STRATEGIC PERSPECTIVES

Choices for a more Strategic Europe

‘Choices for a more Strategic Europe’

The EU triple opportunity for energy security, reindustrialisation and competitiveness based on scenarios for 2040.

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Choices for a more Strategic Europe

STRATEGIC PERSPECTIVES

Introduction

Amid the global COVID pandemic, European leaders strengthened the European Green Deal by committing to reduce net greenhouse gas emissions by 55% by 2030. The associated laws became the guiding framework for a decarbonised economy and 'green recovery'. Even then, its promises were compelling: to boost the European economy, create local jobs and stimulate investment in climate-friendly business solutions. In response to Russia's war in Ukraine, Europe recommitted to energy savings and renewable energy to cut Russian fossil fuel supplies as quickly as possible. By accelerating its energy transition, Europe is increasing its security and reducing finance that could go to Russia's military.

Implementing the European Green Deal has become the smartest economic and security choice. The findings of the 'Turning the European Green Deal into Reality' report[1] are clear: implementing the 2030 laws could reduce gas and oil consumption by a third by 2030, deploy renewable energy 3.2 times faster than in the last 20 years and reduce electricity prices for consumers by more than 7%. Reducing its fossil fuel dependence is also creating greater economic and geopolitical resilience, as gas, oil and coal prices were a driving force behind high inflation in Europe in the past year. The net-zero transition ensures energy security and affordable energy, which are major competitive advantages for the European economy and its citizens. The additional investments are estimated to be around 351 billion Euro by 2030, but could reduce the EU's gas and oil import bills significantly[2].

Acceleration of the energy transition and reindustrialisation have become the strategic response to both the pandemic and Russian war in Ukraine. The growing competition between the US and China for leadership in net-zero technology manufacture points to their alignment in seeing the economic, geopolitical and security advantages of decarbonising their economies. The European Union can choose a path that builds further on an open single market with clear standards, diversified supply chains and reinvigorated domestic industry. It is in Europe's interest to create a framework and new economic partnerships that incentivise other economies to decarbonise as well.

Beyond 2030, the recent scale and speed of renewable energy, electric vehicle (EV) and heat pump deployment will become the new norm. However, **the anticipated transformation through electrification, the circular economy and modernising European industry requires a stronger enabling framework for 2040.** Planning for the net-zero transition beyond 2030 is the natural next step as it provides the necessary clarity on the milestones towards achieving climate neutrality by 2050 at the latest. Agreeing to the post-2030 climate targets provides additional predictability to businesses and financial actors about the right investment choices and areas that need further innovation.

Strategic Perspectives recommends agreeing to the 2035 and 2040 climate targets in the first half of 2024 as they can then be instrumental in guiding the mandate of the next European Commission. The Commission will be able to factor them in when proposing a new financial architecture, including the next Multiannual Financial Framework (MFF), as well as the legislative framework, in order to enable the implementation of post-2030 targets across the economy.

Throughout this report, CLIMACT provided the modelling on the trajectories towards 2040 with the Pathways Explorer, an open-source energy simulation model. The findings inform Strategic Perspectives' analysis and policy recommendations in line with our expertise and priorities. Please note that they will not cover all sectors of the economy. A full overview of the analytical findings for each sector by CLIMACT's Pathways Explorer Tool can be found in the form of 'Fact Sheets' on our website www.strategicperspectives.eu.

Madrid, Spain

Analytical scope

This report sets out three scenarios leading up to 2040 with net-emission reductions of -85%, -90% and -95% compared to 1990, including carbon sinks (considered as part of land use, land use change and forestry [LULUCF])[3] and all international aviation and maritime emissions[4]. A net emissions target for 2035 is deducted from the different decarbonisation trajectories, with the base assumption of some measures already having an effect over the next few years and the 2030 laws effectively leading to an emissions reduction that is higher than -55%. The milestones indicated are based on early action, especially in the industry and power sector.

The three scenarios will be presented as 'Standard Scenario' (-85%), 'Visionary Scenario' (-90%) and 'Full Acceleration Scenario' (-95%).

The modelling undertaken by CLIMACT treats natural and technical carbon removals separately, as shown in Table 1. This approach also allows for transparency and increases robustness, especially regarding the frequent variation in estimations of land use sinks.

Table 1.

