conservative estimates of the social and environmental costs associated with climate change. Economically, the proposed 2040 target necessitates a considerable early investment push, particularly in the energy supply sector. These investments are projected to increase by 1.2 to 1.5% of the GDP over the 2031-2050 period, facilitating a swift transition to sustainable energy systems and fostering long-term economic stability and growth.

3.2.4 Greenhouse gas budget

The GHG budget under the 2040 climate target is critical for ensuring that the EU remains within its permissible emissions limits while working towards its climate objectives. For the period spanning 2030 to 2050, the indicative GHG budget is capped at 16 Gt CO_2 eq. Cumulative gross emissions between 2030 and 2050 are projected to range between 21 to 24 Gt CO_2 eq, with cumulative net removals estimated at 5 to 8 Gt CO_2 eq during the same period. The GHG budget includes contributions from LULUCF and industrial carbon removals. The annual reduction rate is maintained at a pace of at least 3.3% per year between 2031 and 2040.

3.2.5 Key impacts

The implementation of the 2040 climate target is anticipated to yield profound and multifaceted impacts across various sectors, encompassing environmental, economic, social, and technological dimensions.

Table 1: Specific pathways towards a 90% GHG reduction by 2040

Area	Scenario 3 Pathways for 2040
GHG emissions	-90-95% compared to 1990 levels by 2040. 16 Gt CO_2 eq cumulative 2030-2050. LULUCF Net Removals: -220 to -230 Mt CO_2 eq.
Power sector	Coal-fired power plants phased out by 2040. Cap under ETS I reaches almost zero by 2040. Cap under ETS2 reaches zero in 2044.
Energy system and costs	-50-63% fossil fuel import bills 2040 compared to 2020, €1.3 tn savings 2031-2040. Total energy system investment needs: €665 bn p.a. 2031-2040. Energy purchases for transport: € 12 billion in 2031-2040. Capital costs in industry: € 2 bn 2031-2040. Capital costs in the tertiary service sector: € 4 bn 2031-2040. Achieve cumulative energy cost savings of 20% compared to baseline projections (S1).
Renewable energy	Electricity generation: Renewable energy share in electricity generation increases to 81%-87% by 2040. Total installed capacity of renewables: 3,027 GW by 2040. Net installed capacity of RES: Increases from 1,285 GW in 2020 to 3,027 GW in 2040. Gross Final Energy Consumption (FEC): Renewable energy share increases to 75% by 2040. Storage and flexibility options reach 275 GW by 2040. Wind and solar: 50% of gross electricity generation in 2040. Biomass and waste: Approximately 20% of the Gross Available Energy (GAE) share. Final Energy Consumption (FEC): Total FEC reduces to 604 Mtoe (25.3 EJ) by 2040. Electricity's share in FEC increases to above 45% in 2040.
Hydrogen	Domestic hydrogen production: 20 Mt domestically by 2040 (up from 0.1 Mt in 2020). Hydrogen imports: 10 Mt by 2040.
Transport	EVs (including freight transport) to constitute 80% of new vehicle sales by 2040. RFNBOs and biogenic fuels cover 30% of transport fuel needs by 2040. Energy consumption by HGVs decreases by 32% in 2040 compared to 2015 Charging Infrastructure: Over 3 mil public charging points. Battery storage capacity will reach 135-200 GW by 2040. Stored electricity in batteries will reach 200-240 TWh by 2040. € 23 bn will be invested in battery manufacturing by 2040.
Buildings and heating	Renewable heating coverage: 50% of heating demand by 2040. District Heating Share of Total Energy Demand in Buildings by 2040: 11%. Final Energy Consumption (FEC) of Renewable Heating in 2040: 15% of total FEC. Reduction in Gaseous Fuel Consumption in District Heating Plants by 2040: 54-68% reduction from 319 Mtoe in 2020 to 100-150 Mtoe in 2040.
Jobs	Create 2 mil new jobs in the green economy by 2040.
R&D	Double R&D investments in clean energy technologies by 2040.
Agriculture and LULUCF	Net removals from LULUCF limited to -220 to -230 Mt CO_2 eq by 2040. Total non-CO_2 emissions projected to be around 460 Mt CO_2 eq by 2040.
Energy efficiency	Achieve a 45% improvement in energy efficiency across all sectors by 2040 Renovations Wave: Target of doubling annual energy renovation rate of buildings to 2% by 2030, with further acceleration by 2040
Circularity	Implement circular economy strategies to reduce waste by 50% by 2040.

Carbon capture	Deployment of an additional 350 Mt CO_2/year captured by 2040.
Specific sectoral reductions	Reduction in steel demand by 15% compared to 2015. Reduction in cement demand by 38% compared to 2015. Reduction in meat consumption by 40% compared to 2015. Reduction in milk consumption by 20% compared to 2015.
Investment needs (2031-2040)	Energy supply investment: € 341 billion annually. Industry investment: € 48 billion annually. Services investment: € 57 billion annually. Residential investment: € 248 billion annually.
Social	Household energy costs will represent 8.2% of private consumption (of the total amount that households spend on goods and services), rising to 14.4% for low-income households. Electricity prices for households are expected to stay stable at € 288-290/MWh during 2031-2040. Household transport costs are projected to decrease to € 915-1025 per year by 2036-2040.
Environment	80% reduction in acidification and a 23.5% decrease in eutrophication by 2040.

3.2.6 Assumptions

The realization of the 2040 climate target depends on assumptions about technological advancements, economic growth, and policy continuity.

Technologically, it assumes continued rapid progress in renewable energy, particularly wind and solar, which are already the cheapest sources for new power plants. Costs for these technologies are expected to drop by 30-40% by 2040, making them even more competitive. The energy system is expected to be nearly fully decarbonized by 2040, with wind and solar capacities reaching 2,525 GW and 2,180 GW, respectively. CCS technologies are anticipated to capture 500 Mt CO_2 annually by 2040, crucial for reducing GHG emissions in hard-to-abate sectors. Green hydrogen is projected to expand significantly, with consumption reaching 55-95 Mtoe by 2040. Advances in energy storage and grid management will support high renewable energy integration.

Economically, the EU's 2040 climate target assumes a 40% increase in real GDP by 2040 compared to 2015. The industrial sector's GVA is expected to grow by 26%, while the transport sector's GVA remains stable at 5%. The construction sector is projected to see a 27% increase in GVA by 2040. Energy system investments will rise to 1.2-1.5% of GDP over 2031-2050, supported by a 3% reduction in energy import dependency. The financial viability of the transition relies on affordable financing and maintaining global competitiveness through innovation and investment in low-carbon technologies.

Demographically, a slight population increase of 2.6 million is expected by 2040, along with a 13% decline in the working-age group by 2050, raising the dependency ratio to 76.1%. Retraining 500,000 people and €144 billion from the RRF and JTF will support labor market shifts. Urbanization will drive investments in sustainable infrastructure, with cities playing a key role in climate-friendly development. VKU member companies will have opportunities to provide grid-connected, centralized energy services.

Policy assumptions: Reaching the proposed 2040 target is contingent on implementing established 2030 policies and legislation. Policy assumptions include continued decarbonization trends post-2030, focusing on electrification, renewable energy, and energy efficiency. The ETS is expected to evolve, with potential adjustments to the LRF after 2030 to sustain GHG emissions reductions. Sector-specific policies include full deployment of CCS by 2040, zero CO_2 standards for heavy-duty vehicles, and sustainable aviation fuel mandates reaching 38% by 2040. The policy framework will support low-carbon technology adoption and regulatory measures across all sectors. The impact assessment emphasizes that the overall climate target must be translated into specific sectoral targets,

with the ETS, renewable energy targets, and energy efficiency targets remaining central.

3.2.7 Feasibility

The EU Commission's confidence in achieving the 90% GHG reduction target by 2040 is built on historical success, technological advancements, a strong policy framework, economic planning, and a commitment to innovation.

Historical Success and Progress: The EU has decoupled economic growth from GHG emissions, with a 67% increase in economic growth and a 32.5% reduction in GHG emissions from 1990 to 2022. Policies like the ETS and the "Fit-for-55" package, aiming for a 55% reduction by 2030, provide a solid foundation for the proposed 2040 target. Technological and Sectoral Transformations: The EU aims to generate 81%-87% of its electricity from renewable sources by 2040, with 70% renewable-powered heating. Plans include 50 GW of green hydrogen production and transitioning 85-90% of vehicles to electric, supported by over 3 million charging points. Energy efficiency will improve by doubling building renovation rates. Policy Framework: The European Climate Law, binding the EU to climate neutrality by 2050, is key to achieving the proposed 2040 target, supported by sectoral policies like the Energy Efficiency Directive. Economic Viability: Achieving the 90% target requires around €3 trillion in investments by 2040, primarily in clean energy and green technologies, expected to yield significant economic benefits. Legislative and Financial Support: The European Green Deal Investment Plan aims to mobilize €1 trillion by 2030, with total green investments exceeding €3 trillion by 2040. The EU Climate Law will ensure Member States remain on track. Global Leadership and Cooperation: The EU leads in global climate diplomacy, contributing over €28.5 billion to international climate finance in 2022, reinforcing its commitment to global climate action. Resilience and Adaptation: The EU Adaptation Strategy protects infrastructure, agriculture, and communities from climate impacts, ensuring progress toward the proposed 2040 target. Feasibility Assessment: The proposed 2040 targets require €3.5 to €4.5 trillion in investments from 2020 to 2040, sourced from public and private financing. Technologies for these targets are highly developed, with projected capacities of 2,525 GW for wind, 2,180 GW for solar, and 150 GW for hydrogen by 2040. CCS technologies are advancing toward widespread use. Sector-Specific Perspective: The power sector will decarbonize through renewable energy and grid modernization, with annual investments of about €85 billion from 2031-2050. SMEs: Energy costs for SMEs may initially rise by 15-20% but are expected to decline over time. Supportive policies will help SMEs navigate this transition.

3.2.8 Risks and challenges

The proposed 2040 climate target presents various risks and challenges, as identified and discussed in the impact assessment report, which need to be carefully assessed and mitigated to ensure successful outcomes.

Technological risks include potential delays in deploying critical technologies like CCS and advanced renewable energy. Dependence on breakthroughs in hard-to-abate sectors introduces uncertainty, requiring strong R&D support and contingency plans. Extensive reliance on bioenergy raises biodiversity concerns and land-use competition, stressing the need for sustainable practices. Economic risks involve substantial upfront investments that could strain vulnerable regions and sectors. Fluctuations in global energy markets and fossil fuel prices, though mitigated under the proposed 2040 target, remain economic vulnerabilities. Equitable cost distribution across socio-economic groups requires targeted support and inclusive policies. Environmental risks stem from large-scale renewable energy deployments, which could impact natural habitats. Increased demand for critical raw materials highlights the need for responsible sourcing and circular economy principles. Supply chain risks focus on securing essential materials like lithium and cobalt, which geopolitical issues could disrupt. Building resilient, diversified supply chains and investing in recycling are essential. Social risks include job losses in fossil fuel industries, requiring retraining programs, social safety nets, and economic diversification. Ensuring affordable energy access during the transition is crucial to prevent energy poverty and maintain public support for climate policies.

4 The current policy framework

To achieve the proposed 2040 target, the EU will rely on both making existing policy instruments more stringent and introducing new policies. Since the mandate of the EU's communication was not to lay out a concrete policy reform agenda for the decade between 2030 and 2040, this chapter will first focus on the existing policy framework with a focus on how it was reformed considering the 2030 targets. After showing the results of those policy actions through the analysis of historical and projected emission trends this report will discuss the possible policy implications of the proposed 2040 target.

Key findings in this chapter

The EU's policy framework, grounded in the European Climate Law and operationalized through the Fit for 55 package, aims to achieve a 55% GHG reduction by 2030 and climate neutrality by 2050. Fit for 55 is comprehensive, covering all sectors, and emphasizes expanding renewable energy, enhancing energy efficiency, and extending carbon pricing to previously uncovered sectors like maritime and aviation. The EU Emissions Trading System (ETS), particularly ETS 1, is central to reducing emissions from power, heat, and industrial sectors. While the ETS is uniformly implemented across member states, challenges arise in maintaining economic competitiveness during the transition, particularly as member states work to achieve consistent progress in sectors outside the ETS.

As the EU's largest emitter, Germany plays a crucial role in achieving climate goals. Its Energiewende has significantly expanded renewable energy, but the decarbonization of power stations including the coal phase out by 2038, presents challenges. In the transport and building sectors, policies are lagging, particularly in promoting electric vehicle (EV) adoption and retrofitting efforts. Industry decarbonization requires not only the Hydrogen and Carbon Management Strategy but also other key measures such as decarbonization programms, instruments to address high energy prices, access to raw materials, technology support, and infrastructure development. While Germany's policies generally align with EU climate goals, significant challenges remain in achieving full implementation.

4.1 European Union

The EU's climate policy framework is underpinned by primary law, and a series of regulations, directives, and strategies together form a comprehensive approach to climate action across the Union.

The objective to reduce GHG emissions has been set at the highest level of EU legislation. With the ratification of the Paris Agreement, the EU has established the goal to limit global temperature increase" well below 2°C above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5°C[8]" and to set corresponding emission reduction commitments. The commitment has subsequently been enshrined into the second highest level of EU legislation through the European Climate Law, and the EU is legally committed to becoming climate neutral by 2050.

The European Climate Law also established the 2030 interim target of reducing emissions by 55% compared to 1990 levels and mandated the setting of the 2040 climate target, which has been currently proposed to aim for 90% reduction compared to 1990 levels, in line with scientific advice (see 3). The European Green Deal is the main collection of initiatives to set the EU on the path to a green transition with a modern and competitive economy and achieve climate neutrality by 2050. Its main components are the European Climate

[8] Art 2 (1)a Paris Agreement

Law, the Fit for 55 package, and a series of strategies.[9]

Fit for 55 is the most important set of proposals to revise climate-, energy- and transport-related legislation[10] and implement new legislative initiatives[11] to align EU laws with the EU's climate goals.

Three key policy instruments exist in the current policy framework to achieve the 2030 target of reducing GHG emissions by at least 55% compared to 1990 levels: The EU ETS I & ETS II, the ESR, and the LULUCF regulation.

The ETS is a cornerstone of the EU's climate strategy. The system, as currently operative, also known as ETS I, covers electricity and heat generation, energy-intensive industry sectors, and commercial aviation within the EEA, totaling about 36% of the EU's total GHG emissions. The system includes an emission cap set to achieve a 61% reduction in covered GHG emissions by 2030 compared to 2005. The linear reduction factor is 4.3% per year from 2024 and 4.4% from 2028. ETS I will be expanded gradually to maritime transport between 2024 and 2026 and municipal waste incineration installations, starting in 2028 with an opt-out clause for member states until 2030. A parallel system - ETS II - has been designed to cover emissions from road transport, buildings, and additional sectors (mainly small industries not covered by the existing ETS), covering approximately 37% of the EU's total GHG emissions. ETS II aims for a 43% reduction in emissions from these sectors by 2030. The annual linear reduction factor is 5.1% from 2027 and 5.38% from 2028. The sectors covered by ETS II fall within the scope of the ESR. The introduction of the trading system is intended to create stronger economic incentives to reduce emissions in these sectors. At the same time, however, ETS II does not replace the overarching objectives of the ESR.

A variety of auxiliary policies exist around the EU ETS. The revenues from the ETS I auction of allowances have financed the Innovation Fund and the Modernization Fund. The Innovation Fund, one of the world's largest funding programs for innovative low-carbon technologies, supports projects in renewable energy, CCS, and green hydrogen. The fund is essential in driving the deployment of technologies necessary for meeting the 2040 climate targets. The fund focuses on scaling up technologies that can significantly reduce emissions in energy-intensive sectors. The Modernization Fund, established in 2018, supports the modernization of energy systems and energy efficiency in 13 lower-income EU Member States from 2021-2030 to help them achieve climate targets aligned with the European Green Deal. It focuses on investments in renewable energy, energy efficiency, energy storage, low-income household support, and just transitions in carbon-dependent regions.

CBAM, is designed to substitute the free allocation of allowances to prevent carbon leakage by applying a carbon price on imports of certain goods from outside the EU. This mechanism ensures the ETS price signal becomes biting for industries while at the same time preventing the relocation of emissions outside the geographic boundaries of the system. Financed by the ETS.

ESR is the second pillar of EU policy framework, as it covers sectors not included in the ETS I, such as transport, buildings, agriculture, and waste management. ESR has established annual emission reduction targets for each individual country. In case of under or over-achievement of those targets, countries could trade Annual Emission Allocations (AEAs). In the years since the establishment of the ESR system, only a limited number of transactions took place. However, this was mainly because most countries achieved their

[9] European industrial strategy, Circular economy action plan, Batteries and waste batteries, EU chemicals strategy for sustainability, EU strategy on adaptation to climate change, EU biodiversity strategy for 2030, Farm to fork strategy, EU forest strategy for 2030, complemented by measures in the context of clean energy and a just transition.

[10] EU ETS MSR, EU ETS Directive, EU ETS2 as regards to aviation, CO_2 emissions standards for cars and vans, Alternative fuels infrastructure regulation, Energy Performance of Buildings Directive, Effort-sharing Regulation, Gas and Hydrogen Directive, Gas and Hydrogen Regulation, Renewable Energy Directive, Energy Efficiency Directive, Energy Taxation Directive, LULUCF Regulation

[11] CBAM, Social Climate Fund, Notification on CORSIA, RefuelEU Aviation, FuelEU Maritime, Methane regulation

targets. With the revision of the targets following the increased ambition of reducing emissions by 55% by 2030, the annual emission allocations calculation is being revised, and a higher volume of transactions could be expected.

The EU Regulation on Land Use, Land Use Change, and Forestry (LULUCF Regulation) is the third pillar of the EU policy framework, as it tackles GHG emissions stemming from Land use, which are excluded in both ETS and ESR. The regulation sets up the EU's legal framework for managing emissions and removals in the land use sector for the 2021-2030 period, introducing the target of not generating net emissions while enhancing forest and soil sinks.

A plethora of other sector-specific policies support the decarbonization of the European continent. In the power sector, the Renewable Energy Directive (RED III) is a key policy that mandates EU member states to increase the share of renewable energy in their energy mix. Currently, RED III sets a binding target of achieving at least 40% of the EU's energy consumption from renewable sources by 2030. The directive is critical in reducing GHG emissions from the energy sector, which accounts for a significant portion of the EU's overall GHG emissions. By 2040, the EU aims to increase this share to approximately 70-75%, directly contributing to the 90% reduction in GHG emissions.

In the transport sector, the Performance Standards for Cars and Vans mandate a 37.5% reduction in GHG emissions from new cars and a 31% reduction for vans by 2030 compared to 2021 levels. By 2040, these standards are expected to drive significant reductions in transport emissions. The Alternative Fuels Infrastructure Regulation (AFIR) supports the deployment of sufficient charging and refueling infrastructure across the EU, which is necessary to meet the anticipated growth in electric vehicles (EVs) and reduce GHG emissions from the transport sector.

In the building sector, the Energy Performance of Buildings Directive (EPBD) sets the goal of achieving a zero-emission building stock by 2050, with intermediate milestones aiming for significant reductions by 2030, while the Renovation Wave Strategy targets the doubling of renovation rates across the EU, with a focus on deep renovations that enhance energy efficiency

To incentivize the decarbonization of industry various critical policies are currently in palce. At the higher level, the Net-Zero Industry Act and the European Industrial Strategy function as regulatory frameworks designed to accelerate the development and deployment of net-zero technologies across the EU, while maintaining EU international competitivness. The EU Industrial Carbon Management (ICM) Strategy focuses on advancing technologies for capturing, storing, transporting, and utilizing CO_2 emissions from industrial sources and removing CO_2 from the atmosphere. The strategy outlines plans to scale up CO_2 storage capacity to 50 million tonnes annually by 2030 and further integrate carbon management into the EU economy by 2040, a crucial step to curb carbon emissions in heavy industries. Alongside the ICM strategy, the EU CCS Directive governs the deployment of CCS technologies, particularly in industries where emissions are challenging to reduce through other means.

As a critical component for the full decarbonization of industry, the scale-up of hydrogen supply is fostered by the EU's Hydrogen and Gas Decarbonization Package. Adopted in May 2024, this package updates the EU's gas market rules and introduces a new regulatory framework for dedicated hydrogen infrastructure. These measures aim to facilitate the integration of renewable and low-carbon gases, including hydrogen, into the energy market, while ensuring energy security and affordability. The package also promotes the development of cross-border hydrogen infrastructure, the repurposing of existing natural gas infrastructure for hydrogen use, and better market access for renewable and low-carbon gases, all of which are crucial for scaling up the hydrogen supply and achieving the EU's climate neutrality goals by 2050.

The regulations layed down at the EU level directly influence member´s states policies and actions while interacting with their own initiatives. Next section will discuss EU policies that affect Germany and how German´s policies interact with the EU policy framework.

4.2 Germany

EU policies directly influence Members states policies. This section outlines Germany's current state of climate action.

Germany is a key player in the EU's efforts to achieve the 2040 climate targets, given its position as the largest economy and one of the largest GHG emitters in the EU. The following policies outline Germany's current state of climate action.

German Climate Protection Act (KSG): The German Climate Protection Act (KSG), last revised in 2024, commits Germany to reducing GHG emissions by at least 65% by 2030, by at least 88% by 2040 and achieving climate neutrality by 2045. The act sets legally binding sector-specific targets, ensuring that each sector contributes to the overall emissions reduction.

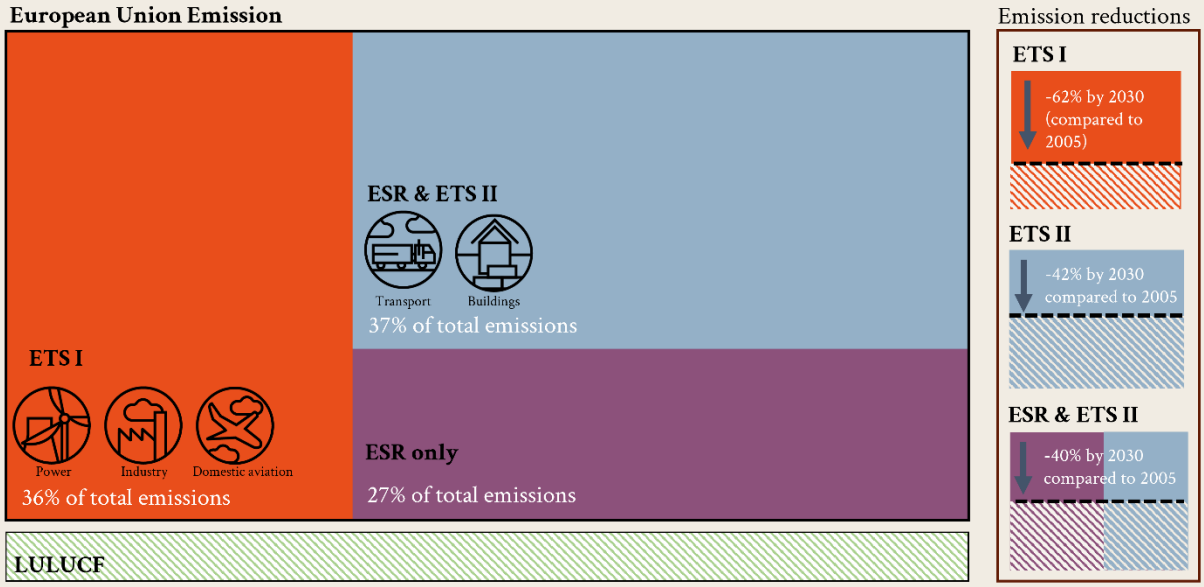
Energiewende and Renewable Energy Sources Act (EEG): Germany's Energiewende is the national strategy for transitioning to renewable energy. The Renewable Energy Sources Act (EEG), a key component of Energiewende, supports renewable energy production through feed-in tariffs and auction systems. Germany aims to achieve 80% of its electricity from renewable sources by 2030 which is vital for reducing emissions from the energy sector, one of the largest sources of GHGs in Germany.

Green Hydrogen Strategy: The National Hydrogen Strategy sets a target for Germany to develop at least 5 GW of electrolyzer capacity by 2030, with expectations to expand beyond 20 GW by 2040. This strategy focuses on producing green hydrogen, which is essential for decarbonizing sectors like heavy industry and transport that are difficult to electrify.

Heating and Building Policies: Germany's building sector, responsible for a significant share of GHG emissions, is regulated by the Building Energy Act (GEG), which mandates energy efficiency in buildings. The act supports the transition to zero-emission buildings by 2030. Additionally, the KfW Energy Efficiency Program and the Federal Funding for Efficient Buildings (BEG) provide financial incentives for energy-efficient renovations.

Transport Policies: Germany's transport sector, which is a major emitter, is addressed through several policies aligned with the EU's broader strategies. The Electromobility Law (EmoG) and the Charging Infrastructure Master Plan aim to expand the adoption of electric vehicles and the necessary infrastructure. The CO_2-differentiated toll (Lkw-Maut) incentivizes the use of low-emission vehicles by varying toll rates based on

Figure 2: Conceptual framework of the key EU instrument, ESR, ETS I and ETS II



CO_2 emissions. The abrupt end of the Umweltbonus on December 17, 2023, has left a gap in incentives for electric vehicle purchases, but with the auto industry in crisis, the Government is expected to announce new tax incentives through amortization rules—allowing 40% of the vehicle's cost to be written off in the first year—marking the first real incentive since the bonus ended[12].

CCS: Germany's CCS Act KSpG governs the deployment of CCStechnologies, particularly in heavy industries. CCS is critical for sectors like cement and steel, which are difficult to decarbonize through other means.

The Circular Economy Act, Kreislaufwirtschaftsgesetz (KrWG), establishes a comprehensive legal framework for waste management in Germany. It sets ambitious recycling targets, requiring at least 50% of municipal waste to be recycled by January 1, 2020, with increases to 55% by 2025, 60% by 2030, and 65% by 2035. For construction and demolition waste, the target is at least 70% by January 1, 2020. The law also promotes circular economy practices across industries to enhance resource efficiency and reduce waste. The Resource Efficiency Program (ProgRess III) supports these goals by promoting the efficient use of resources throughout the production and consumption cycles.

The Packaging Act specifically targets the reduction of plastic waste, mandating that by 2025, 90% of plastic bottles must be recycled, with overall packaging waste recycling rates required to reach 70%. These measures are essential in reducing emissions from the waste sector, which contributes to Germany's overall GHG emissions.

Germany has implemented a National Emissions Trading System (nEHS) for sectors not covered by the EU ETS, specifically targeting transport and buildings. Introduced in 2021, the nEHS applies a carbon price to fossil fuels used in various sectors, starting at €25 per tonne of CO_2. This price is set to increase annually, reaching €45 in 2024 and €55 in 2025. From 2026 onwards, carbon allowances will be auctioned within a price corridor of €55 to €65 per tonne.

Upcoming and Ongoing Legislative Processes

Germany continuously evolves its climate policy framework to align with EU directives. The ETS is implemented through the German Treibhausgas-Emissionshandelsgesetz (TEHG), which is currently being revised to align with the 2023 ETS directive as part of the EU's "Fit for 55" package[13]. This revision includes updates to ETS I and the introduction of ETS II, where the nEHS will be replaced by the new EU-wide system. The changes aim to ensure consistency in CO_2 pricing and integrate sectors not previously covered. The revision also includes rules for the CO_2 Border Adjustment Mechanism (CBAM). Relevant expected TEHG changes are described in more detail in chapter 8.

Other Upcoming processes include the expansion of the National Hydrogen Strategy, which aims to scale up hydrogen production capacity beyond the initial 5 GW target by 2030, with ambitions to exceed 20 GW by 2040. This expansion is vital for decarbonizing sectors that are difficult to electrify, such as heavy industry and long-haul transport. Additionally, Germany is likely to enhance support for energy-efficient renovations through increased funding and incentives under programs like the KfW Energy Efficiency Program and the Federal Funding for Efficient Buildings (BEG). The Carbon Management Strategy (CMS), though in the early stages with a framework approved, has no detailed measures yet. It is expected to play a key role in Germany's climate policy, focusing on managing carbon emissions. The Kohlendioxid-Speicherungsgesetz (KSpG), which governs carbon dioxide storage, is under revision. A draft in the Bundestag aims to update regulations for the permanent underground storage of CO_2, essential for reaching Germany's 2045 climate neutrality goals. These revisions will also improve legal clarity for CO_2 transport and storage projects.

[12] Automobilbranche: Steuervorteile für E-Autos von mehr als 600 Millionen Euro geplant (Handelsblatt, 3. September 2024)

[13] BMWK - TEHG-Novelle, available from: https://www.bmwk.de/Redaktion/DE/Artikel/Service/Gesetzesvorhaben/20240730-entwurf-anpassung-treibhausgas-emissionshandelsgesetz.html

5 Historical and projected emissions trends

This chapter provides an analysis of historical and projected GHG emissions in the context of European and national climate goals.

Key findings in this chapter

Since 1990, the EU has reduced its total GHG emissions by 32.5%, driven by policies focused on renewable energy and energy efficiency. While this marks some progress, challenges persist, especially in sectors like transport, which remains a significant source of emissions, and agriculture, where reductions are more complex due to inherent sectoral constraints.

Germany, France, Italy, Poland, and Spain made up 66.1% of the EU's GHG emissions in 2022. Germany remains the largest emitter, due to coal reliance and its substantial industrial base. While France benefits from nuclear energy, it faces challenges in transport and agriculture. Italy and Spain have successfully reduced energy sector emissions, but transport and industry still require significant improvements. Poland's dependency on coal continues to be a major hurdle, though efforts to transition to cleaner energy sources are underway.

The Netherlands, Romania, Belgium, Czech Republic, and Greece accounted for 16.7% of the EU's GHG emissions in 2022. The Netherlandshave made significant progress in energy efficiency and renewable energy adoption, though challenges persist in reducing emissions from agriculture and transport. Romania and the Czech Republic are making headway in phasing out coal, while Belgium continues to show steady improvements in energy efficiency. Greece, despite having lower overall emissions, faces obstacles due to its continued reliance on fossil fuels, though it has made substantial strides in expanding renewable energy capacity.

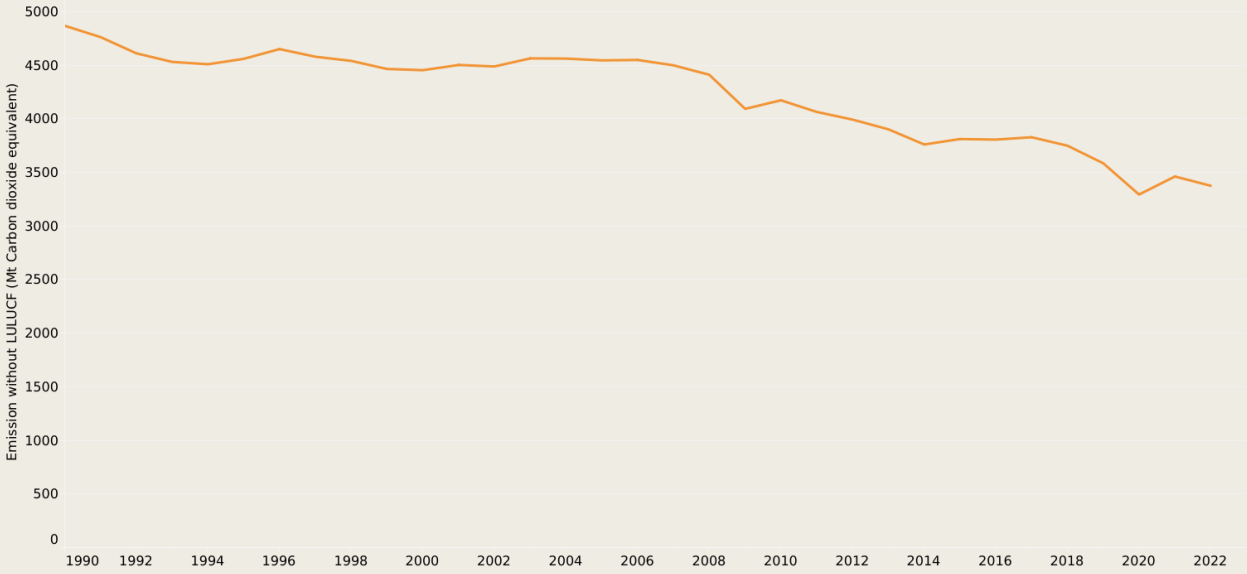
The remaining 17 countries contributed 17.2% of the EU's total GHG emissions in 2022. Nordic nations such as Denmark, Finland, and Sweden lead in the adoption of renewable energy, yet continue to face hurdles in reducing emissions from agriculture and transport. Baltic and Southern European countries, including Lithuania and Bulgaria are effectively balancing economic growth with GHG reductions by increasing renewable energy adoption, improving energy efficiency, and implementing policies to phase out coal.While these countries contribute less individually, their collective efforts remain essential to the success of the EU's overall climate strategy.

5.1 Historical emissions trends

The policy framework presented in the previous section, alongside with social and technological evolutions have driven GHG emissions over the past decades. Since 1990, the EU's collective efforts have led to a marked decline in total GHG emissions, albeit with variations among member states and sectors. From 1990 to 2022, the EU's emissions (excluding Land Use, Land-Use Change, and Forestry - LULUCF) have steadily decreased. This reduction is primarily driven by advancements in energy efficiency, the transition to renewable energy sources, and the implementation of environmental regulations. Despite the overall downward trend, certain years, notably the early 2000s and post-2008 financial and state debt crisis, witnessed temporary upticks in emissions due to economic fluctuations.

In recent years, the EU has successfully aligned its climate policies with its ambitious targets, resulting in a 3% decrease in net emissions in 2022 compared to 2021. This decrease follows a slight

Figure 3: Total GHG emission trend for EU



rebound in emissions in 2021 after the unprecedented reduction in 2020 due to the COVID-19 pandemic.

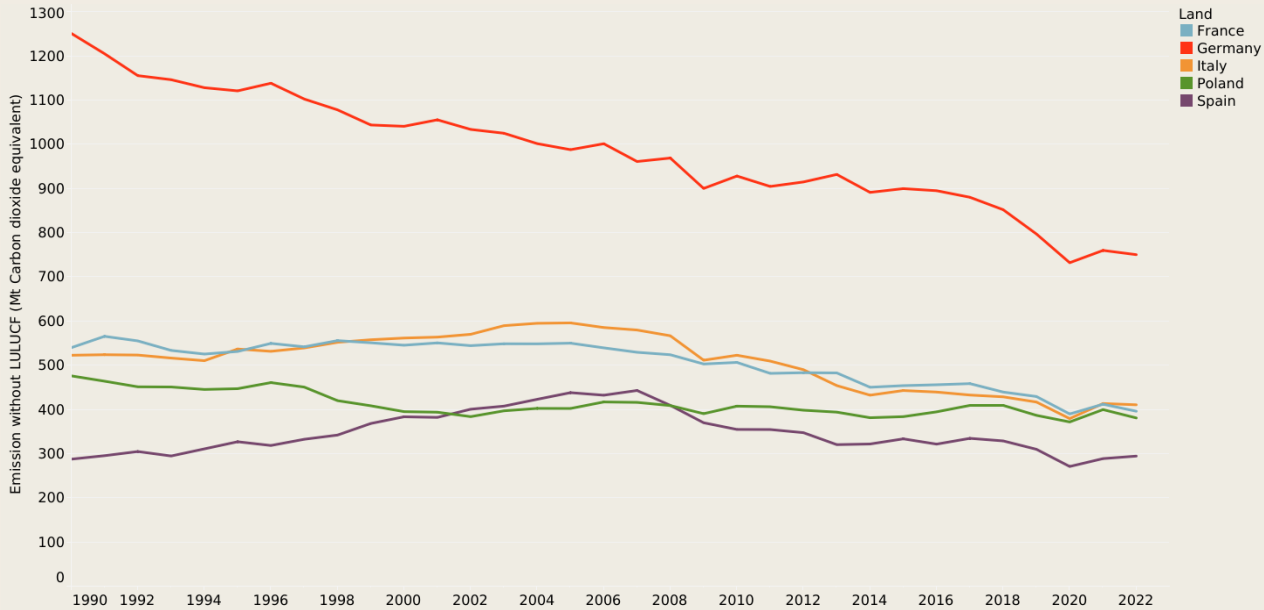
5.1.1 Top five emitters

To better understand the dynamics within the EU, member states are grouped into three clusters here, based on their GHG emissions levels: the top five emitters, the middle five emitters, and the remaining countries. This categorization highlights the diverse challenges and progress across the region.

The top five emitting countries within the EU – Germany, France, Italy, Poland, and Spain – accounted for 66.10% of the EU's total GHG emissions in 2022. These countries have historically been major industrial hubs, with significant contributions from energy, manufacturing, and transportation sectors.

Germany remains the largest emitter, with GHG emissions largely driven by its industrial base and energy sector. Despite being a leader in renewable energy, Germany's reliance on coal has posed

Figure 4: Total GHG emission trend for top-emitting member states



challenges in achieving better reductionsGHG emissions. Reducing emissions from road transport, residential fuel combustion, and agriculture remain a challenge.

France, while benefiting from a large nuclear energy sector, still faces GHG emissions challenges, particularly in transportation and agriculture.

Italy and **Spain** have made significant progress in recent years, particularly in reducing GHG emissions from energy generation, though transportation and industry remain key areas for further improvement.

Poland has struggled with GHG emissions reductions due to its heavy reliance on coal, although recent years have shown a growing commitment to energy transition.

Together, these five nations are crucial to the EU's overall climate objectives. Their progress, or lack thereof, significantly influences the Union's ability to meet its emissions targets.

5.1.2 Middle five emitters

The middle cluster of emitters includes the Netherlands, Romania, Belgium, Czech Republic, and Greece, which accounted for 16.67% of EU's total GHG emissions in 2022. These countries represent a mix of industrial and service-based economies with varied energy portfolios.

The Netherlands has made strides in reducing emissions through energy efficiency and a strong push towards renewable energy, though challenges remain in agriculture and transportation.

Romania and **the Czech Republic** face similar challenges due to their industrial bases, but both have made notable progress in transitioning away from coal.

Belgium has shown steady improvements in GHG emissions reduction, particularly through advancements in energy efficiency.

Greece while lower in total GHG emissions compared to the top emitters faces unique challenges due to its reliance on fossil fuels for energy and transportation, though recent efforts to expand renewable energy are promising.

5.1.3 Remaining EU member states

The remaining 17 EU countries accounted for 17.23% of EU's total GHG emissions in 2022 but play crucial roles in achieving regional targets. These countries often have smaller industrial bases and lower overall GHG emissions but face unique challenges such as energy security, economic development, and geographic vulnerabilities.