GHG emissions per category and scenario

Scenario	Unit	Net emissions 2040	Excluding			Milestone 2035[6]
		Base scope[5]	International bunkers	Removals[7]		Base scope
				Natural sinks	Tech.	
Full Acceleration Scenario: -95% net	%	**-95.5%**	**-96.9%**	**-85.7%**	**-84.9%**	**-82.2%**
	Mt CO_2e	210.4	97.3	-471.0	-35.51	843.17
Visionary Scenario: -90% net	%	**-90.2%**	**-92.8%**	**-81.8%**	**-80.6%**	**-79.2%**
	Mt CO_2e	462.5	155.4	-412.5	-61.35	1031.78
Standard Scenario: -85% net	%	**-85.4%**	**-88.3%**	**-78.2%**	**-77.0%**	**-73.2%**
	Mt CO_2e	690.9	176.3	-369.3	-59.37	1270.14

The Vltava River,
Prague, Czech Republic

Executive Summary

A Visionary Scenario

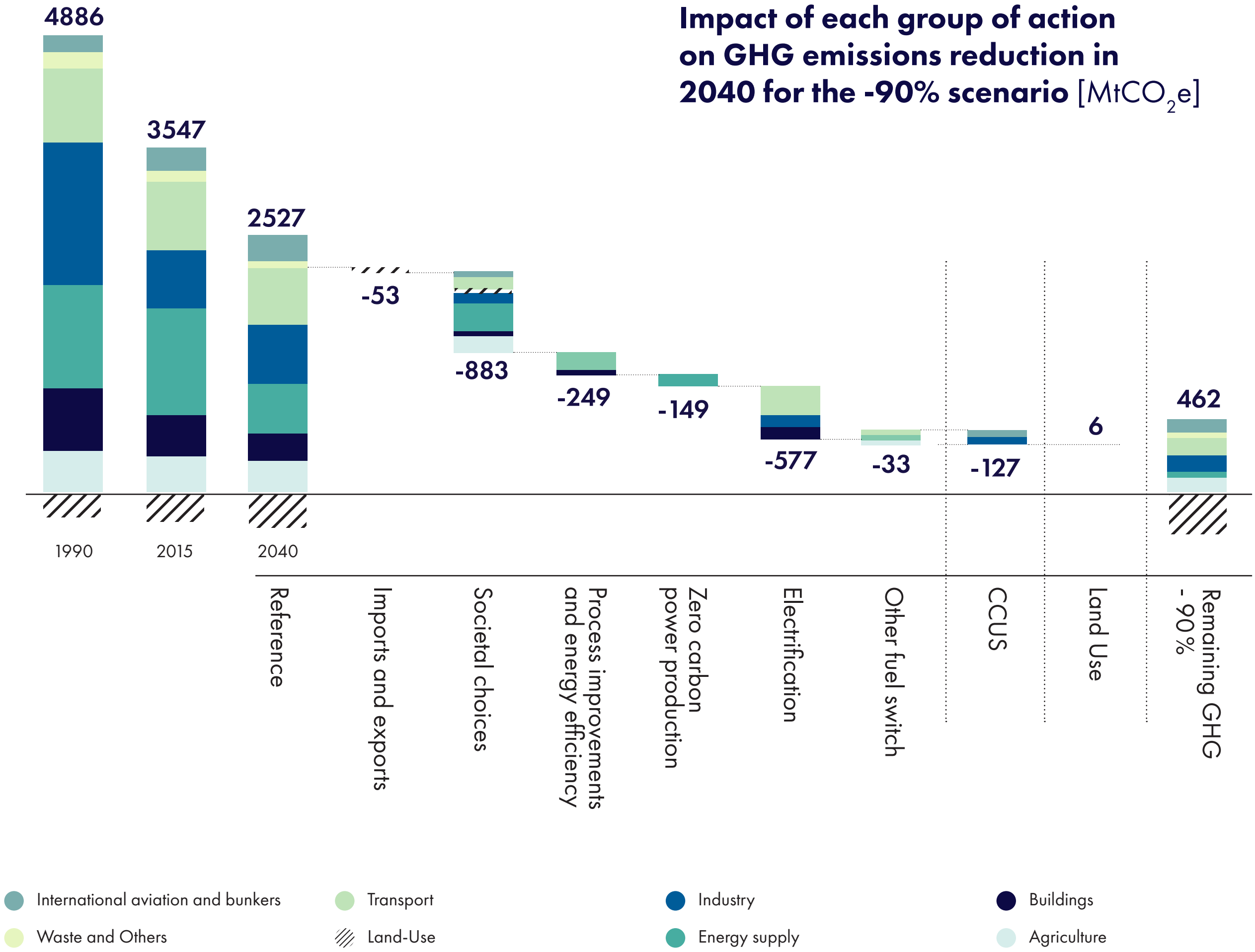
Based on the analysis of the three potential scenarios, Strategic Perspectives considers the Visionary Scenario a feasible pathway that provides a strong contribution by the European Union to the global effort to fight climate change. This scenario maintains the same pace of decarbonisation after 2030, approximately 3.3% greenhouse gas (GHG) emissions reduction per year. **This scenario reduces emissions fastest where it matters most, is feasible and cost effective in the power sector. It captures a commitment to making EU industry more competitive in a world of constrained resources, volatile energy prices and unreliable supply chains by embracing circularity and electrification.** Early action in the power and industry sectors is a strong asset, allowing other sectors to take sufficient time for technological innovation or systemic change. By pledging a -90% net reduction, the EU would incentivise innovation and transformation across sectors, clearly addressing the responsibility of sectors like agriculture, international shipping and aviation, where progress has been slow so far. **The Visionary Scenario maximises the electrification potential across sectors, sets clear phase-out milestones for gas consumption and endorses circularity.** It relies on technological innovation driven through policies, whilst maintaining a conservative approach to societal choices (i.e., lifestyle changes, individual demand reductions or behaviour changes).

The Visionary Scenario provides a strong basis for **rethinking Europe's energy security,** phasing out dependence on fossil fuels and redirecting money that is otherwise spent on imports towards enabling the transition. By 2037, gas would be phased out in the power sector, significantly reducing geopolitical risk and exposure to volatile markets. Only 17.4% of final energy consumption[8] would depend on fossil fuels, with remaining oil being mostly consumed in the transport sector and as feedstock (raw material) for the chemical industry. This would result in a new energy architecture based on massive deployment of domestic energy production, especially renewables, coupled with electrification and energy efficiency gains.

Similarly, this scenario incentivises a **reindustrialisation plan for Europe.** It represents a strong vision for the future for multiple sectors that prosper and create jobs based on a deep modernisation of the current industrial base and the scale up of net-zero technology manufacturing. Rapid electrification, investments in circularity and technological innovation have the potential to position Europe as a global leader, setting standards and maximising benefits in terms of employment. It would also make Europe more resilient to global supply chain shocks, thus ensuring its transition is achievable.

Within the Visionary Scenario, progress on electrification would be significant: 86% of the car fleet, 58% of heating and 63% of industrial energy demand can be electrified by 2040, replacing gas, oil and coal. Such a high degree of electrification across sectors would lead to an electricity demand of approximately 4019

Figure 1.
Impact of each group of action on GHG emissions reduction in 2040 for the -90% scenario [$MtCO_2e$]



Terawatt hours (TWh) by 2040 (compared to 2780T Wh in 2019). Only an accelerated deployment of renewable power production (reaching 80% of the electricity mix) would ensure rapid supply, whilst allowing sustainable decarbonisation of electrified end uses. This would require multiplying renewable capacities by four by 2040, corresponding to installing 70 Gigawatt (GW) of renewables per year. Additionally, reaching those targets relies on efficient use of energy. Failure to do this would necessitate even higher levels of renewable deployment, thus increasing costs and required resources.

As coal is already phased out by 2030, **fossil fuel power generation could be completely phased out by 2037.** This trajectory is credible given the current rapid deployment of renewables [9]. Electrification with a high renewable energy share would lead to end use efficiency gains, given over 60% of primary energy is wasted[10] as heat when electricity is produced from fossil fuels. Given the levelized cost of electricity is lower for renewable energy in comparison to fossil fuels, electrification then becomes a compelling business case.

Under a Visionary Scenario, societal choices, major gains in energy efficiency and the circular economy would also drive significant greenhouse gas emissions reductions in all sectors. For instance, policies supporting an increased modal shift to railways for goods and passengers would stabilise the aviation industry's steady growth. Strengthening trends of making public and active mobility (eg. cycling) more user-friendly in most European cities, coupled with the emergence of 'mobility as a service', could effectively lead to 20% of the car fleet becoming redundant. 'Mobility as a service' integrates various forms of transport and transport-related offers into a single, comprehensive and on-demand mobility service. Increasing the share of public transport would not only reduce emissions but also improve air and noise quality and, by extension, living conditions for citizens.

Industrial transformation also has the potential to reduce overall emissions, enhance competitiveness and improve resource efficiency of companies through the circular economy. The 'reduce, reuse, recycle' principle could achieve almost 50% reduction in greenhouse gas emissions in the industrial sector, whilst making European industry more resilient to supply shocks, more innovative and less dependent on primary raw materials. Under the Visionary Scenario, by 2040 the share of recycled materials would increase significantly in most energy-intensive industries. For example, 68% of steel, 64% of glass and 66% of paper production would come from recycled materials.