Figure 5: Total GHG emission trend for middle-emitting member states

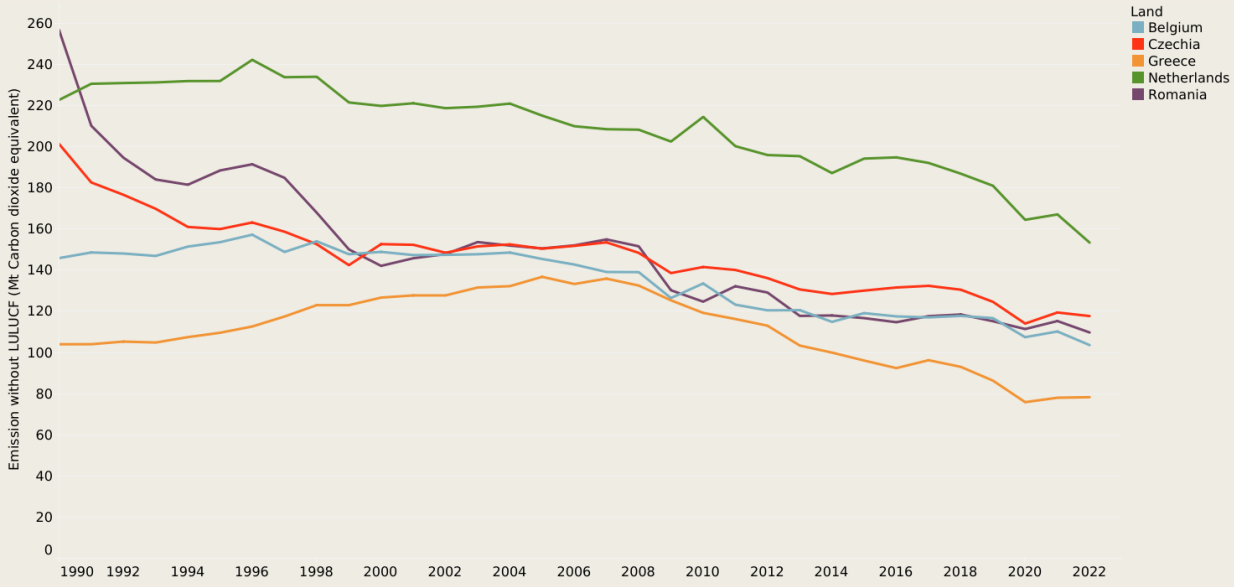
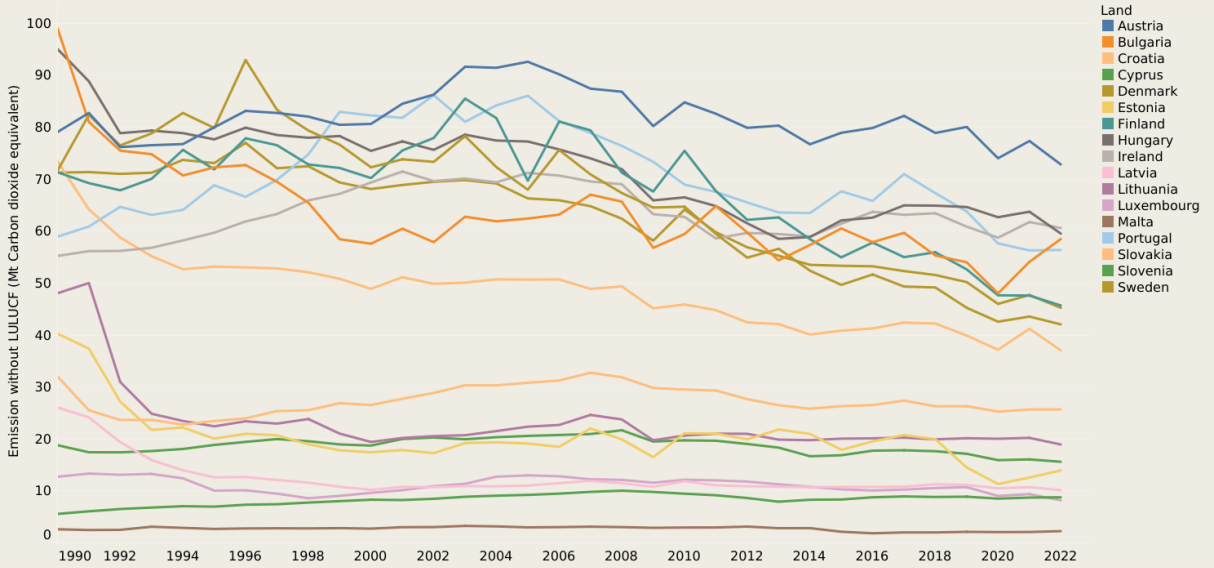


Figure 6: Total GHG emission trend for all other member states



Nordic countries like Denmark, Finland, and Sweden have led the way in renewable energy adoption but must address GHG emissions in transport and agriculture. Sweden, in particular, has made significant progress in reducing overall emissions, especially in the last decade. Baltic states such as Lithuania, Latvia and Estonia, despite smaller economies, have focused on improving energy efficiency and reducing dependence on fossil fuels.

Southern and Eastern European countries, including Greece, Hungary, and Bulgaria, are at various stages of transition, often balancing economic growth with the need for GHG emissions reductions.

These nations, while individually contributing less to total EU GHG emissions, collectively represent a significant component of the EU's climate strategy. Their continued progress is essential for the EU to meet its long-term climate goals.

The EU has made substantial progress in reducing GHG emissions over the past decades, driven by coordinated policy efforts and advancements in renewable energy. However, the diverse GHG emissions profiles among member states underscore the importance of tailored strategies that consider the unique challenges and opportunities within each country.

6 Progress towards climate targets

This chapter focuses on future projections, dividing targets into two main categories based on the scope of the main EU legislation. On the one hand, ETS I sectors with an EU-wide 62% reduction target; on the other hand, the ESR sectors with an overall 40% reduction target, broken down to country-specific targets. Given the overlap between ESR and the newly designed ETS II this section will also discuss their interactions. Targets and projections for the LULUCF regulation are outside the scope of this report.

Key findings in this chapter

By 2030, energy and industry emissions (ETS I sectors) are projected to reduce by 61% compared to 2005 levels. The key driver of reductions is the rapid shift toward renewable energy, aided by the EU's robust carbon pricing system and policy incentives.

The sectors under the ESR and ETS II, including road transport, buildings, and agriculture, are projected to reduce emissions by 43% by 2030. However, progress in road transport and buildings remains slower, hindered by the delayed adoption of electric vehicles, insufficient retrofitting of buildings for energy efficiency, and challenges in implementing primary energy reductions through heat pumps and district heating.

Top emitters such as Germany, France, and Italy are projected to achieve the most significant reductions but still face challenges in decarbonizing industrial processes and other hard-to-abate sectors. Middle emitters, such as the Netherlands and Belgium, are on track to meet their targets due to strong renewable energy policies. Countries with lower emissions profiles, including Nordic member states, are progressing steadily, especially in transport, but still struggle with reducing emissions in agriculture.

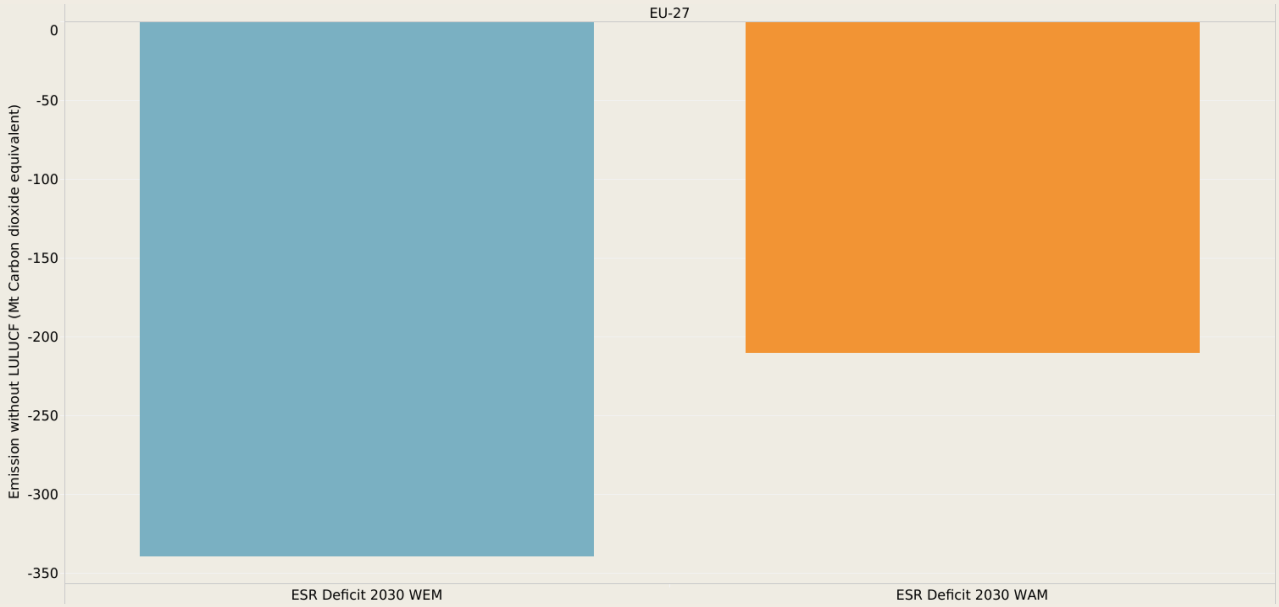
Several member states, including Germany and Poland, may face emission deficits by 2030, while others like Sweden and Denmark are expected to generate surpluses. These disparities will likely lead to an increase in emissions trading within the EU to balance deficits and surpluses across member states.

By 2040, the energy sector will likely achieve a 70-75% reduction in emissions compared to 2005 levels, primarily through the expansion of renewables (up to 87% of electricity). Industry sectors will decarbonize more slowly, achieving a 50-65% reduction depending on the deployment of CCS and green hydrogen technologies.

By 2040, transport, agriculture, and buildings are projected to reduce emissions by 40-60%, with transport electrification expected to reach 75%. Agriculture and buildings will require further policy measures and technological advancements. Germany will lead emission reductions in energy and industry, while middle emitters benefit from renewable energy growth. Countries with a low emissions profile will need to focus on reducing harder-to-abate emissions in agriculture and transport. In non-ETS sectors, top-emitting countries will face challenges with transport electrification and building efficiency, while middle and low emitting countries will struggle to meet ESR targets.

Figure 7: ESR GHG emission deficit and surplus 2030 for EU

*** The total EU deficit and surplus considers the ESR projections from the EEA GHG projections 2023



6.1 Projections for 2030

6.1.1 ETS I sectors

Progress towards meeting the 2030 targets for the EU has been significant but is currently insufficient to meet the targets set forth. As of 2023, the EU ETS I has achieved a 47% reduction[14] in GHG emissions since 2005, contributing substantially to EU-wide climate targets and proving to be an effective instrument for decarbonization. The emission reduction target under the scope of the ETS I is a 62% reduction compared to 2005 levels by 2030. In terms of policy leverage, this reduction is meant to be achieved with a progressive tightening of the cap following a linear reduction pathway of 4.3% per year between 2024 and 2027, and 4.4% from 2028. The reductions are coupled with the reform of the Market Stability Reserve (MSR), the gradual phase-out of free allowances, and the parallel introduction of the CBAM. Both the ESABCC progress report on climate neutrality[15] and EU Climate Progress Report 2023 stress the need for faster emissions reductions to meet 2030 targets. The ESABCC notes that the EU must more than double its current reduction rate, as progress under ETS I is insufficient. Similarly, the Climate Progress Report[16] highlights that while GHG emissions dropped by 3% in 2022, reductions in key sectors like buildings, transport, and agriculture remain inadequate.

Progress at the Member State level towards the 2030 targets has been uneven and generally falls short of the 2030 target. The ESABCC report states that with existing measures in place, GHG emissions under ETS I are projected to decrease by 55% by 2030. Even with additional measures, the reduction is expected to peak at 59%, still falling short of the revised target of a 62% reduction by 2030. To meet the target, annual reductions of 65 Mt CO_2 eq are required, yet the current average is only 46 Mt CO_2 eq per year, indicating a significant gap that needs to be addressed. The report

[14] Record reduction of 2023 ETS emissions due largely to boost in renewable energy - European Commission (europa.eu)

[15] European Scientific Advisory Board on Climate Change. (2024). *Towards EU climate neutrality: Progress, policy gaps and opportunities – Assessment report 2024* (TH-02-23-251-EN-C). Publications Office of the European Union. https://doi.org/10.2800/73564

[16] European Commission. (2023). *Climate Action Progress Report 2023: Accelerating towards a green and prosperous future* (COM/2023/653 final). Retrieved from https://managenergy.ec.europa.eu/publications/climate-action-progress-report_en

highlights a critical issue: while ETS I is designed to ensure that the emissions cap is met, the sum of Member States' projected emissions suggests that current and even additional measures are insufficient to reach the 2030 target. Although the ETS enforces a cap, this discrepancy underscores the need for collective ambition, stresses the urgency for stronger national policies and more effective implementation to align with the 2030 targets and to ensure the ETS I cap is effectively met.[17]

6.1.2 EU ESR and ETS II sectors

The EU is currently projected to miss its 2030 GHG emission reduction target under the ESR, which is set at a 40% reduction compared to 2005 levels, by approximately 13.49 percentage points with existing measures, resulting in a projected shortfall of -339.60 Mt CO_2 eq. With additional measures, this shortfall is expected to decrease to about 8.36 percentage points, reducing the deficit to -210.53 Mt CO_2 eq (see figure 8).

The impact assessment report considers and integrates ETS II into the EU's broader climate strategy, covering sectors buildings and road transport that were not included in the original ETS, as well as some energy, manufacturing, and construction industries. This extension of carbon pricing is designed to incentivize emissions reductions across these additional sectors and is a key component in the scenarios considered for meeting the 2030 climate targets. ETS II interacts closely with the ESR, which governs sectors outside the ETS, particularly agriculture, waste, buildings and the road transport sector. While ETS II aims to drive emissions reductions through market-based mechanisms, the ESR sets binding national targets for emissions reductions. The impact assessment highlights that ETS II's impact is gradual, particularly in sectors like buildings and road transport, where the adoption of low-carbon technologies is progressing more slowly than necessary. This gradual pace of transition reduces the immediate effectiveness of ETS II in delivering substantial emission reductions by 2030. While ETS II plays an important role in reducing emissions, it does not fully address the projected shortfall because these sectors are slower to decarbonize. The shortfall for 2030 remains because additional measures and faster technological adoption are needed to meet the 2030 targets. Furthermore, the complementary nature of ETS II and the ESR is critical.

The Climate Action Progress Report 2023 also discusses the introduction of ETS II. The establishment of the Social Climate Fund alongside ETS II is also intended to mitigate the socioeconomic impacts of this expanded carbon pricing, ensuring that vulnerable households, micro-enterprises, and transport users receive support during the transition.

6.1.3 Top, middle, and low emitters

The 2030 target is set to reduce GHG emissions by 40% (1,510.20 Mt CO_2 eq) compared to 2005 values. Collectively the top 5 emitters are projected to have a total deficit of 221.32 Mt CO_2 eq (65.17%) under WEM scenario, and 210.53 Mt CO_2 eq (75%) under WAM scenario, from the total 2030 EU deficit.

The top five emitters—Germany (2024)[18], France, Italy, Poland, and Spain—are all projected to miss their 2030 ESR targets. Under the WEM scenario, Germany (2024)[19] is expected to miss its target by 10.14 percentage points, France by 13.99 percentage points, Italy by 15.39 percentage points, and Poland by 21.90 percentage points. Spain will fall short by 8.71 percentage points under WEM, but

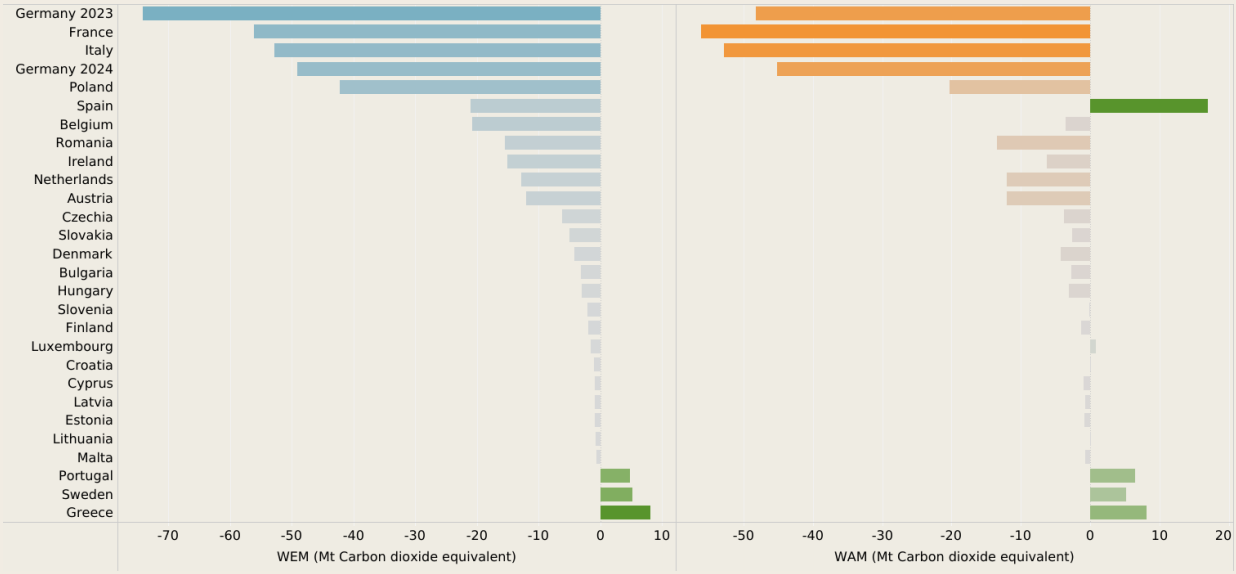
[17] The 55% reduction projection for ETS I by 2030 is not aligned with the revised 62% target, indicating a gap in national implementation and delivery rather than a failure of the ETS mechanism itself.

[18] Harthan, R. O., Förster, H., Borkowski, K., Braungardt, S., Bürger, V., & et al. (2024). *Treibhausgas-Projektionen für Deutschland: Technischer Anhang der Treibhausgas-Projektionen 2024 für Deutschland (Projektionsbericht 2024)*. Umweltbundesamt. https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/projektionen_technischer_anhang_0.pdf

[19] While this section of the text presents the German projection numbers for 2024, the graph also illustrates the German projection numbers for 2023. It demonstrates a difference of approximately 25 Mt CO_2 eq (with 2024 emissions projections being lower) in the WEM scenario, and around 3 Mt CO_2 eq in the WAM scenario (with 2024 GHG emissions projections also being lower). This represents a significant difference and suggests that other EU member states may experience a similar shift in their emissions projections for 2024. Therefore, it would be prudent to consider these new numbers and integrate them into such analyses once they become available for all member states.

Figure 8: ESR GHG emission deficit and surplus 2030 for all EU member states

*** The deficit and surplus considers the ESR targets and projections for 2030 from the EEA GHG projections 2023 for all member states and additionally the updated numbers from the German projections 2024. Germany has two rows , Germany 2023 and Germany 2024



under the WAM scenario, Spain is projected to achieve a surplus of 7.01 percentage points.

The middle emitters—Belgium, Czech Republic, Greece, Netherlands, and Romania—are projected to miss their 2030 ESR targets. Under the WEM scenario, Belgium is expected to miss its target by 25.42 percentage points, Czech Republic by 9.57 percentage points, and Netherlands by 10.03 percentage points. Greece, however, is projected to exceed its target by 12.82 percentage points, while Romania will miss its target by 19.83 percentage points. Under the WAM scenario, Belgium has a deficit of 4.37 percentage points, while Romania slightly improves to a 17.18 percentage point shortfall.

For the remaining 17 countries, most are projected to miss their 2030 ESR targets under the WEM scenario, though a few show noteworthy results. For example, Ireland is expected to miss by a significant 31.75 percentage points, while Malta stands out with the largest gap of 68.32 percentage points. On the other hand, Sweden and Portugal are projected to exceed their targets, with Sweden surpassing by 11.89 percentage points and Portugal by 9.78 percentage points. Under the WAM scenario, Portugal improves further, achieving a surplus of 13.30 percentage points, while Slovenia reduces its shortfall drastically to just 1.49 percentage points.

6.1.4 Deficit and surplus

Based on how far each country is from their 2030 ESR targets (Figure 10), we can anticipate which nations are likely to be buyers, sellers, or fall into a middle category regarding emission allowances under the ESR (so called AEAs). Note: this estimate is only an approximation, as it does not yet take into account the additional economic incentives from ETS II.

Likely Buyers: Countries that are projected to miss their 2030 targets by substantial margins under both the WEM and WAM scenarios are expected to be net buyers of emission allowances. Germany (2024), with a shortfall of 9.32 percentage points under the WAM scenario, is a prime example. Despite ambitious targets, the country struggles to meet its goals, indicating it will likely need to purchase additional emission credits. Belgium also stands out, missing its target by 25.42 percentage points under WEM and still facing a 4.37 percentage point deficit under WAM. Poland, with a 21.90 percentage point shortfall under WEM, will similarly need to rely on purchasing

credits. These countries will need to compensate for their inability to meet their targets by buying credits from countries with surpluses.