A new chapter of EU policy making

The current European policy framework has already initiated trajectories beyond 2030, notably the electrification of the car fleet. However, it is **not sufficient to drive a well-managed phase-out of fossil fuels in all sectors whilst supporting Europe's reindustrialisation.** The deep transformation of the economy after 2030 requires additional measures and a complementary enabling framework. The full overview can be found in chapter 4 - highlights include:

- **A new Energy Security Architecture:** Ending Europe's heavy dependence on burning coal, gas and oil imported from abroad can be achieved by electrifying large parts of the economy, using renewable energy and energy saving measures. The Visionary Scenario estimates 4019 TWh of electricity needed by 2040 in order to meet the demand of electrification across sectors. However, only if electricity is provided through zero emissions sources, can all sectors decarbonise in a cost-efficient way. There is currently no framework that scales up sufficient deployment whilst ensuring that the additional electricity needs are not met by fossil fuels. It will take: A European Zero Emissions Electrification Plan, phasing out fossil fuels with a just transition and more affordable electrified equipment.

- **An enabling framework for a competitive industry:** A clearer incentive scheme for electrification (direct and indirect), circularity and the scaling up of manufacturing of net-zero technologies are assets for a competitive European industry. The 2040 horizon allows proper planning of capacities and investments based on a cost-effective roll-out of net-zero technologies. Standards, quotas and new financial tools for the coming decade can support the modernisation and reindustrialisation. The co-benefits are clear: this can create thousands of quality jobs, improve European cohesion and position European manufacturers as global leaders.

- **A reform of the target and policy framework:** The major questions for the future climate architecture evolve around the definition of the future target and how target achievement can be secured at the national level whilst maintaining social cohesion and environmental integrity. A transparent and interactive target definition with three separate sub-goals for emission reduction, technological and natural carbon removals would allow effective monitoring and corrections if necessary. Special support can be given to countries that struggle to enhance their carbon sinks.

2040 pathways overview

Table 2.
Main indicators for each of the 3 scenarios

Indicator			2015	-95%	-90%	-85%
Fossil fuel share (of final sector energy demand)	**Total** [%]		/	12.1%	17.4%	20.4%
	Buildings	**Gas** [%]	32%	0%	0%	0%
		Oil [%]	13.6%	0%	0%	0%
		Coal [%]	2.8%	0%	0%	0%
	Transport, excluding international aviation and shipping	**Gas** [%]	~0%	0.3%	0.5%	0.8%
		Oil [%]	92.7%	37%	48%	53%
	Industry, excluding feedstocks	**Coal** [%]	12.8%	1.1%	2.6%	4.4%
		Gas [%]	32.2%	4.6%	8.9%	14%
		Oil [%]	9.3%	1.4%	2.5%	3.7%
	Industry, including feedstocks	**Coal** [%]	9.3%	0.9%	1.9%	3.3%
		Gas [%]	27.4%	5.8%	9.8%	13%
		Oil [%]	28.8%	20%	21.7%	22.6%
Renewable energy	**RES incl. biomass** [%]		20%	74.8%	68.0%	62.9%
	RES excl. biomass [%]		10%	65.3%	57.4%	52.5%
	Share in power production, incl. biomass [%]		32.3%	82.8%	81.2%	79.3%
	Share in power production, excl. biomass [%]		25.3%	77.5%	77.5%	75%
Share of efficient buildings	**Zero emission buildings** [%](< 85kWh/m^2)		0	39.4%	37.4%	32.2%
	Zero +energy plus buildings [%] (< 15kWh/m^2)		0	7.8%	7.4%	6.5%
	Average final energy consumption for space heating [kWh/m^2]		95	45.87	48.6	51
Green hydrogen	**local demand** [TWh]		0	460.5	482.31	512.55
	local production [TWh]		0	307.4	321.54	341.7
	imports [TWh]		0	154.1	160.77	170.85
Carbon capture and sinks	**CC & DAC, excluding LULUCF** [$MtCO_2e$]		0	73.75	80.75	79.26
	Net land sink from LULUCF [$MtCO_2e$] (includes sinks and sources)		-311	-470.9	-412.5	-369.29
Energy demand	**Primary** [PWh]		13.4	8.877	8.988	10.04
	Final [PWh]		12.25	7.209	7.671	8.308
	Final electricity consumption [PWh]		2.65	3.82	3.74	3.84
	Share of electrification of the economy		21%	53%	48.8%	46.2%

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CHAPTER I

Untapped potential to accelerate the electrification trajectory

For many sectors, electrification is the best business model for decarbonisation, in particular when zero-emission electricity is cheaply available. In 2030, at least 55% of the electricity consumed in the EU could come from solar and wind if the European 2030 laws are implemented. If it is produced in the European Union, companies are protected from supply disruptions or price shocks. This argument becomes even more compelling when one considers the recent price increases and volatility of liquefied natural gas (LNG). Energy efficiency and digitalisation can be an ideal addition for electrification as it can lower the increase of electricity demand. This will, in turn, reduce energy bills for companies and households.

The analysis shows that in the Visionary Scenario, 86% of the car fleet, 46% of the truck fleet, 63% of industrial energy demand (up from 30% today) and 58% of heating could be directly electrified by 2040. The electrification across sectors would lead to an increase in electricity demand to around 4019 TWh by 2040 (compared to 2780 TWh in 2019). Renewables are the only rapidly deployable source of energy that could match the pace and growing demand of the electrification trajectory of all sectors. The findings estimate 80% of renewables in the electricity mix in 2040 (reaching 862 GW of solar and 766 GW of wind).

The accelerated deployment of solar and wind in response to the Russian war in Ukraine has the potential to become the new normal. In 2022, 41.4 Gigawatt (GW) of solar photovoltaics[11] and 16GW of wind power[12] were added to the energy mix in the European Union, reaching a total of 208.9GW for solar and 255GW for wind respectively. The added capacity of

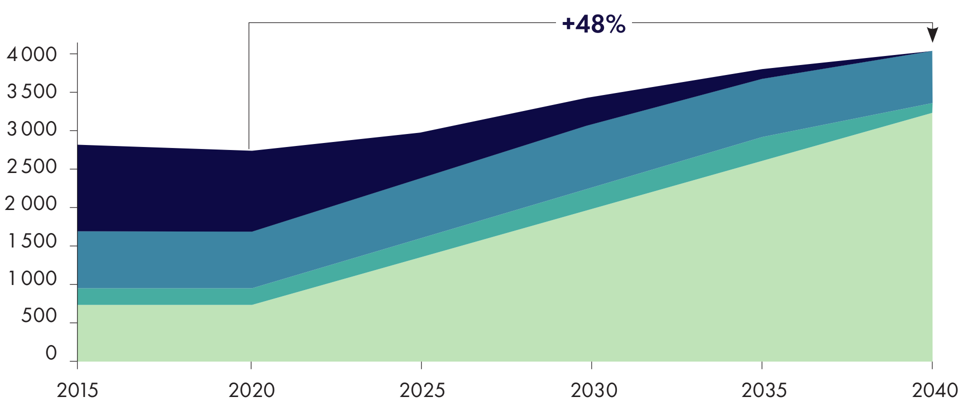


Figure 2. Evolution of electricity production [TWh]

solar matches the Visionary Scenario but the yearly wind capacity would need to scale up; this is realistic given current plans for offshore wind. If this rate of increase continues for solar and wind, electrification across the building, transport and industry sector could be fully exploited. This would be, however, conditional on meeting energy demand reduction targets as well, without which more extensive deployment will be necessary.

The 2022 rates are a clear sign that governments and business actors alike considered it the smart economic and security choice. **Renewable energies are the cheapest source of locally produced electricity, securing affordable power for businesses and households whilst reducing dependence on the international energy market.** They also enable a more local economic redistribution compared to fossil fuels.


Electric vehicle charging station

Current trends, projections and potential to scale up

The modelling for the Visionary Scenario envisages an **80% share of renewables in the electricity mix, with wind and solar alone accounting for 68.4%**. In total, solar and wind capacities would be multiplied by 4 between 2022 and 2040, allowing **fossil fuel electricity generation to decrease by 7% per year over the same period and to be completely phased out by 2037.** The use of biomass is also expected to decline for base-load power production, while the overall use is set to remain stable as the model envisages a small growth in the transport sector (mainly aviation and maritime) and industry. The plans by a series of countries to build new nuclear capacities[13], reaching up to 150 GW by 2050, could also contribute to the electrification goals. However, given the regular delays, increasing costs occurring between the planning phase and the actual start of operations, as well as the current phase-out processes in some countries like Germany and Spain, this analysis took a conservative approach towards nuclear power generation. Current capacities are reduced in the analysis by 10% by 2040 (in comparison to 2015), foreseeing around 100 GW of nuclear power that then contributes to the higher electricity and hydrogen demand.

Current trends of renewable energy deployment encourage confidence that 80% of electricity will come from renewables by 2040. The recent growth rates on solar photovoltaics are promising. If the rate stays above 40 GW per year, it is well on track to reach the envisaged 320 GW in 2025 and overachieve the 600 GW in 2030 as set out in the European Solar Energy Strategy[14]. Germany[15] alone plans to add 22 GW of solar capacity per year to reach its domestic target of at least 80 percent of domestic gross electricity consumption coming from renewable energy by 2030.