Likely Sellers: Some countries are projected to exceed their 2030 targets and may become net sellers of emission allowances. Sweden, with a surplus of 11.89 percentage points under both WEM and WAM scenarios, is in a position to sell emissions credits. Similarly, Portugal shows a surplus under the WAM scenario of 13.30 percentage points, suggesting that it too could be a seller. Greece is also positioned as a seller, exceeding its target by 12.82 percentage points under WEM and maintaining that position under WAM. These countries could capitalize on their overachievement by selling credits to nations falling short.

On the Brink (Middle Ground): A few countries are close to meeting their targets and could go either way—becoming net buyers or sellers depending on the final outcomes of their emissions policies. Czechia, for instance, misses its target by 9.57 percentage points under WEM but improves to a shortfall of 5.81 percentage points under WAM. Netherlands shows similar potential, with a gap of 10.03 percentage points under WEM and 9.35 percentage points under WAM. Slovenia also exhibits significant progress, reducing its shortfall from 18.08 percentage points under WEM to just 1.49 percentage points under WAM, positioning it on the brink. These countries may need to purchase allowances or could potentially meet their targets with further improvements, putting them in a fluctuating position in the emissions market.

Overall, ETS II will drive a market for emissions credits, with countries like Germany and Poland likely to be buyers, while Sweden and Portugal could be sellers, and a range of countries, like Czech Republic and Slovenia, find themselves in a middle zone, where their final status depends on further policy measures and emissions reductions.

6.2 Projections for 2040

This chapter analyzes projected GHG emission reductions after 2030 considering the proposed 2040 target of a 90% net GHG emissions reduction relative to 1990 levels. The analysis addresses two major regulatory frameworks: ETS I, which covers emissions from electricity and heat generation, industrial manufacturing, as well as aviation and maritime transport, and ESR, which regulates emissions from sectors like agriculture, transport, residential and commercial[20] buildings, manufacturing and construction[21], and waste[22] management. Emissions data are normalized to 2005 levels to align with the onset of significant EU-wide climate policies. This provides a consistent baseline to assess progress. The data from 2023 to 2040 are projections under two scenarios: WEM, reflecting current policies, and WAM, considering potential additional actions. This chapter examines the EU's overall progress and the emissions performance of the top five emitters: Germany, France, Italy, Spain, and Poland.

6.2.1 EU- ETS I sectors

The energy and industry sectors, which are mainly covered by ETS I, have made progress in reducing emissions since 2005. The energy sector has seen the most substantial progress, benefiting from the EU's robust carbon pricing mechanism and the gradual transition from fossil to renewable energy sources. Between 2005 and 2022, historical data shows a sharp reduction in emissions, with energy industries achieving approximately a 40% decrease. This progress is driven largely by the rapid deployment of renewable energy technologies and the decline in coal-fired power plants, especially after 2015. Looking forward, projections under the WEM scenario show that emissions from the energy sector could fall by 65-70% by 2040. The WAM scenario is even more ambitious, forecasting emissions reductions of up to 75%, driven by accelerated coal phase-out plans and increased investment in renewable energy infrastructure. The

[20] Emissions from residential and commercial buildings include those from heating, cooling, lighting, and the use of appliances in homes, offices, and other facilities.

[21] Emissions from the manufacturing and construction sectors include energy use and material production in industries like steel, cement, chemicals, and activities related to building, demolition, and infrastructure development.

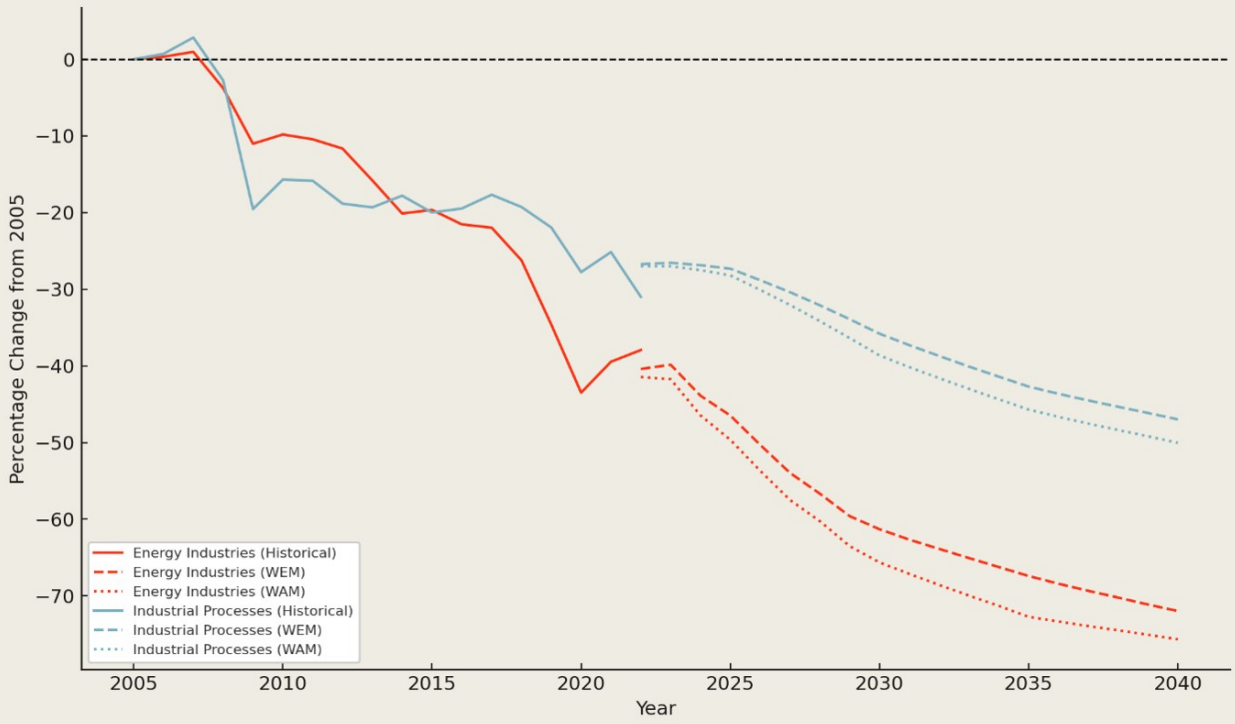
[22] Waste sector emissions come from the treatment and disposal of waste, including landfills, incineration, composting, and wastewater management.

steepness of the projected reductions is most pronounced between 2023 and 2030, as countries ramp up efforts to decarbonize their energy sectors. After 2030, the pace of emissions reductions slows slightly, reflecting the fact that many of the coal phase-outs and renewable energy expansions will have been completed by then. Two aspects are noteworthy here: By 2040, the energy sector will be one of the largest contributors to the EU's overall emissions reductions. Nevertheless, the reductions are insufficient because the number of available allowances in ETS I, under which the sector is regulated, has already reached zero before 2040.

In contrast, industry[23] faces more challenges in decarbonization. While historical data indicates a steady reduction of emissions—about 30% between 2005 and 2022—the pace has been slower than that of energy. This is primarily due to the inherent difficulties in decarbonizing energy-intensive industries such as steel, cement, and chemicals, which rely on high-temperature processes and have high process emissions. Despite these challenges, projections for 2040 suggest that emissions from the sector could decrease by 50-55% under WEM, with the potential to reach 60-65% under WAM. The key driver of future reductions will be the adoption of advanced technologies, including CCS and green hydrogen, which have the potential to significantly cut emissions in hard-to-abate sectors. Remarkably, the most significant GHG reductions are expected up to 2030, while

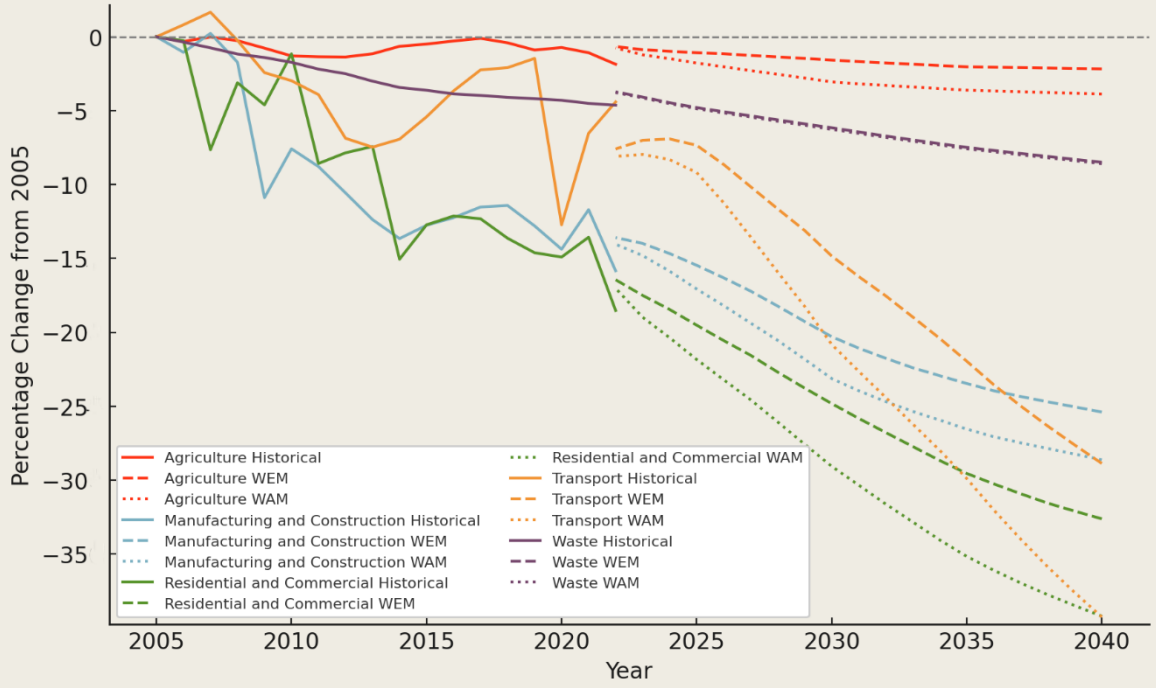
Figure 9: Historical and projected emissions reductions in EU ETS I sectors (2005-2040)

*** In Figures 9-17, the apparent jump between historical emissions data and the WEM and WAM projections for 2022 reflects the transition from observed trends to model-based forecasts, which often incorporate updated assumptions and policy measures that may not align perfectly with the historical trajectory. This can lead to visible discontinuities at the transition point between the two data sets.



[23] Industry here means industrial processes according to the 2006 IPCC Guidelines. The largest part of the sector is covered by ETS I.

Figure 10: Historical and projected emissions reductions in EU ESR sectors (2005-2040)



the rate of reduction is projected to slow down between 2031 and 2040. However, beyond 2030, the rate of emissions decline is likely to slow as the remaining emissions come from sectors that are harder to decarbonize. Overall, while industry lags behind energy, both sectors are projected to make substantial contributions toward the EU's 2040 climate target.

6.2.2 EU-ESR sectors

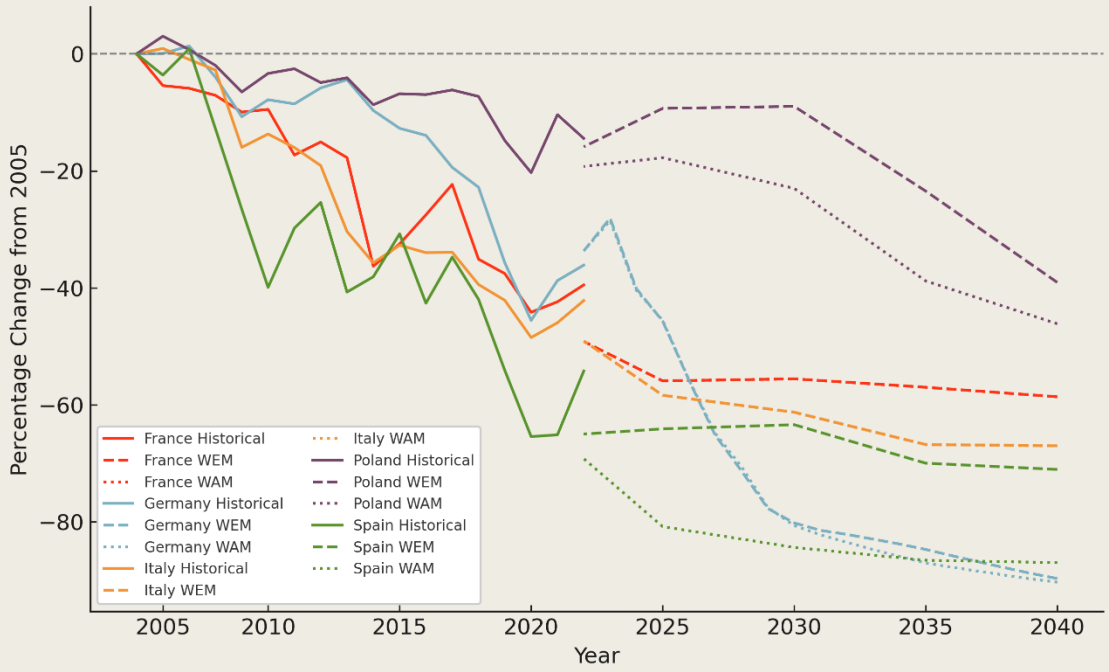
ESR sectors—which include agriculture, transport, residential and commercial buildings, manufacturing and construction, and waste management—present a more varied picture of progress.

Among these sectors, residential and commercial buildings have seen the most significant emissions reductions since 2005, thanks to the widespread adoption of energy-efficient technologies, retrofitting of older buildings, and renewable heating systems. By 2022, emissions had fallen by ca. 25-30%. Projections indicate that by 2040, emissions from this sector will decrease by 65-70% under WEM and by 70-75% under WAM. The steepest reductions are expected between 2023 and 2030, with a more gradual decline through to 2040 as the remaining emissions become harder to eliminate.

The transport sector remains one of the most challenging sectors to decarbonize. Although there has been progress in electrification, especially in passenger vehicles, the sector still relies heavily on fossil fuels, particularly for road freight and aviation. Between 2005 and 2022, transport emissions decreased by approximately 10-15%, with further reductions projected to reach 40-50% by 2040 under WEM, and 55-60% under WAM. The slower progress in this sector is due to the high cost of electric passenger cars, insufficient charging infrastructure, and the complexity of transitioning to electric vehicles for heavy-duty transport. Aviation lacks suitable mitigation options to achieve climate neutrality by 2050. The most substantial reductions in transport emissions are expected between 2023 and 2030, as the adoption of EVs accelerates, but more effective policies and technological innovations will be needed to achieve deeper cuts in the following decade.

The agriculture sector has seen the least progress in reducing emissions, with only modest reductions of 5% achieved by 2022. The sector's reliance

Figure 11: Top 5 emitters – emissions in energy industries (2005-2040)



on livestock farming and nitrogen-based fertilizers, both of which are major sources of methane and nitrous oxide emissions, makes it difficult to decarbonize. Projections for 2040 indicate a 20-30% reduction under WEM and 35-40% under WAM, driven by the adoption of more sustainable farming practices and advancements in agricultural technologies. The steepness of emissions reductions in agriculture is expected to be gradual throughout the 2023-2040 period, reflecting the sector's challenges in achieving deep decarbonization.

In waste management, emissions reductions have been more encouraging, with a 30-35% decrease observed between 2005 and 2022. The sector has benefited from strong recycling programs, waste-to-energy initiatives, and reductions in landfill use, particularly in countries with advanced waste processing infrastructure. By 2040, waste emissions are projected to fall by 50-60% under WEM and 60-65% under WAM. The steepest declines are anticipated between 2023 and 2030, with further reductions coming from continued waste processing improvements and landfill waste reductions in the subsequent decade.

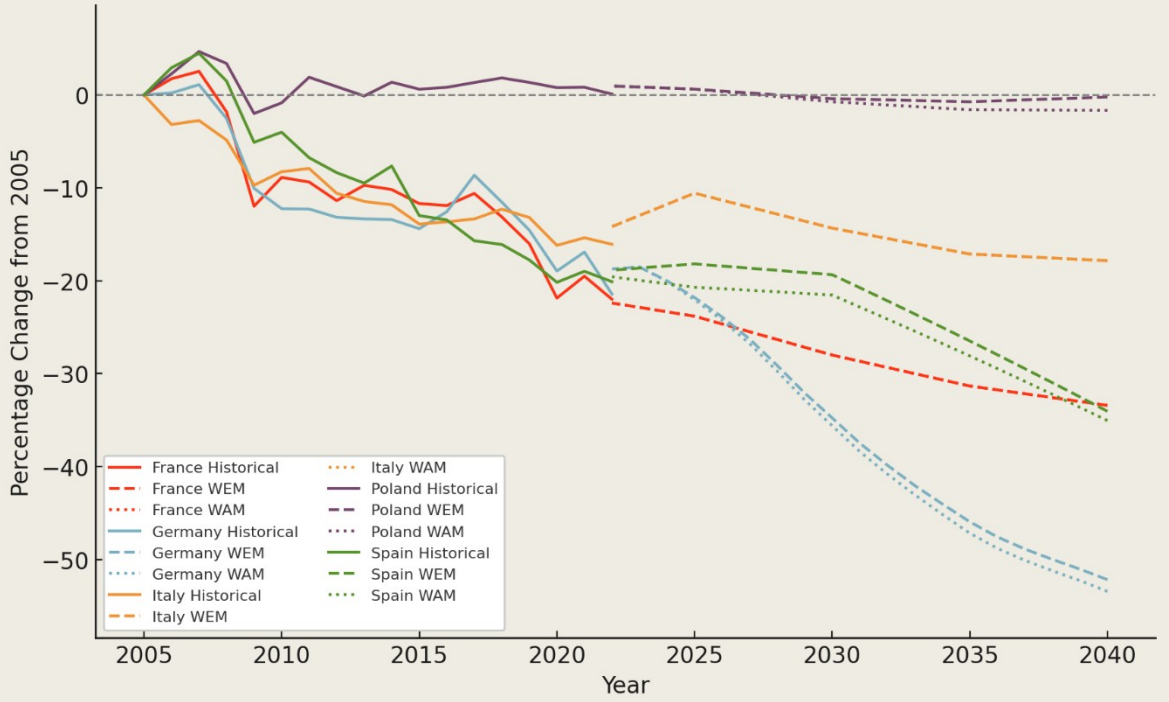
Manufacturing and construction emissions have also shown steady progress, with emissions reductions of approximately 15-20% by 2022. Projections for 2040 indicate a 40-50% decrease under WEM, with reductions reaching 50-60% under WAM. The steepest reductions are projected between 2023 and 2030, with slower progress expected through to 2040 as the sector moves toward decarbonizing its most energy-intensive processes.

6.2.3 Top five emitters – ETS I sectors

In Germany, the energy industries sector has shown remarkable progress, largely driven by its renewable energy expansion under the Energiewende strategy. By 2040, emissions in Germany's energy industries are projected to decrease by 70-75% under the WAM scenario and by 65-70% under WEM. Germany has been a leader in the deployment of wind and solar energy, which has contributed to this steep decline in emissions, although the phase-out of coal presents some challenges for energy grid stability.

In contrast, Germany's industrial processes sector has struggled more with decarbonization. By 2040, emissions from industries such as steel, cement,

Figure 12: Top 5 emitters – emissions in industrial processes (2005-2040)



and chemicals are projected to fall by 50-55% under WEM and by 60-65% under WAM. These reductions depend heavily on emerging solutions like CCS and green hydrogen.

In France, energy industries have also made strong progress in reducing emissions, primarily due to the country's reliance on nuclear energy, which has kept emissions relatively low compared to other EU countries. By 2040, emissions from energy industries are expected to decrease by 70-80% under WAM, reflecting the continued investment in nuclear and renewable energy sources. However, the industrial processes sector in France faces similar challenges to those in Germany, with projected emissions reductions of 50-60% by 2040 under WAM. France's industrial sector, particularly in areas such as steel and chemicals, remains reliant on carbon-intensive processes, and further reductions will require the adoption of technologies like CCS and green hydrogen.