For wind, the 2022 installations of 19 GW[16] fell short of the anticipated 30 GW[17] per year for a renewable energy target of 40% by 2030 due to scarcity in the value chain and inflation affecting the onshore wind industry. These shortcomings need to be addressed soon, especially given the increased target of 42.5% outlined in the Renewable Energy Directive. However, the construction of offshore wind is expected to increase significantly over the coming years, reaching 300GW[18] by 2050. In 2020, eight[19] EU countries signed the Baltic Sea declaration[20] which sets out the aim to build offshore wind farms in the region, the potential energy addition being estimated at above 90GW. In September 2022 at the North Sea Summit, nine[21] EU countries pledged to build 193GW of offshore wind generation by 2040 and 260GW by 2050. Accelerating the deployment of renewables has the potential to cut electricity prices for European households and businesses by 7% by 2030[22], shielding them from higher bills due to gas price rises and inflation. This effect could be amplified by 2040 if the foreseen renewable energy share is met.
The electrification of road transport and heating is set out in the next paragraphs, whereas the electrification of industry will be covered in chapter 3.

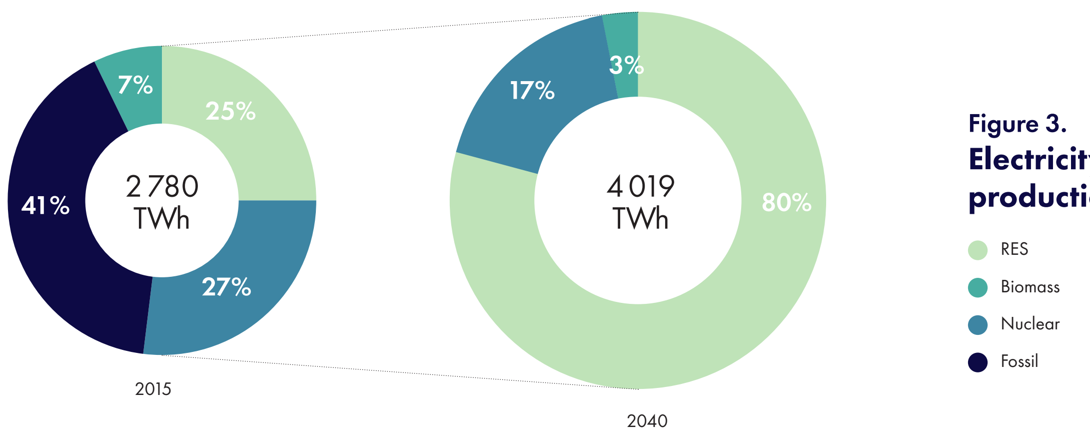


Figure 3.
Electricity production mix [%]

Electrification of road transport

The Visionary Scenario predicts that at least 86% of passenger cars on the streets would be electric in 2040. This represents the effect of new electric cars and light duty vehicles being sold on the European market as of 2035. In 2022, battery electric vehicles took 12.1% of the total market share in new car sales (compared to 9.1% in 2021 and 1.9% in 2019)[23]. At this rate, by 2030, one in ten cars will be electric, setting the pace for the next decade. In anticipation of the law, several car companies are planning to only sell electric cars after 2030: Renault, Mercedes-Benz, Stellantis, Volvo, Jaguar and Ford[24]. The European Commission has also proposed to only allow the sale of electric buses from 2030. The legislation currently under discussion to decarbonise the truck fleet has the potential to kick-start the electrification of the freight transport segment, which is currently one of the most polluting and least energy efficient. The analysis shows that 46% of trucks could be electric by 2040.

However, the remaining car fleet and heavy-duty vehicles are still expected to consume a significant amount of oil. This is also despite an anticipated increase in car sharing and active transport as cities create more space for walking and biking. In the Visionary Scenario, oil consumption in the transport sector (excluding the demand by international maritime and shipping) would still represent 48% of final energy consumption in 2040, partially due to internal combustion engines being less efficient than electric motors. The biggest share of remaining oil consumption is clearly in freight. Thus, only with additional incentives can the oil import dependency of the European Union be reduced more substantially. The European Commission has partially addressed this concern through its proposal on CO2 standards for heavy duty vehicles, suggesting a 90% emission reduction for new vehicles by 2040, but further reduction can be achieved by a shift to other modes of transport (see section 1.2).

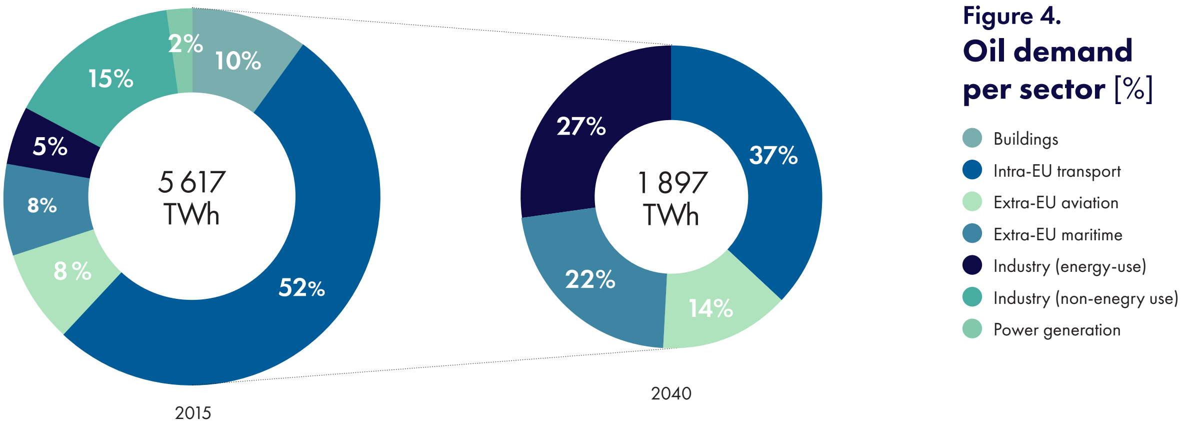


Figure 4.
Oil demand per sector [%]

Electrification of residential heating

In 2015, fossil heating (coal, oil and gas) still accounted for 57% of heating across Europe. In the Visionary Scenario, fossil heating would be gradually phased out by 2040 and replaced largely by heat pumps and district heating. **The share of electrified heating would reach 63%** (without district heating), including 12% electric heating and 46% by heat pumps. The EU-wide debate on policies that support the roll-out of heat pumps or other renewables-based systems is still ongoing. In 2022, heat pumps have seen an unprecedented demand across the European Union - in Poland alone, the demand for heat pumps surged 120%, while a record 500,000 heat pumps have been sold in Italy[25].

The analysis suggests that renewable heating will overtake fossil fuel heating in 2031. The heat pump installation rate will increase to 3% in line with the building renovation rate in order to moderate the increase of electricity demand. Additional measures are recommended to achieve this level of deployment, such as the ongoing discussions at European level to phase out the sale of new fossil fuel-fired boilers under the Energy Performance of Buildings Directive or the Ecodesign Directive.

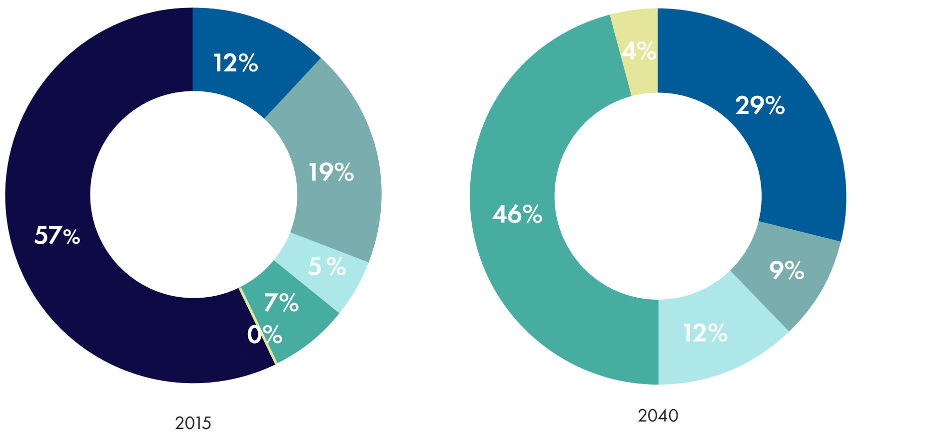


Figure 5.
Technolog mix in residential heating
[%]

Complementary measures to electrification

The anticipated electrification across sectors requires a range of accompanying measures to ensure its cost-effectiveness. Energy efficiency gains and other forms of demand reduction are the best way to moderate the overall growth in electricity needs.

In the **building sector** for example, in addition to replacing old fossil heating systems with renewable heating, deep renovation of buildings can reduce overall energy consumption and limit growth in electricity demand. Across the scenarios, a renovation rate of 3% from 2030 to 2040 applies. At least half of the buildings have an energy requirement below 85 kWh/m² and approximately 15-20% of the buildings will only have an energy requirement below 15kWh/m². European legislation such as the Energy Performance of Buildings Directive, which is currently under negotiation, could help accelerate the renovation of buildings in the coming years by setting a minimum energy performance requirement. It will be a key driver for reaching a zero-emission building stock by 2040.

Similarly, additional measures are needed to complement the electrification trend in **transport**. These can encourage a modal shift to further reduce oil consumption in Europe and improve energy efficiency. The areas of biggest potential are a shift from road to rail or barge in freight and, for passengers, the use of public transport or active mobility (walking and cycling) instead of the car. The use of trains for transporting people and goods will slightly increase to 13% and walking and biking would play a major role by accounting for 18% of the total mobility in cities under the Visionary Scenario.