Italy has made moderate progress in reducing emissions from energy industries, driven primarily by an increase in solar and renewable energy deployment. By 2040, emissions from energy industries are projected to decrease by 60-70% under WAM. However, Italy's industrial processes sector is expected to see slower progress, with emissions reductions of 50-60% by 2040. Much of this progress will depend on the ability to transition to low-carbon technologies and reduce reliance on natural gas, which continues to play a significant role in Italy's energy mix.

In Poland, the energy industries sector remains heavily reliant on coal, leading to slower progress in emissions reductions compared to other EU countries. Projections show a 50-55% reduction under WEM and a 60-65% reduction under WAM by 2040. However, recent investments in wind and solar energy are expected to accelerate the country's transition away from coal, particularly in the second half of the period leading to 2040. In Poland's industrial processes sector, emissions reductions are expected to reach 50-60% by 2040 under WAM, but further progress will require significant investment in cleaner industrial technologies and processes.

Spain has made significant strides in reducing emissions from energy industries, particularly through investments in wind and solar energy. By 2040, emissions from energy industries are

expected to decrease by 70-75% under WAM, with continued focus on renewable energy development. In the industrial processes sector, Spain faces similar challenges to its peers, with projected emissions reductions of 50-60% by 2040. The adoption of low-carbon technologies will be crucial for meeting Spain's climate goals, especially in industries such as steel and cement.

6.2.4 Top five emitters – ESR sectors

In Germany, the agriculture sector has faced significant challenges in reducing emissions. By 2022, emissions had only decreased by 5-7%, primarily due to the difficulties associated with reducing methane emissions from livestock farming and nitrous oxide emissions from fertilizers. By 2040, emissions reductions are projected to reach 20-25% under WEM and 30-35% under WAM. While Germany has been promoting sustainable farming practices, further progress will depend on the development of new agricultural technologies and practices, such as the adoption of low-emission fertilizers and feed additives to reduce methane emissions. In France, Italy, Spain, and Poland, agriculture has similarly struggled to reduce emissions, with reductions of only 5-15% by 2022. These countries face comparable challenges in livestock farming and fertilizer use, making it difficult to achieve deeper emissions cuts. Projections under the WAM scenario suggest some improvement, with emissions reductions of 30-40% by 2040. However, without significant breakthroughs in agricultural technologies, these sectors are unlikely to meet the EU's proposed 2040 target for emissions reductions.

The transport sector in Germany has made slow progress, achieving only a 10-15% reduction in emissions by 2022. By 2040, emissions are projected to decrease by 40-50% under WEM and 55-60% under WAM. While Germany has made strides in the adoption of electric vehicles (EVs), the sector still faces challenges in decarbonizing heavy-duty transport and aviation. Similar trends can be seen in France, Italy, Spain, and Poland, where transport emissions remain a significant challenge. By 2040, emissions reductions are expected to reach 40-60%, depending on the scenario and country, but all five emitters will need to accelerate the transition to EVs, expand EV infrastructure, and invest in alternative fuels for aviation and freight transport to achieve more substantial reductions.

Figure 13: Top 5 emitters – emissions in agriculture (2005-2040)

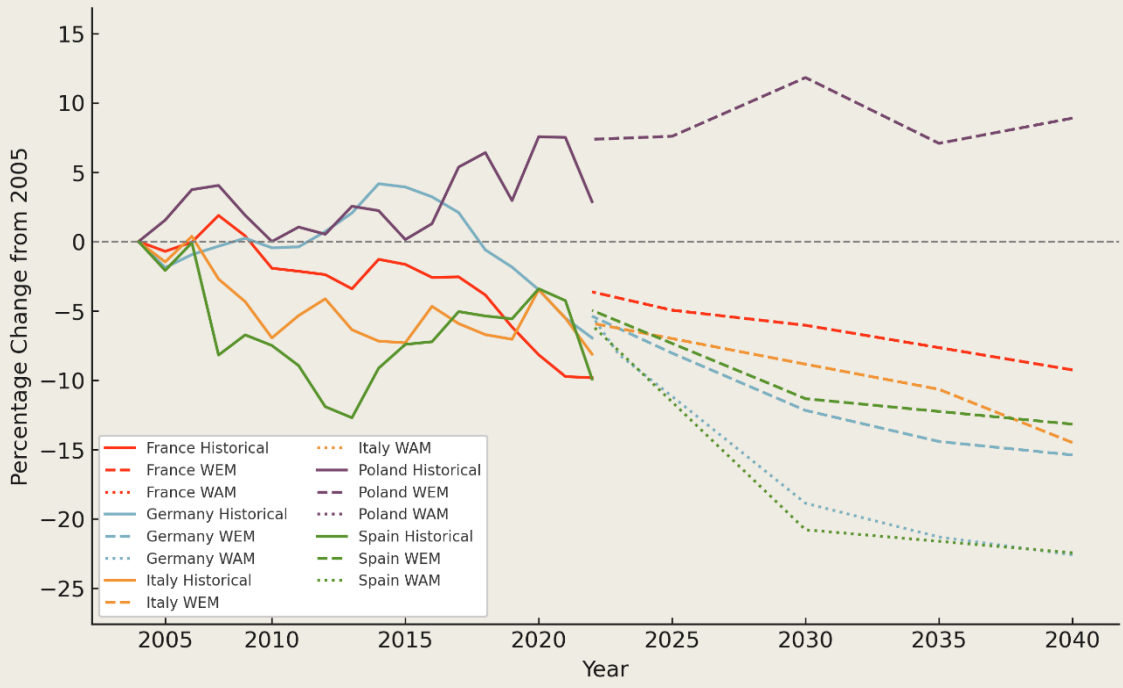


Figure 14: Top 5 emitters – emissions in transport (2005-2040)

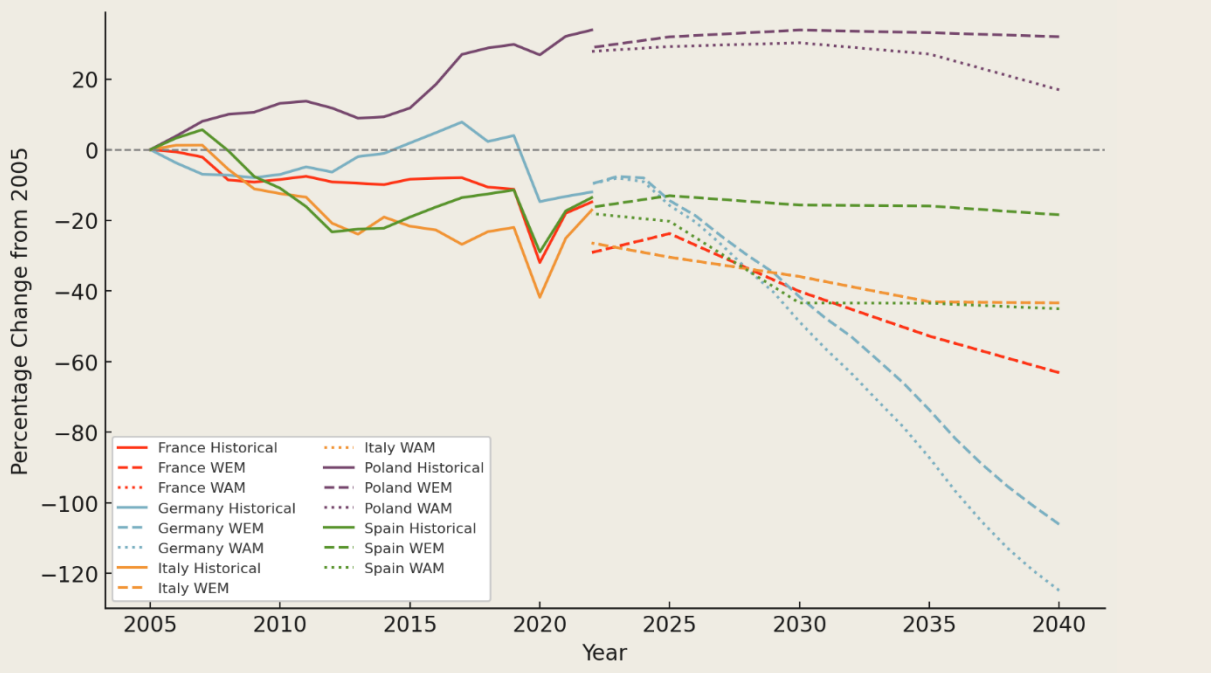


Figure 15: Top 5 emitters – emissions in residential and commercial buildings (2005-2040)

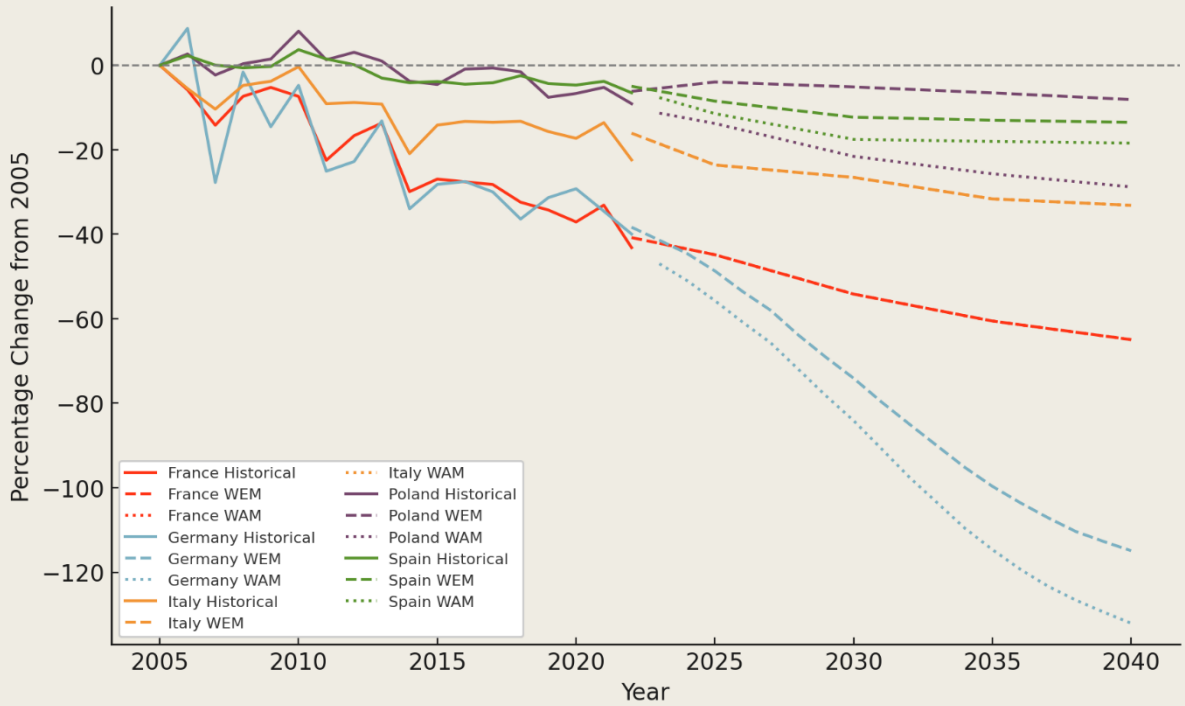
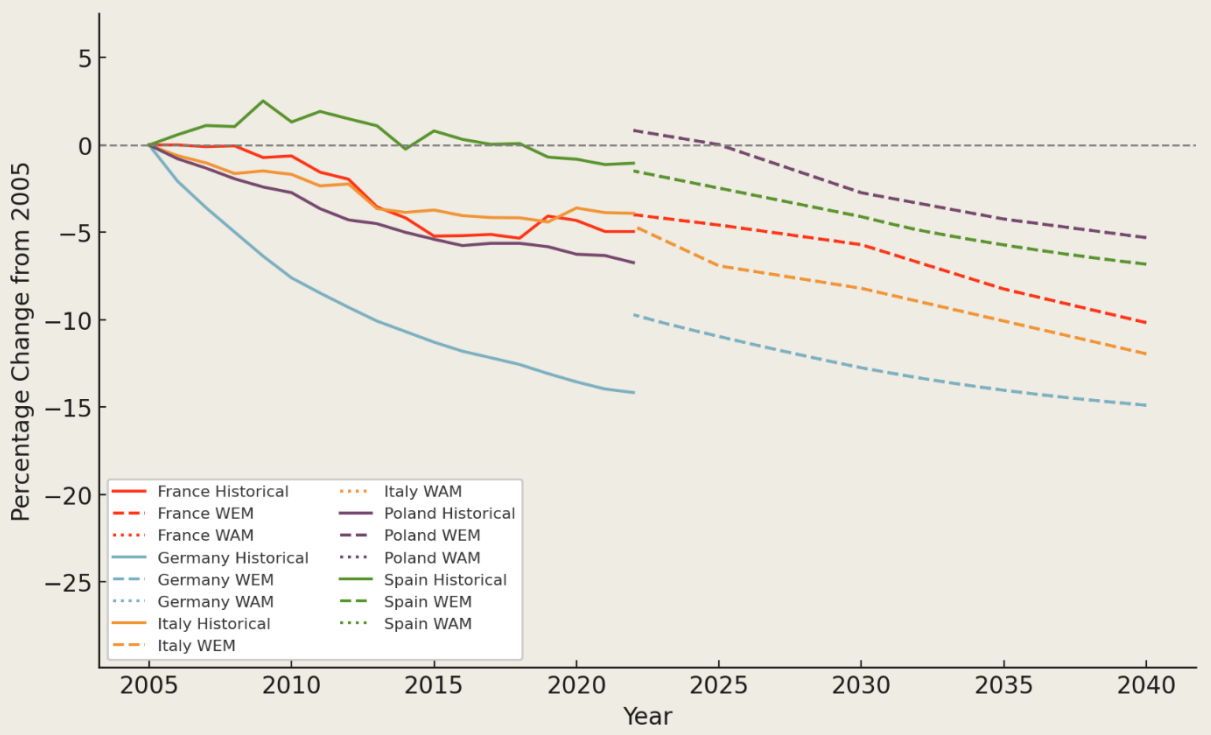


Figure 16: Top 5 emitters – emissions in waste management (2005-2040)



In Germany, emissions from residential and commercial buildings have declined by 20-25% since 2005, thanks to strong energy efficiency policies and retrofitting programs. By 2040, emissions are expected to decrease by 65-70% under WEM and 70-75% under WAM. Germany's commitment to retrofitting old buildings and encouraging the use of renewable heating systems will be critical for achieving these targets. In France, Italy, Spain, and Poland, similar reductions are expected, with emissions projected to decline by 60-75% by 2040 under the WAM scenario, driven by energy efficiency standards and retrofitting efforts.

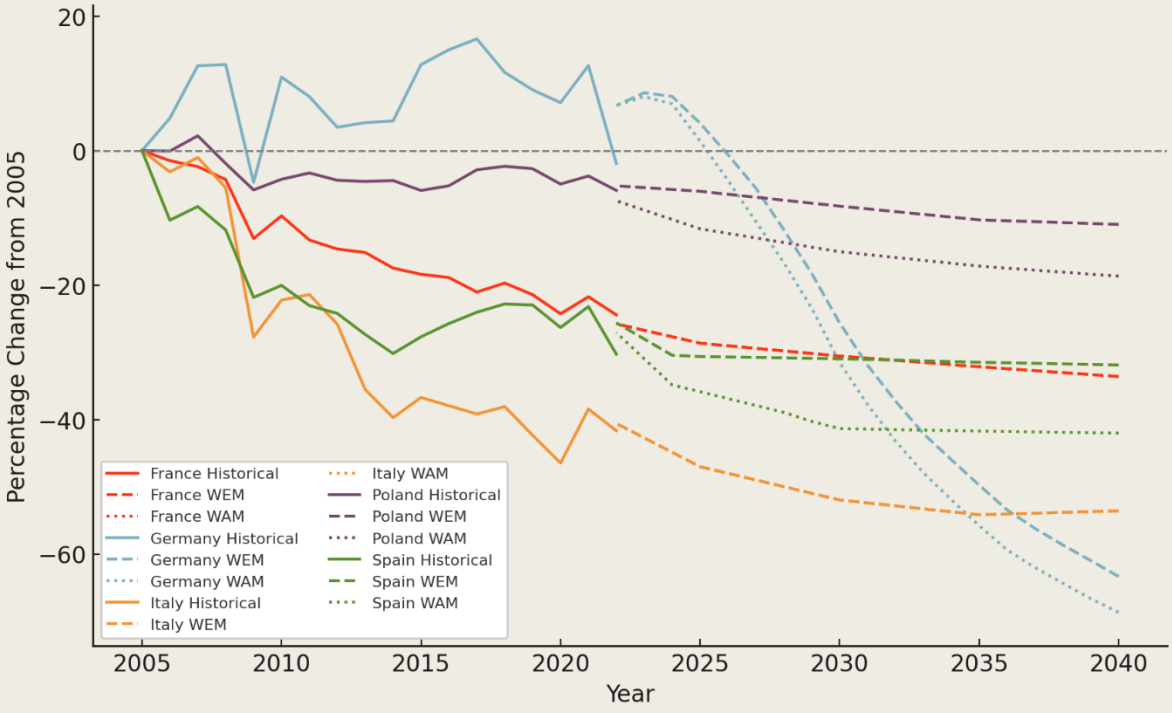
In Germany, the waste management sector has made significant progress, with emissions reductions of 30-35% by 2022. By 2040, emissions are expected to decrease by 50-60% under WEM and 60-65% under WAM. Germany's strong recycling programs and waste-to-energy initiatives have played a key role in these reductions. In France, Italy, Spain, and Poland, the waste sector has also seen steady improvements, with projected reductions of 50-65% by 2040 under WAM. These countries have implemented similar recycling initiatives, but further reductions will depend on the continued development of advanced waste processing technologies and reductions in landfill use.

In Germany, emissions from manufacturing and construction have decreased by around 15-20% by 2022, with further reductions projected to reach 40-50% by 2040 under WEM and 50-60% under WAM. Germany has made progress in developing low-carbon building materials and energy-efficient construction practices, but further improvements will require additional innovations and stricter emissions standards. Similar trends are seen in France, Italy, Spain, and Poland, where manufacturing and construction emissions are projected to decrease by 40-60% by 2040 under WAM. These reductions will depend heavily on the development of new materials and technologies for energy-efficient construction and low-carbon manufacturing processes.

In summary, substantial challenges remain, particularly in the transport, industrial processes, and agriculture sectors. The steepest reductions are expected by 2030, driven by the decarbonization of energy industries and residential buildings. However, from 2031 to 2040, the rate of reduction is

projected to slow, as the hardest-to-decarbonize sectors, such as transport and industrial processes, face increasing pressure. While ETS I sectors, particularly energy industries, have performed well, the ESR sectors have lagged. Without significant progress in agriculture, transport, and industrial processes, which remain reliant on carbon-intensive practices, the EU risks falling short of its proposed 2040 climate goal.

Figure 17: Top 5 emitters – emissions in manufacturing and construction (2005-2040)



7 Implementing the proposed climate target of -90% by 2040 in the EU

The analysis presented in the previous section highlighted how the EU as a whole, and most member states individually are not on track to meet the 2030 targets. The following sections delve into the policy outlook, focusing on the strategies needed to align these sectors with the 2030 and proposed 2040 target. This includes necessary policy enhancements, financial investments, and technological innovations. The discussion is divided into two sections: 1) Policies related to emissions under the ESR, and 2) policies related to emissions under ETS.

Key findings in this chapter

ETS sectors have reduced emissions significantly, especially in the power sector, driven by carbon pricing. Full decarbonization of power and heavy industry is crucial, with industry facing challenges in carbon-intensive processes. The introduction of the CBAM aims to prevent carbon leakage despite the phase-out of free allocation.

Key technologies, such as CCS (requiring €50-60 billion in investments) and green hydrogen (targeting 60 GW by 2040), are vital for deep decarbonization but face high costs, infrastructure, and regulatory challenges.

The EU ETS will continue to be a core tool in reducing emissions from energy and industrial sectors. Ensuring that the cap reaches zero by 2039 and maintaining the expanded scope which includes maritime and aviation. Revenue generated from the auctioning of allowances will support the transition to clean energy and technology deployment.

The ESR sectors, particularly transport, buildings, and agriculture, are at risk of missing overall 2030 emissions reduction targets without accelerated efforts. Transport remains the largest emitter with 803 Mt CO_2-eq in 2022, facing slow infrastructure development and reliance on fossil fuels. The buildings sector, with 400 Mt CO_2-eq in 2022, struggles due to slow renovation rates and high retrofitting costs. ETS II is expected to help reduce emissions in these sectors, becoming fully operational in 2027, but its partial overlap with ESR may create inefficiencies. Agriculture, responsible for 366 Mt CO_2-eq in 2022, and waste management (110 Mt CO_2-eq) also pose challenges due to methane and nitrous oxide emissions. Sector-specific policies like the Sustainable and Smart Mobility Strategy, Energy Performance of Buildings Directive, and Circular Economy Action Plan will play crucial roles in meeting the proposed 2040 target.

To meet the 2030 target, the EU needs an average annual reduction of 125 Mt CO_2-eq. From 2031–2040, this increases to 163 Mt CO_2-eq annually, a 30% rise in the reduction rate, reflecting the increasing difficulty of achieving deep emissions cuts. Projections suggest that the EU is likely to miss its 2030 target under both the WAM and WEM scenarios, with a shortfall of up to 462 Mt CO_2-eq under the WEM scenario. Missing this milestone will significantly raise the burden for the 2031–2040 period, requiring a much faster pace of decarbonization.

7.1 Policies related to emissions under the ETS

The sectors under the EU ETS have reduced their emissions substantially. The power sector has seen significant reductions, driven by the shift from coal to renewable energy sources, facilitated by high carbon prices under the ETS. However, the power sectors must achieve full decarbonization to ensure emission reductions in other sectors through electrification. Similarly, the industrial sector has to reduce its GHG emissions significantly through the incentives provided by the ETS and the innovation fund, with many industries

adopting processes and technologies that are compatible with a net-zero target. However, the sector still faces challenges in reducing GHG emissions from inherently carbon-intensive processes such as cement and steel production.

Alongside the progressive tightening of the ETS I cap, one of the main developments to be expected is the progressive phase-out of free allocations. These are planned to be fully phased-out by 2034 and substituted with the CBAM to ensure continued protection against carbon leakage.

Yet the industrial sectors covered by free allocation are also amongst the hardest to decarbonize and for which technological developments and investments in CCS technology and hydrogen development are most important.

To this purpose, the CCS framework currently provides a frame for CCS deployment in heavy industry. Under Scenario 3, the EU will need to capture and store 300-400 Mt of CO_2 annually by 2040. The Innovation Fund will be expanded to support CCS projects, with anticipated investments of up to €50-60 billion required by 2040 to develop and deploy these technologies at scale. A CO_2 transport and storage network across Europe will be essential, potentially involving cross-border cooperation. Scaling up CCS is necessary to achieve the deep decarbonization required under Scenario 3. Key challenges include high costs, technological underdevelopment, and public opposition to storage sites. There are also risks related to uncertain return on investment, regulatory delays, and technical feasibility concerns.

The Green Hydrogen Strategy currently focuses on developing hydrogen technologies to support decarbonization. Scenario 3 calls for a massive scale-up in green hydrogen production, targeting 40 GW of electrolysis capacity by 2030, with further expansions to 60 GW by 2040. This will involve significant investments, with expected capital expenditures for hydrogen production infrastructure reaching approximately €180-470 billion by 2050. Green hydrogen is essential for decarbonizing hard-to-abate sectors like heavy industry and long-haul transport, contributing to the overall 90-95% reduction in GHG emissions by 2040. Key challenges include infrastructure bottlenecks, high production costs, and barriers to market adoption. Coordination across sectors and regions, slow regulatory approvals, and uncertainty in hydrogen market development also pose significant risks.

7.2 Policies related to emissions under the ESR

The prospected underachievement of targets in the emission reduction of ESR sectors, particularly in transport and buildings, is a major concern. Without accelerated efforts and the implementation of additional measures, achieving the 2030 targets may be out of reach. Looking towards 2040, the EU's goal of reducing emissions to 850 Mt CO_2 eq(excluding LULUCF) represents an even greater challenge. The significant underperformance in ESR sectors poses a substantial risk to achieving this target. In this respect, it will be crucial to see whether the newly introduced ETS II will work.

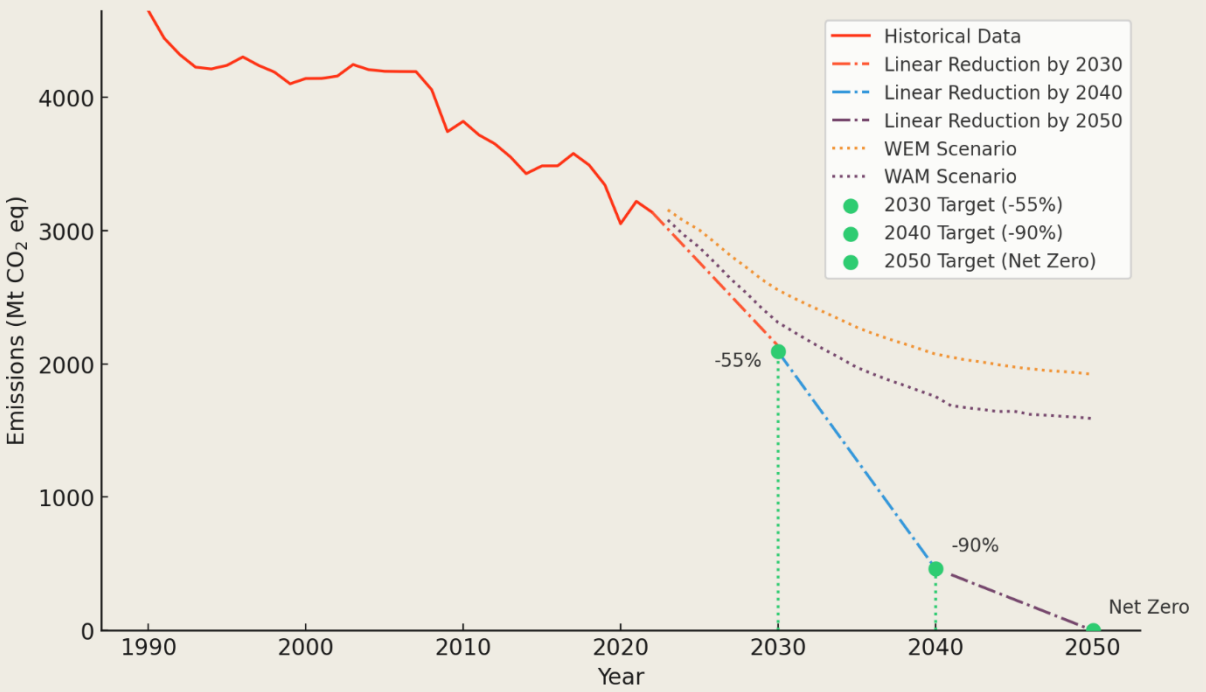
The transport sector remains the largest emitter within the ESR framework, with GHG emissions in 2022 reaching approximately 803.28 Mt CO_2 equivalent. Despite some progress in the adoption of electric vehicles, the sector has not seen the necessary reductions due to slow infrastructure development, continued reliance on fossil fuels, and increasing demand for mobility.

In the buildings sector, GHG emissions in 2022 were approximately 400.29 Mt CO_2 eq. The slow rate of building renovations and the high costs associated with retrofitting for energy efficiency are major obstacles. The renovation rate is aimed to be doubled by 2030, increasing from below 1% to 2-3% annually[24]. With a focus on decarbonizing heating and cooling systems.

The ETS II is the main policy instrument envisioned to help achieve the necessary emission reduction in the transport and building sectors, by providing a market incentive to mitigation. Monitoring and reporting of GHG emissions under the ETS II will start already in 2025, and the system will become fully operational in 2027. To provide

[24] EUR-Lex - 52020DC0662 - EN - EUR-Lex (europa.eu)

Figure 18: EU historical GHG emissions, climate targets, WEM and WAM projections (1990-2040)



liquidity in the newly established market, a volume corresponding to 130 % of the auction volumes for 2027 will be auctioned in 2027. The additional allowances will be deducted from auction volumes for the 2029-2031 period. To mitigate potential economic impacts, especially on low-income households, the EU designed the social climate fund to introduce social compensation mechanisms, such as rebates or subsidies, to offset the increased costs of heating and fuel.

The ETS II can help bridge the gap between the currently projected GHG emissions in the EU and the 2030 target in the ESR sector. However, the only partial overlap between EST II and ESR and their mismatch in terms of the level at which they set the targets (Union-wide and member states) may create inefficiencies. On the one hand, the ESR sets country-specific goals, whereas the ETS II has Union-wide coverage and a single price and, therefore, does not differentiate upon where GHG emissions are abated. Such design increases economic efficiency as it encourages the most cost-effective emission reduction. However, this design can lead to an overachievement of the ESR targets in some countries and an underachievement in others, triggering the necessity for inter-country trade of certificates. This effect could be most severe for countries like Germany, where higher income levels compared to other countries might lead to lower short-term reduction of GHG emissions under ETS II despite more ambitious ESR targets. A realignment of the two systems might, therefore, be necessary. On the other hand, ETS II covers only about 60% of the ESR emissions as it excludes non-road transport, agriculture and waste, while it only targets CO_2. The agriculture sector is responsible for around 365.72 Mt CO_2 equivalent in 2022, also struggles to reduce GHG emissions, particularly methane and nitrous oxide from livestock and fertilizer use. Without major changes, the sector will likely continue to underperform relative to its targets. The waste management sector, with GHG emissions of about 109.71 Mt CO_2 equivalent in 2022, faces ongoing challenges despite improvements in recycling. The largest share of its emissions – those from municipal waste incineration - will be regulated under ETS I from 2028 or 2030. Methane emissions from landfills and inefficiencies in waste treatment processes continue to be significant issues.

Alongside the ETS II, other sector-specific policies and strategies highlighted in section 2 will play an important role. Those are particularly important in cases where price signals cannot be relied upon

solely to dictate the right paste of the transition. In the transport sector, for example, the Sustainable and Smart Mobility Strategy supported by the stricter emission standards on cars and van and by the Alternative Fuels Infrastructure Regulation (AFIR), could provide the necessary impetus to transition away from combustion engines-based transportation. This would address one of the main challenges in the sector, namely the insufficient EV infrastructure and the slow adoption of hydrogen technology for heavy-duty vehicles, resulting from a lack of investments due to uncertainty in long-term price developments.

Similarly, in the building sector, the Energy Performance of Buildings Directive (EPBD) aims to increase the renovation rate to at least 3-4% annually, up from the current 1% rate, which would be essential to meet the 38% energy savings required in buildings under Scenario 3 by 2040. However, high renovation costs, slow adoption of energy-efficient technologies, and the complexity of retrofitting older buildings can pose significant challenges.

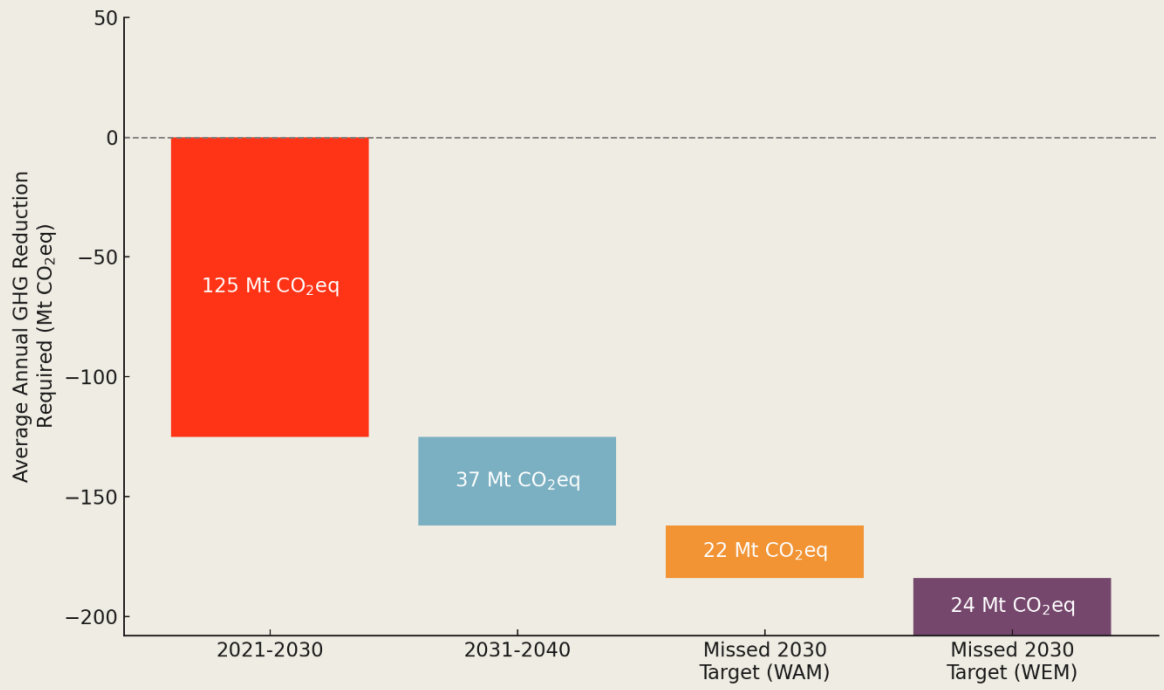
Finally, while the waste sector is not currently included in the ETS II, the Circular Economy Action Plan and the Waste Framework Directive are designed to boost the development of recycling infrastructure and the adoption of circularity in resource use. The improved recycling rate and waste reduction are crucial for achieving the 2040 GHG targets. Specific targets include a 60% reduction in plastic packaging waste by 2030, progressing towards zero plastic waste by 2040.

7.3 Achieving the 90% GHG reduction target for EU

The EU climate targets require deep emissions cuts. To meet the 2030 target, an average annual reduction in total emissions of 125.3 Mt CO_2 eq is required in the 2021–2030 period. From 2031–2040, the average annual reduction increases to 162.7 Mt CO_2 eq. This represents a 30% or 37 Mt CO_2 eq increase in the annual reduction rate between the two decades, reflecting the steep challenge of achieving such deep cuts in emissions.

Reaching the 2030 target is critical for staying on track to meet the 2040 goals, but projections suggest the EU may miss this milestone under both the WAM and WEM scenarios. In the WAM

Figure 19: Annual GHG emission reductions: 2021–2040 and impact of missing 2030 targets



scenario, projected emissions for 2030 are 2,311.34 Mt CO_2 eq, which means the EU would miss the target by 218.94 Mt CO_2 eq. In the more business-as-usual WEM scenario, projected emissions for 2030 are 2,554.53 Mt CO_2 eq, leaving a much larger gap of 462.13 Mt CO_2 eq. These shortfalls suggest that without stronger policies and immediate actions, the EU will not meet its 2030 goals, which will have a cascading effect on the ability to meet the proposed 2040 target.

If the 2030 target is missed[25], the required reduction rate for the 2031–2040 period would need to increase substantially to make up for the shortfall. In the WAM scenario, where emissions in 2030 are 2311.34 Mt CO_2 eq, the required average annual reduction for 2031–2040 would rise to 184.64 Mt CO_2 eq. This represents an increase of 59 Mt CO_2 eq per year compared to the 2021-2030 average. In the WEM scenario, where 2030 emissions are projected to be 2554.53 Mt CO_2 eq, the required average annual reduction for 2031–2040 would escalate to 208.96 Mt CO_2 eq per year – an increase of 84 Mt CO_2 eq per year over the 2021-2030 average. Such a sharp increase in the reduction rate would place significant pressure on the EU to decarbonize rapidly, presenting enormous technical and economic challenges.

[25] The missed 2030 target is calculated based on the projected GHG emissions for 2030, as outlined in the EU Projection Report 2023, which was submitted by all member states.

8 Impact of an EU climate target of -90% by 2040 on Germany

Key findings in this chapter

Germany needs significant changes in its legal frameworks to meet the EU's 2040 climate targets. Existing policies such as the Renewable Energy Sources Act and the Building Energy Act will require updates to accelerate renewable energy growth, decarbonize heating systems, and expand infrastructure to meet these ambitious goals.

Achieving Germany's energy targets, including 80-100% renewable electricity by 2040, demands substantial investments in grid infrastructure and energy storage. Public resistance to wind projects, ground-mounted photovoltaic systems, and grid expansion delays remain significant hurdles.

The building sector requires an increase in retrofit rates from 1% to 3-4% annually to meet the proposed 2040 target. High costs and the slow pace of energy-efficient renovations present key challenges.

Although the transition to zero-emission vehicles is critical, current adoption rates of electric vehicles remain low, and significant investments in charging infrastructure are needed. Heavy-duty vehicle decarbonization also requires rapid technological innovation.

Germany risks missing its 2030 targets, which would impose greater pressure on achieving the 2040 goal. Gaps in carbon pricing mechanisms, underfunded policies, and delayed technological adoption in key sectors, particularly energy and transport, pose substantial risks.

The proposed 2040 targets will reshape municipal energy suppliers' roles, especially in expanding district heating networks and integrating renewable energy. Municipal companies face both opportunities and challenges as they adapt to new business models in energy generation, storage, and management.

For industry, the decarbonisation of hard-to-abate sectors and the transition to a new carbon leakage regime will be key challenges. There is a high level of infrastructure exposure here, particularly with regard to hydrogen, CCS and the power grid. With the introduction of ETS II, both systems may record emissions from industrial and commercial companies, resulting in an inconsistent price signal.

8.1 Need for changes in legal frameworks and emission reduction targets

The EU's main instruments for achieving the 2040 climate target are the ETS I, ETS II and the LULUCF regulation. Where necessary, the climate targets are implemented directly through the national implementation of these instruments, by adapting the TEHG. However, as further supporting policy measures are also required to realize the proposed 2040 target, a whole series of other laws and regulations will have to be adapted. For example, the legal basis for a carbon management industry and a hydrogen industry must be created. Several important pieces of legislation are discussed below, although they are and cannot be exhaustive at this moment.

Electricity and renewable energy

The Renewable Energy Sources Act (EEG) is fundamental to Germany's strategy to meet its 2040 climate targets. The EEG supports the expansion of renewable energy, particularly wind and solar power, with incentives like feed-in tariffs. By 2022, renewable energy accounted for approximately 50% of Germany's electricity generation, with targets to increase this share to 80% by 2030 and nearly 100% by 2040. This ambitious expansion is supported by specific goals, such as increasing offshore wind capacity to 30 GW by 2030 and potentially 70-75 GW by 2040. However, the significant increase in renewable capacity will require substantial investments in grid infrastructure and energy storage solutions to manage the intermittency of renewable energy sources. The phase-out

of nuclear energy by 2023 poses additional risks to energy security, particularly during periods of low renewable output, necessitating enhanced energy storage capacity and potentially increased electricity imports.

Heating and buildings

The Building Energy Act (GEG) is crucial in driving energy efficiency in the building sector, which is responsible for a significant portion of Germany's carbon emissions. The GEG mandates strict energy performance standards, aiming for near-zero energy buildings (NZEB) as part of Germany's efforts to reduce GHG emissions by 40% in the heating sector by 2030 compared to 2020 levels. However, the high costs associated with deep retrofits—often exceeding €500 per square meter—and the slow adoption rate pose significant challenges. These challenges are particularly acute in older building stock, where energy inefficiencies are most pronounced. The success of the GEG depends on the effective implementation of stricter building codes and sufficient financial support for renovations.

Federal Funding for Efficient Buildings (BEG) complements the GEG by providing financial incentives for energy-efficient building renovations. This policy is crucial in supporting the decarbonization of the building sector, especially in retrofitting existing buildings to improve energy efficiency. For instance, BEG funding can cover up to 45% of the renovation costs for deep retrofits, significantly reducing the financial burden on property owners. However, low uptake and potential underfunding could limit the policy's effectiveness, especially given that Germany needs to retrofit approximately 2% of its building stock annually to meet its proposed 2040 target.

The Heat Planning Act (Gesetz für die Wärmeplanung und zur Dekarbonisierung der Wärmenetze, abbreviation WPG) came into force together with the amendment to the Building Energy Act (GEG) on 1 January 2024. Both laws contribute to achieving the climate targets in 2045. All of Germany's approximately 11,000 municipalities should have a heating plan by mid-2028 at the latest: In large cities (municipal areas with more than 100,000 inhabitants) they should be available by 30 June 2026, in municipalities with less than 100,000 inhabitants by 30 June 2028. Smaller municipalities (less than 10,000 inhabitants) can undertake a simplified heat planning procedure. This is decided by the federal states. District heating will play a prominent role in the climate-neutral heat supply of the future, especially in urban areas. This is why heating networks need to be expanded and converted to heat from renewable energies. Currently, only around 14% of households nationwide are supplied with district heating. Only 20% of this is currently generated from renewable energies.

The Heat Planning Act contains minimum targets for the proportion of heat from renewable energies and unavoidable waste heat and is gradually increasing the proportion of renewable energies in the heating networks. From 1 January 2024, at least 65% renewable heat must be fed into every new heating network. By 2030, half of grid-based heat is to be generated in a climate-neutral way. By then, 30% of the heating networks are to be supplied with heat from renewable energies or unavoidable waste heat, and by 2040, 80%. By 2045, all heating networks must be climate neutral. This means that 100% renewable energy must then be introduced. The federal law must be implemented in state regulations which marks the start of the actual heat planning process.

Transport sector

The CO_2 Emissions Standards for Passenger Cars and Light Commercial Vehicles are key to reducing GHG emissions in the transport sector, which is responsible for about 20% of Germany's total GHG emissions. The standards mandate that by 2035, all new car sales in the EU, including Germany, must be zero-emission vehicles (ZEVs). The shift to electric vehicles (EVs) is crucial for achieving these targets. As of 2023, EVs account for about 14% of new car registrations in Germany, and this share needs to increase significantly to meet the 2035 target. The challenges include the high costs of EVs, which are approximately 40% higher than their internal combustion engine counterparts, and the need to expand the charging infrastructure from 80,000 public charging points in 2023 to over 1 million by 2030.

The Electromobility Law (EmoG) further supports the transition to EVs by providing additional incentives, such as reduced taxes and access to restricted zones in urban areas. While these incentives are crucial for driving EV adoption, the challenges of expanding charging infrastructure and managing the increased demand for electricity remain significant. Germany's electricity grid will need to accommodate an estimated additional 100 TWh of demand from EVs by 2040, requiring substantial upgrades to both the grid and energy storage capacities.

The CO_2-Differentiated Lkw-Maut, a carbon-based toll system, incentivizes the use of low-emission trucks by imposing higher tolls on more polluting vehicles. This policy is crucial for reducing GHG emissions in the freight sector, which contributes significantly to Germany's overall GHG emissions. The system is expected to reduce GHG emissions from heavy-duty vehicles by up to 20% by 2030, contributing to the broader ETS targets. However, the transition to low-emission trucks, including electric and hydrogen fuel cell vehicles, is slowed by the high costs and the need for a comprehensive refueling infrastructure. Without sufficient incentives and infrastructure development, the effectiveness of this policy could be limited.

Waste management and circular economy

Germany's Circular Economy Action Plan and the Waste Framework Directive are critical to meeting ESR targets by reducing GHG emissions from waste management. The Circular Economy Action Plan sets ambitious targets, such as increasing the recycling rate for municipal waste to 65% by 2035 and reducing landfill use to less than 10% of total waste. However, Germany's recycling rate has plateaued at around 67%, indicating that further progress will require significant policy and technological advancements. The Waste Framework Directive reinforces these goals by setting specific recycling targets and promoting waste prevention measures. The main challenges include the slow adoption of circular practices, the economic impact on industries dependent on raw materials, and the need for significant investment in waste management infrastructure to achieve these targets.

Industrial sector

The Decarbonization in Industry (BIK) program is essential for reducing emissions in Germany's industrial sector, which accounts for approximately 25% of the country's total CO_2 emissions. The BIK program supports energy-intensive industries, such as steel, cement, and chemicals, in adopting green technologies like carbon CCS and hydrogen. For instance, the steel industry alone emits about 60 Mt CO_2 annually, and decarbonizing this sector is critical for meeting the 2040 targets. However, the high costs associated with CCS—estimated at around €50-100 per tonne of CO_2 captured—and the early-stage development of hydrogen technologies present significant challenges. The BIK program needs to scale up to meet the estimated €50 billion investment required to decarbonize these industries by 2040.

Klimaschutzverträge (Carbon Contracts for Difference, CCfD) are another critical tool under the ETS, designed to secure long-term CO_2 savings through contracts with industrial entities. These contracts provide financial support for industries to implement transformative technologies that can achieve significant GHG emissions reductions. The effectiveness of Klimaschutzverträge depends on clear and enforceable targets, adequate funding, and broad industry participation. If successful, these contracts could help reduce industrial emissions by up to 80% by 2040, contributing significantly to Germany's overall climate goals.

Carbon Pricing: National CO_2 pricing is a fundamental element of Germany's ETS framework, applying carbon pricing to the heat and transport sectors to drive GHG emission reductions. The German national ETS will be replaced by the introduction of ETS II.

Hydrogen and Power-to-X Technologies The National Hydrogen Strategy is a cornerstone of Germany's approach to decarbonizing the electricity sector. The strategy aims to establish at least 5 GW of electrolyzer capacity by 2030, with the potential to scale up to over 20 GW by 2040. This is crucial for producing green hydrogen, which can be used to decarbonize hard-to-abate sectors such as steel and chemicals. The strategy is expected to reduce CO_2 emissions by up to 30 million tonnes annually by 2040. However, the cost of green hydrogen,

currently around €4-6 per kilogram, needs to decrease to around €2-3 per kilogram to be competitive with fossil fuels. Significant investment in hydrogen infrastructure, including pipelines, refueling stations, and storage facilities, is also required to support the widespread adoption of hydrogen as an energy carrier.

Power-to-X technologies are essential for converting surplus renewable electricity into other forms of energy, such as hydrogen or synthetic fuels, which are critical for sectors where direct electrification is not feasible. These technologies could reduce Germany's CO_2 emissions by up to 50 million tonnes annually by 2040, particularly in the aviation and heavy industry sectors. However, the high costs of these technologies, coupled with the need for significant research and development, pose substantial challenges. For example, the cost of producing synthetic fuels using Power-to-X technologies is currently around €2 per liter, significantly higher than conventional fuels. Overcoming these cost barriers will require substantial public and private investment, as well as strong policy support to accelerate the adoption of Power-to-X solutions.

8.2 Achieving the 2040 climate target for Germany

Germany's climate targets are almost in line with the reduction path proposed by the EU Commission. While Germany's 2040 target of an 88% reduction 2040 compared to 1990 is two percentage points lower than the 2040 proposal, its target to achieve net-zero by 2045 is more ambitious compared to the EU's 2050 climate neutrality goal.

However, whether Germany will be able to achieve its climate targets depends on several critical factors. First, it is important that Germany does not miss its 2030 targets, or only misses them by a small margin. This is because every percentage point of reduction that is missed will become a burden for the future.

It is also crucial to ensure that important climate protection instruments are effective. From a climate policy perspective, there are two key challenges here: firstly, the transition to ETS II must be successful. The new system starts with a high level of pressure to reduce emissions from the outset, which arises from the expected failure to meet targets in the effort sharing area for the ETS II. There is a risk of significant cost burdens for companies, private individuals and local authorities. This applies to Germany and all other EU member states.

On the other hand, the transition from free allocation to the CBAM must successfully protect against carbon leakage. If the new system does not provide effective protection against leakage, this will pose a significant threat to the economy and employment for all EU member states, and especially for Germany with its industrial base.

Besides these key points, the alignment between Germany's national policies and broader EU frameworks is essential.

Germany's role is pivotal within the EU due to its economic size—accounting for around 25% of the EU's GDP and 20% of its GHG emissions—and its industrial base, which includes energy-intensive sectors such as steel, chemicals, and cement. With a -50 per cent target for 2030 with 2005 levels, Germany has the highest level of ambition in effort sharing[26]. This also entails a responsibility, especially in view of the high share of total EU emissions, since the success or failure of Germany in achieving its 2040 target will significantly impact the EU's ability to meet its overall climate ambitions.

The recent 2024 expert report on Germany's GHG emissions projections[27] has highlighted the scale of these challenges, underscoring that Germany is at risk of missing its 2030 targets across key sectors. The projections suggest that Germany's emissions will fall by 32.5% from 2023 levels by 2030, resulting in emissions of 455 Mt CO_2 eq compared to the legally mandated limit of 438 Mt CO_2 eq,

[26] Besides Germany, Denmark, Luxembourg, Finland, and Sweden also have a -50 per cent target. 2030 ESR targets of the other large emitters are -47.5 per cent for France, -43.7 per cent for Italy, -37,7 per cent for Spain, and -17.7 per cent for Poland.

[27] Expertenrat für Klimafragen (2024): Gutachten zur Prüfung der Treibhausgas-Projektionsdaten 2024. Sondergutachten gemäß § 12 Abs. 4 Bundes-Klimaschutzgesetz. Online verfügbar unter: https://www.expertenrat-klima.de

leading to a slight overshoot of the 2030 target. At the same time, the total budget for the period 2021-2030 would just be met with a buffer of 47 Mt CO_2 eq in accordance with the Climate Protection Act (KSG).

On the one hand, the report critically comments on the projection data itself. In the opinion of the Expert Council, the GHG emissions in the energy, buildings and transport sectors and – with some reservations – in industry are underestimated. As a result, the 2021-2030 budget will not be achieved according to the KSG. The Expert Council therefore concludes that the target will not be met.

With a view to the period 2031 to 2050, the expert council speaks of a significant failure in 2031 to 2040 and the net zero target in 2045, which would also not be achieved in 2050. The committee criticizes the fact that this finding will not result in a mandatory course of action under the KSG until 2030 at the earliest. The LULUCF sector, which is not considered here, is also expected to fall well short of its target. At times, this sector would even become a source of GHG emissions instead of a sink.

The report of the Expert Council is in line with the picture of the quantitative analysis of emissions data carried out here, according to which the transport sector, but also the building sector, lag behind in comparison, while the strongest reductions are achieved in the energy and industrial sectors.

When comparing the sectoral projections, it is striking that Germany projects significantly steeper decarbonization paths in the Effort Sharing sectors of transport, buildings, and manufacturing and construction than the other four major EU emitters. Whether this is due to Germany's significantly more ambitious measures, or the German projections are more confident, cannot be determined in the context of this study.

8.2.1 Specific challenges for Germany's 2040 climate goals

Energy sector challenges

Germany's goal of producing 160 GW of onshore wind and 400 GW of solar power by 2040 is one of the most ambitious in Europe. However, substantial barriers remain:

Bureaucratic delays and permitting: Permitting for onshore wind projects can take up to 5 years, significantly slowing deployment. The government aims to streamline processes, but without these changes, the pace of wind expansion is unlikely to meet the 2040 target.

Public opposition and local resistance: Many onshore wind projects face resistance from local communities, which have delayed or halted installations. Surveys indicate mixed support for wind farms, with some regions more open to renewable energy infrastructure than others.

Grid infrastructure: Expanding and modernizing Germany's energy grid is essential for integrating intermittent renewable sources like wind and solar. However, grid expansion projects are also facing delays due to planning approval and public opposition.

Transport sector challenges

Germany's transport sector remains a significant obstacle to achieving the 2040 climate targets. In 2023, transport emissions increased, mainly due to the rise in vehicle kilometers traveled and slow adoption of electric vehicles (EVs).

Electrification of transport: Germany has set ambitious goals for EV adoption, but as of 2023, electric vehicles account for less than 20% of new car sales, and the electrification of heavy-duty transport lags even further behind. To meet the 2040 transport goals, Germany will need to dramatically increase EV sales, requiring enhanced financial incentives, expanded charging infrastructure, and stricter emissions regulations.

Freight and heavy-duty vehicles: Decarbonizing road freight is a critical challenge, as heavy-duty vehicles are responsible for a disproportionate share of emissions. Germany is exploring hydrogen-based and electrified truck technologies, but these solutions are still in early stages and face high costs.

Buildings sector challenges

The buildings sector is one of the slowest to decarbonize in Germany, with energy efficiency and

renewable heating system upgrades lagging the pace needed to meet the 2040 goals. Buildings account for nearly 30% of Germany's total energy consumption, and addressing this will require major retrofitting efforts.

Retrofit rates: To meet the 2040 decarbonization goals, Germany will need to more than double its current building retrofit rate, which currently stands at about 1% annually. Experts suggest this rate must reach 3-4% to meet long-term climate objectives.

Heating systems: Germany aims to decarbonize 80% of its heat networks by 2040, shifting from fossil-fuel-based systems to renewable energy or unavoidable waste heat. However, this will require significant investment in district heating networks and household-level heating system replacements. Current incentives for homeowners to switch to heat pumps or renewable heating systems have not been sufficient to drive widespread adoption.

Cost and financing: Retrofits and heating system upgrades are expensive. Estimates suggest that achieving the necessary renovations could cost Germany €400 billion by 2040, and questions remain about how these costs will be distributed between homeowners, the government, and the private sector. Without significant subsidies or financial innovations, achieving the building sector targets will be difficult.

Industrial decarbonization challenges

Germany's industrial sector, which includes high-emissions sectors like steel, cement, and chemicals, faces significant hurdles in decarbonizing. These industries are particularly challenging because of their high energy intensity and reliance on processes that are difficult to electrify.

CCS: Germany is considering the use of CCS for hard-to-abate industrial sectors. Public opposition to CCS technology was a barrier for a long-time resistance has since diminished. Only a limited number of CCS projects are currently operational, and large-scale deployment will require significant government support and private sector investment. An effective implementation of the Carbon Management Strategy is essential to meet climate targets also in hard-to-abate sectors.

Hydrogen: The use of green hydrogen in industries like steelmaking is seen as a potential decarbonization pathway, but hydrogen production at scale remains expensive and requires massive investments in electrolyzers and renewable electricity. Germany plans to increase its green hydrogen capacity, but it will need to ramp up production far beyond current levels to make hydrogen a viable industrial fuel by 2040.

8.2.2 Economic impact and policy gaps

The Bundes-Klimaschutzgesetz, updated in 2024, plays a crucial role in aligning national policies with broader EU frameworks. However, the 2024 expert report emphasizes the economic impact of achieving these targets. The KSG projections highlight substantial economic challenges, especially in the transport and buildings sectors. For example, Germany will need to invest heavily in carbon pricing mechanisms under ETS II to accelerate decarbonization in these sectors, which may face political resistance due to rising energy costs. Additionally, the 2024 projections point out that even with current measures in place, Germany is unlikely to meet its ESR targets beyond 2024, leading to a potential overshoot of 126 Mt CO_2 eq by 2030. This shortfall underscores the need for more aggressive policies and potentially higher carbon prices to close the emissions gap.

Conditions for achievability

Germany's progress toward its 2040 climate goals requires accelerated renewable energy deployment, particularly in onshore wind and solar, by reducing permitting delays, expanding grid capacity, and addressing local opposition. Electric vehicle (EV) adoption must rise sharply through expanded charging infrastructure, stricter emissions standards, and financial incentives. In the buildings sector, stronger policies are needed to boost retrofitting and renewable heating systems, backed by increased subsidies and financing options. Decarbonizing heavy industry will rely on large-scale investments in CCS and green hydrogen, with government support through carbon contracts and R&D funding. Public support is critical, as resistance to CCS and wind farms poses challenges, necessitating public outreach, consultations, and compensation schemes. The National Energy and

Climate Plan (NECP) emphasizes stakeholder engagement, social equity, and targeted subsidies to mitigate the impact of rising energy costs on low-income households, ensuring a fair transition to a low-carbon economy.

For Germany to meet its 2040 climate targets, multiple critical factors must operate in concert, each requiring precise execution and sustained momentum. The scope of these tasks is substantial, and the projections for rapid decarbonization, particularly in transport, highlight the need for well-coordinated policies. The 90% reduction target also introduces an additional layer of urgency, with the potential for a "Knick" in the decarbonization curve— a situation where early-stage delays and inadequate progress by 2030 would force a dramatic acceleration of efforts in the final decade before 2040. Such a scenario risks economic disruption and could ignite political tensions, as more stringent and potentially unpopular measures would be required to close the gap.

In summary, for Germany to achieve its 2040 climate targets, every key element—renewable energy deployment, transport electrification, building retrofits, and industrial decarbonization—must progress simultaneously and at an accelerated pace. The scale of these interdependent challenges means that if even one area falters, the entire foundation of Germany's climate strategy could be compromised, making it impossible to reach the set goals. Achieving these targets will not only require careful coordination but also robust public and political support to navigate the difficult trade-offs ahead.

8.3 Impact on municipal energy suppliers and industry

8.3.1 EU ETS I

Impacts on VKU member companies

Municipal businesses may be directly affected by the EU-ETS I as operators of installations subject to emissions trading. In the energy generation sector, municipal companies often operate heating (and cogeneration) plants for electricity and heat production. According to current technology standards, these plants predominantly use natural gas or, in some cases, biomethane, with heating oil serving as a reserve fuel.

There could also be an indirect impact through the operation of heating networks due to the pass-through of CO_2 costs from ETS installations (e.g., industrial plants that feed waste heat into the heating networks).

The municipal waste management sector, under legal mandate, operates facilities for thermal waste incineration (municipal waste and sewage sludge) in many locations. Waste heat from thermal waste incineration is a central component of municipal heat planning. The proposed inclusion of these facilities within the scope of EU-ETS I would result in additional cost burdens for the heating networks.

Potential impacts of the 90% reduction target by 2040 on EU-ETS I:

It is currently unclear whether the 2040 target will lead to a tightening of the linear reduction factor in EU-ETS I, thereby increasing pressure to reduce emissions. This is because the current reduction path already means that no emission allowances will be issued by 2040.

As the most important tool in European climate policy, it is conceivable that the scope of EU-ETS I could be expanded to sectors or areas within sectors that are not currently subject to CO_2 pricing. This would extend the market-based incentives for emission reduction to previously untaxed sectors, holding them accountable. Specifically, an expansion to cover the transport sector, including international aviation (currently under CORSIA) and international shipping, is plausible. Article 24 of the EU-ETS Directive regulates the procedure for unilaterally incorporating additional activities and gases into the ETS. Sweden and Denmark, for example, have already taken the lead by unilaterally integrating thermal waste incineration plants into the ETS.

According to the draft amendment to the German Greenhouse Gas Emissions Trading Act (TEHG), Germany plans to include waste incineration plants in EU-ETS I starting in 2027. Since 2024, these plants have been covered by the national Fuel

Emissions Trading Act (BEHG). A unique aspect of the national system is that no threshold for participation is set, meaning that even smaller plants are subject to BEHG. In 2027, the German national emissions trading system will be integrated into EU-ETS II. Waste incineration plants are explicitly excluded from EU-ETS II. However, with the planned opt-in to EU-ETS I starting in 2027, the continuous CO_2 pricing for waste incineration will continue in Germany, at least for plants with a thermal input of over 20 MW.

Including waste incineration in EU-ETS I would strengthen incentives for emission reduction and promote a circular economy. In terms of the 2040 target, Germany's planned opt-in could serve as a model for other countries. However, the unilateral inclusion of plants by individual member states is viewed critically by the waste management sector, due to the potential shift of waste streams within the EU. The European Commission will decide by 2026 whether to include waste incineration plants in the ETS starting in 2028. Given the limited possibilities for emission reduction in thermal waste processing, dealing with residual emissions will be crucial. Rising ETS I prices could incentivize CCS/U technologies to capture unavoidable emissions.

Article 30 of the EU-ETS Directive outlines the possibility of lowering the thresholds for participation in the ETS for already covered activities from 2031 onwards. This could be particularly relevant for industry. Fuel emissions from industrial sectors outside EU-ETS I are already covered by EU-ETS II, and by incorporating these facilities into EU-ETS I would create uniform incentives across sectors.

Managing Residual Emissions

As we approach the proposed 2040 target and the phase-out of certificate allocations by 2039, regulations for hard-to-avoid residual emissions will be necessary. The current design of the ETS provides incentives only for the use of CCS technologies, yet even after the use of CCS/U, residual emissions may remain. Additionally, CCS/U may not be economically or technically feasible for all plants. Politically, the development of options for crediting CO_2 removals in the ETS is planned for 2026, and the integration of CCU will also be decided at that time.

Various options are being considered for integrating CO_2 removals:

- Full integration of removal methods without quantity limits
- Limited approval of removal methods
- Approval for specific types of emissions and/or removal methods
- No integration of removal methods, with financing through auction revenues

If the right framework conditions are in place, rising EUA prices could create market-based incentives to invest in CO_2 removal technologies. For integration into the EU-ETS, at least in the short- to medium-term, a certification system for CO_2 removal credits will be necessary. This could be established under the CRCF framework. The additional certificates generated in the market will create a new equilibrium price, potentially leading to opposing incentive effects. As an alternative to integration, adjusting the Linear Reduction Factor is being discussed scientifically to continue allowing emissions while financing the compensation of residual emissions through auction revenues. The chosen integration option will, in turn, impact the achievement of the 2040 reduction target.

Free allocation of certificates

According to the EU allocation regulation, free allocation for district heating is secured, though limited, until 2030. It is unclear whether this will continue after 2030. Operators of municipal heating networks should expect the gradual reduction of the annual cap in the ETS and a tightening of heating benchmarks, which already represent a mix of natural gas and biomass. Currently, only 0.3 of the benchmark is achieved, which suggests a decline in free allocation, resulting in higher costs for fossil heat generation. If a reduction factor like the CSCF is applied, the allocation could be further reduced. For heat used in installations not at risk of carbon leakage, the allocation will cease entirely by 2030. CBAM will lead to a reduction in allocations for heat used in carbon leakage-exposed production processes starting in 2026, with allocations

ending for these processes by 2034. The development of free allocations for heat in leakage-exposed processes not covered by CBAM remains uncertain. While no allocation reductions are planned before 2030, an expansion of CBAM could lead to cuts in this area. If thermal waste incineration plants are included in EU-ETS I, these plants could be entitled to allocations depending on the use of the waste heat. To achieve the 2040 target, further reductions in free allocations may be necessary to increase emission reduction pressure.

Despite these challenges, there are opportunities, especially through free allocations for technologies like electrolyzers, heat pumps, and e-boilers, which municipal companies could operate or integrate into their heating networks. Such measures could not only contribute to decarbonization but also create new regional value chains, particularly concerning infrastructure and the use of waste heat from waste incineration plants. These incentives and opportunities should be further explored to fully utilize them.

Interaction between EU-ETS I and other regulations

Auction revenues are used to finance climate policy measures, subsidies, and hardship compensation (Modernization Fund, Innovation Fund, Social Climate Fund). With the decreasing supply due to lower caps, rising certificate prices will lead to higher auction revenues. However, a shrinking number of certificates available for auction will lead to lower revenues. Reduced free allocations, leading to higher auction volumes, will result in higher auction revenues – considering the declining number of issued certificates.

8.3.2 EU-ETS II

Municipal companies may be directly obligated to participate in EU-ETS II as suppliers of natural gas and biomethane, referred to as fuel suppliers under BEHG. Similar to EU-ETS I, there is an indirect impact as operators of heating networks, where the CO_2 costs of heat producers (installations under 20 MW) are passed on. It is conceivable that municipal companies themselves operate smaller (heating) power plants under 20 MW thermal input, which are not included in EU-ETS I, and that the fuel used for heat generation will be subject to CO_2 costs under EU-ETS II. Positive incentives could arise in connection with the operation of heating networks or contracting through free allocations for electricity-based heat generation.

EU-ETS II within the Fit-for-55 package

The EU-ETS Directive governs the introduction of EU-ETS II from 2027, or possibly from 2026 if energy prices are very high, with no set time limit, meaning it will continue beyond 2030 without revision. In the context of the 2040 climate protection target, various adjustment options are being evaluated. Under the assumption that the linear reduction factor will continue, the cap will reach zero by 2044.

Potential impacts of the proposed 90% reduction target by 2040 on EU-ETS II

In addition to raising the linear reduction factor and setting more ambitious targets, there is significant discussion about expanding the scope of EU-ETS II to cover more sectors and greenhouse gases – with the idea of sharing the burden among more sectors. Unlike the national emissions trading system, the EU system has a sector-based scope. Fuel emissions from the industry sectors (outside EU-ETS I), buildings, and transport are included, while emissions from other sectors, such as agriculture or rail transport, are not. EU-ETS II is considered less ambitious than the national emissions trading system.

Article 30j of the EU-ETS Directive allows member states to unilaterally include additional sectors starting in 2027. Austria and the Netherlands have been the first to request the inclusion of emissions from rail transport and specific emissions from fuel consumption in agriculture, forestry, and fisheries with the European Commission. To ensure the continuity of fuel emissions pricing already covered by the national emissions trading system, Germany is planning to include fossil fuel emissions from agriculture, forestry, rail transport, and waste incineration (outside of EU-ETS I) in the EU-ETS II as part of the revision of the Greenhouse Gas Emissions Trading Act (TEHG). The plans of these three member states could serve as a model for an EU-wide integration of these emissions by 2030.

Managing residual emissions in EU-ETS II

Just like in EU-ETS I, regulations for dealing with residual emissions must be created for EU-ETS II. For municipal companies as fuel suppliers, the direct impact will decrease with the structural reduction in the use of fossil fuels, especially in supplying private households. However, their role as district heating network operators will increase in importance.

Interaction between EU-ETS II and other regulations

Auction revenues in EU-ETS II will primarily be used to finance climate policy measures, subsidies, and hardship compensation (e.g., Social Climate Fund). The same considerations regarding the development of auction revenues as in EU-ETS I apply, with the distinction that there is no provision for free allocation in EU-ETS II. However, there are opportunities here for building local infrastructure to ensure the availability of affordable, climate-friendly energy. A notable example is the geothermal project in Munich, which could drive decarbonization while simultaneously promoting regional economic growth.

Linking EU ETS I and EU-ETS II

From an economic theory perspective, expanding the scope of an emissions trading system lowers overall economic costs and increases the instrument's efficiency, which is why linking the systems is frequently suggested. In practice, linking in the industrial sector could lead to uniform reduction incentives. However, linking systems with different sectoral cost structures could result in distorted incentives or disproportionately high burdens if technological transformation is not feasible in certain sectors in the short term.

This concern is already relevant for EU-ETS II, where transport and buildings, two very different sectors, are subject to a single price.

In addition to linking the existing systems, there is also potential for linking with the emissions trading systems of partner countries. However, this discussion has receded in the context of the Carbon Border Adjustment Mechanism (CBAM). There has also been renewed consideration of creating a third EU-ETS (EU-ETS III) to cover emissions from the agricultural and forestry sectors.

8.3.3 Challenges and opportunities for municipal companies in the context of the proposed 2040 target

The regulatory requirements at European and national levels and the challenges that will have to be overcome at grid level and in digitalization will lead to major upheavals and changes in the energy industry. Nevertheless, municipal companies in Germany are in a very good starting position for this transformation and have the potential to position themselves more strongly in the market: Not only do they enjoy a high level of trust from their customers, but in many places, they are seen as the first point of contact and carrier for the energy and heating transition locally. As a result, the expectations placed on municipal companies to be able to offer suitable solutions for end customers are correspondingly high. This offers great opportunities but also challenges for municipal companies as business models will change: The sale of energy and the operation of grids in the electricity, gas, and heating sectors have been among the most important business areas to date. However, not only will their generation, distribution, and sale change, but other business areas will be added, such as sector coupling, the digitalization of grid infrastructure, the development and operation of charging infrastructure for electromobility, the provision of car-sharing services, energy contracting in cooperation with industry and the housing sector, and energy and portfolio management, energy consulting, virtual power plants, storage technologies and innovative energy services, neighborhood development, broadband expansion, and smart city applications. Where small municipal companies cannot offer all their services, cooperation is an option.

Many municipal companies are already active as heat suppliers today and are the point of contact for the heat transition thanks to close local customer relationships. This may involve district heating, gas grids, electricity grids, and neighborhood- or building-specific solutions. As district heating is considered a key technology for achieving climate targets alongside heat pumps, the

challenges to be overcome are discussed in more detail below.

Germany has 3,800 individual heating networks over a route length of 36,000 km (2023) with an upward trend. However, district heating is unavailable throughout the country, with the expansion of district heating varying greatly from state to state: from 2.6% in Rhineland-Palatinate to 30.8% in Hamburg for residential buildings. District heating is much more widespread in northern and eastern federal states than in the west and south.

Net heat generation in heating grids in Germany in 2023 is currently dominated by conventional and fossil fuels (natural gas 45%, hard coal 12%, lignite 5%, non-biogenic waste 9%, other conventional energy sources 2%). Waste heat contributes 8% to net heat generation. Renewable energies have an initial share of 20% of grid-based heat generation but are to become completely climate-neutral by 2045 according to the Heat Planning Act WPG requirements. This figure illustrates the considerable effort that network operators will have to make in energy supply. In addition, district heating needs to be expanded at existing locations and new networks need to be established. District heating is enjoying increasing interest, considering that around one in four new builds in Germany would like to be connected to district heating - and the trend is rising. In 2023, 26.6% of building permits stated district heating as the heating type.

As a guide to what decarbonization approaches for local and district heating could look like, it is worth looking at Denmark, where the share of fossil fuels is only 25 percent. Most of the renewable energy currently still comes from biomass, but this is to be gradually replaced by large-scale heat pumps. The basis for this success is the high connection rate. Around two-thirds of all households in Denmark are connected to a district heating network. By 2030, 95 percent of district heating is to be based on renewable sources, including waste. In doing so, Denmark is focusing on a broad energy mix: in addition to wood and biogas, Denmark relies on solar thermal systems, which often have an output of more than 1 GW and are combined with heat pumps. Large heat pumps, as a key technology, are partly operated using innovative approaches such as waste heat or seawater as a heat source. In addition to the types of renewable energy used in Denmark, other renewable energy sources available in Germany include the utilization of unavoidable waste heat (with the newly introduced waste heat register as a basis for planning), deep geothermal energy, hydrogen-capable combined heat and power plants, biogas, power-to-heat plants in which surplus renewable electricity is converted into heat and coupling with central heat storage facilities.

There are various demands on policymakers to meet these challenges. Substantial investments are needed to build new heating networks, strengthen existing ones and switch to renewable energies. This requires planning security for the grid operators, which must be provided by market signals and strengthened by stringent change paths. Implementing local and district heating projects, in which the use of renewable energy sources and energy efficiency aspects are treated equally, can compete with gas supply and sales. This also requires clear political signals.

The German Federal Government's main funding instrument is the "Federal Funding for Efficient Heating Networks", or BEW for short. Homeowners' connections to a district heating network are subsidized with a 30-70% grant via the federal subsidy for efficient individual building measures (BEG EM). Political signals are needed here to maintain funding and back it up with an appropriate budget for the enormous investments required to expand and decarbonize heating grids.

In addition, there are obstacles to the development of renewable energies in the heating sector that should also be addressed by politicians. This includes the acceleration of planning and authorization processes and extends to insurance solutions, for example, to reduce the exploration risk associated with deep geothermal drilling.

Security of heat supply also plays an important role. This requires incentives for flexibility, such as heat storage and power-to-heat modules and combined heat and power generation at peak load times.

Homeowners are not obligated to connect to an existing or new district heating supply. The Building Energy Act (GEG) and the Heat Planning Act (WPG) have not made any changes in this respect. The Building Energy Act only stipulates that newly installed heating systems must be powered by at least 65 percent renewable energy in the future. In the case of district heating, this requirement is automatically deemed to have been met, as the supplier is obliged to decarbonize its network per the provisions of the Heat Planning Act. A public connection and utilization obligation must always be measured against the principle of proportionality. Therefore, the connection to the heating network must be suitable for promoting the desired goal of increasing the use of renewable energies. However, alternative solutions are not prohibited: Even in the case of a connection and utilization obligation, it is possible to choose a building-integrated heating solution and opt out of this obligation with appropriate justification, such as the installation of an individual heating system based on renewable energies (opt-out solution). These political signals make it more challenging to achieve a high connection rate to a heating network and can, therefore, stand in the way of the prerequisites for the economic operation of a network.

Networking with the various local players (local authorities, local politicians, energy producers, citizens, institutions and associations, etc.) is also necessary to meet the enormous challenges, in which the municipal companies will be suitable players thanks to their knowledge of local structures and will therefore play a decisive role as cooperation partners.

9 Conclusions

With the European Green Deal, the EU has implemented a comprehensive reform agenda to align its climate policy with the goals of the Paris Agreement. While the net-zero target for 2050 was enshrined in law in the European Climate Law, the adoption of the Fit for 55 package aligns EU policies with the 2030 climate target.

The 2040 target was proposed in accordance with the requirements of the European Climate Law. It is therefore not surprising that the national policy measures are not yet in line with this. However, it is striking that national policies and measures are also not compatible with a linear path to the already legislated net zero target for 2050 but deviate from it quite significantly.

The impact assessment report is internally consistent in describing how the proposed 2040 target would be feasible and achievable. It proposes a challenging set of measures and lays out how it would be economically and ecologically sensible. It is plausible that the proposed 2040 target is a scientifical necessity to avoid dangerous anthropogenic climate change.

The pathway proposed in the impact assessment contrasts sharply with the member states' climate policy progress. While the impact assessment report points out that full implementation of the 2030 climate and energy framework is essential for the EU's path forward, most member states, including Germany, are not on track to meet their 2030 targets. The EU is therefore at risk of missing the 2030 target. This also jeopardizes the achievement of the proposed 2040 target.

It seems particularly challenging that European climate policy is entering a phase in which several critical elements must function simultaneously. Otherwise, there could be a risk of cascading effects. The new CBAM must be implemented in such a way that it effectively prevents carbon leakage, as the previous protection, free allocation, expires in 2034. The newly introduced ETS II has yet to prove its functionality. While it is similar to ETS I in many respects, there are important differences: as short-term reduction options are only available to a very limited extent and reduction measures often burden private households, it can be assumed that the market behavior will be different from that of ETS I. It will be crucial that the EU and the member states implement complementary measures and prevent social hardship. It is also particularly important that the transport sector does not further shift the necessary emission reductions at the expense of the heating sector. In view of the lower sensitivity of car transport to high CO_2 prices, there is a risk of this happening.

Since MS policies and measures are primarily focused on achieving the 2030 targets, it is crucial to first understand the underlying reasons for these failures and address them comprehensively. Without rectifying these challenges, the path to meeting both the 2030 and 2040 goals will be increasingly difficult.

Our analysis of the five largest emitters – Germany, France, Italy, Poland, and Spain - and the middle five emitters - Netherlands, Romania, Belgium, Czech Republic, and Greece - shows significant shortfalls, particularly in the energy (including commercial, residential, and small-scale combustion plants), transport (specifically road transport), agriculture, and waste sectors. The scale of the challenge for these larger emitters is such that, without meaningful progress in these key sectors, the EU's collective climate ambitions will not be met. The mitigation potential of smaller member states is simply insufficient to offset these gaps.

The greatest emitters cannot achieve their goals if they do not solve their biggest problems. Road transport in particular stands out here. Emission reductions in this sector lag significantly behind, jeopardizing the EU's overall target achievement.

Time is of the essence. Delays in addressing key emissions sources will impose ever-increasing mitigation pressure on future years and drive up costs, with the financial burden increasingly felt through heightened compliance obligations under ETS II and the ESR.

In industry and manufacturing, the main challenges result from a high dependency on

infrastructure, particularly regarding hydrogen, CCS, and the power grid. Decarbonizing the sector while transitioning to a new carbon leakage regime necessitates substantial investments amid elevated risks.

Municipal companies also play a critical role. Successful mitigation almost always relies heavily on robust infrastructure. Here, local actors are essential. They manage critical services like district heating, waste management, public transport, and power generation, all of which are central to decarbonization efforts. Rising costs due to delayed action threaten their ability to lead on climate solutions and may erode the financial stability needed for further investment.

With strong community trust, municipal companies are well-positioned to drive the energy transition from the ground up, providing a more effective and widely accepted approach to meeting both, the 2030 and 2040 climate targets.

List of abbreviations

1) BECCS - Bioenergy with Carbon Capture and Storage
2) BEG - Federal Funding for Efficient Buildings (Germany)
3) CBAM - Carbon Border Adjustment Mechanism
4) CCS - Carbon Capture and Storage
5) CCSU - Carbon Capture, Storage, and Utilization
6) CO_2 - Carbon Dioxide
7) EFSI - European Fund for Strategic Investments
8) EEG - Renewable Energy Sources Act (Germany)
9) EIB - European Investment Bank
10) EmoG - Electromobility Law (Germany)
11) ESR - Effort Sharing Regulation
12) ETS - Emissions Trading System
13) ETS I - Emissions Trading System I
14) ETS II - Emissions Trading System II
15) FEC - Final Energy Consumption
16) GAE - Gross Available Energy
17) GEG - Building Energy Act (Germany)
18) GHG - Greenhouse Gas
19) HGV - Heavy Goods Vehicle
20) InvestEU - InvestEU Program
21) JTF - Just Transition Fund
22) KrWG - Circular Economy Act (Germany)
23) KSG - German Climate Protection Act
24) KSpG - Carbon Dioxide Storage Act (Germany)
25) LULUCF - Land Use, Land Use Change, and Forestry
26) MSR - Market Stability Reserve
27) nEHS - National Emissions Trading System (Germany)
28) NZEB - Near Zero Energy Buildings
29) ProgRess III - Resource Efficiency Program (Germany)
30) RFNBO - Renewable Fuels of Non-Biological Origin
31) RES - Renewable Energy Sources
32) SMR - Small Modular Reactor
33) TEHG - German Greenhouse Gas Emissions Trading Act
34) WAM - With Additional Measures (scenario)
35) WEM - With Existing Measures (scenario)
36) WPG - Heat Planning Act (Germany)
37) ZEV - Zero Emission Vehicle

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IPCC sectors classification

The IPCC sectors classification breaks down GHG emissions into four main sectors. Each sector is clearly defined, covering specific types of activities:

1. Energy: This sector includes emissions from all activities related to energy production and consumption. It includes:

- **Energy industries**: Such as public electricity and heat production, petroleum refining, and the manufacture of solid fuels.
- **Transport**: Emissions from road, rail, aviation, and domestic navigation.
- **Other sectors within energy**: Includes smaller combustion activities like residential heating and commercial/institutional energy use.

Note: Although manufacturing activities consume energy, in this classification, emissions from energy use within manufacturing industries are counted under the Energy sector, specifically under **manufacturing industries and construction**. This sub-sector focuses on emissions resulting from the combustion of fuels for energy purposes in industries like iron and steel production, chemicals, and food processing.

2. Industrial processes: This sector includes emissions generated from the **processes** involved in material production, not from energy use. The emissions come from chemical reactions and industrial activities, not from the fuel combustion typically associated with energy production. It includes:

- **Mineral products**: Such as cement, lime, and glass production.
- **Metal production**: Including iron, steel, aluminum, and other metal manufacturing.
- **Chemical industry**: Emissions from chemical production processes like ammonia or nitric acid manufacturing.

3. Agriculture: This sector addresses biological and land-use activities that emit GHGs. It includes:

- **Manure management**: Emissions from the storage and treatment of animal waste.
- **Crop production and agricultural soils**: Emissions from fertilizer use, soil management, and tilling.
- **Field burning of agricultural wastes**: Emissions from burning agricultural residues in the field.

4. Waste: This sector deals with emissions from waste handling and disposal, including:

- **Biological treatment of waste**: Composting and anaerobic digestion of waste materials.
- **Incineration and open burning of waste**: Emissions from burning municipal, industrial, and clinical waste.
- **Wastewater treatment and discharge**: Emissions from sewage and industrial water treatment.

The German climate law uses different sector classifications. The exact assignment of the data from reporting according to IPCC guidelines to the sector classifications of the German climate law can be found in the legal text.

Source: European Environment Agency. (2019). *EMEP/EEA air pollutant emission inventory guidebook 2019: Part B - Sectoral guidance chapters.* Europa. https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters

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