These shifts towards public transports, 'mobility as a service' or active mobility would lead to a reduction of the car fleet by 20% by 2040. For example, the expansion of night trains and major investment plans to regenerate rail networks in France[26] and Germany[27] have the potential to contribute to an additional increase in low-emission mobility. Other measures such as the Klimaticket in Austria, Germany[28] and Spain[29] also facilitate access to public transport and create an attractive solution for a broader part of the population.

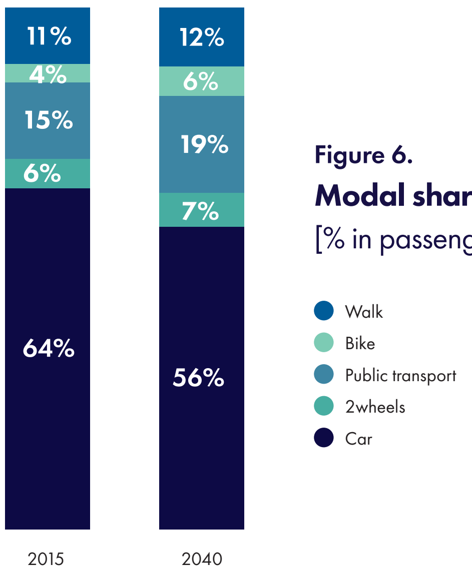


Figure 6.
Modal share urban
[% in passenger km]

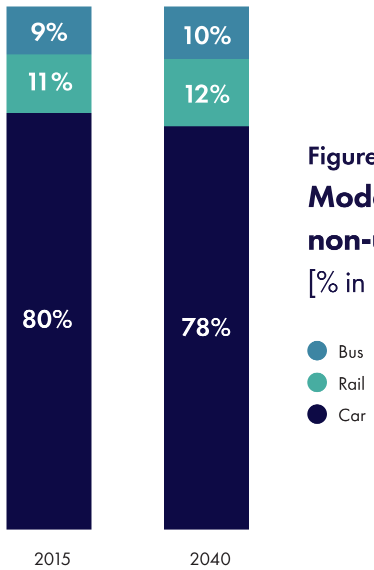


Figure 7.
Modal share non-urban
[% in passenger km]

In addition, **grid expansions** and modernisation will play a key role in enabling a high share of renewable energy to penetrate the grid. Given the fluctuations of renewable energy generation, governments and the private sector should improve demand side management and energy storage in conjunction with the higher share of renewable electricity.

CHAPTER 2

Fossil fuel phase-out as the best economic and security choice

The Russian war in Ukraine exposed Europe's vulnerability to supply shortages and the belligerence of the few exporting regimes who can exert their market powers to drive up prices or assert political pressure. **Despite the unprecedented deployment of wind and solar capacities as well as gas demand reductions, the European Union's gas import bill has risen substantially due to the sharp increases in prices.** The IEA[30] calculates that the European Union paid 400 billion Euro for gas imports in 2022, more than three times the level in 2021. In addition, Bruegel[31] estimates that EU governments allocated 646 billion Euro to shield consumers from the rising costs since the start of the energy crisis in September 2021.

Whilst spending this trillion Euro was politically and socially necessary, it meant that it was not invested in accelerating the renovation of houses, the deployment of renewable energies or other measures that reduce the European gas and oil demand. Diversification of fossil fuel suppliers can only be an interim solution. Given the EU's limited domestic oil and gas resources, fossil fuel imports expose the EU to volatile prices and geopolitical risks. **Setting a clear trajectory for fossil fuel demand reduction is, therefore, the best economic and security choice.** According to findings from our 'Turning European Green Deal into Reality' report, the 2030 laws can already reduce the consumption of gas by 31% and of oil by 34%[32] while coal is no longer cost-competitive and thus phased out. Effective demand reduction policies, especially for gas, must become a key pillar of the 2040 policy framework, **designing a new energy security architecture**.

Power plant,
Groningen, Netherlands

Current trends and policy projections

Whilst a short-term increase in coal use occurred in 2022 due to the urgent need to substitute Russian gas, this is not expected to delay the coal phase-out across Europe. All EU countries have a coal phase-out plan, except Poland. The European carbon market will make coal increasingly uncompetitive, as the current[33] European electricity market rules no longer allow coal plants to be subsidised under the capacity reserve mechanisms from 2025. The oldest coal plants are expected to close by then.
In the Visionary Scenario, coal would be largely phased out by 2030. Keeping large shares of coal in the system beyond 2030 is not cost-efficient[34] and risks unnecessarily delaying or undermining the decarbonisation of sectors that electrify, while increasing electricity prices for consumers and companies. **A serious concern arises from the fact that many governments and companies do not anticipate these market dynamics and, therefore, do not plan for a just transition of coal workers in the coming years**. This is irresponsible and could cause disruptions and social unrest in the regions affected.

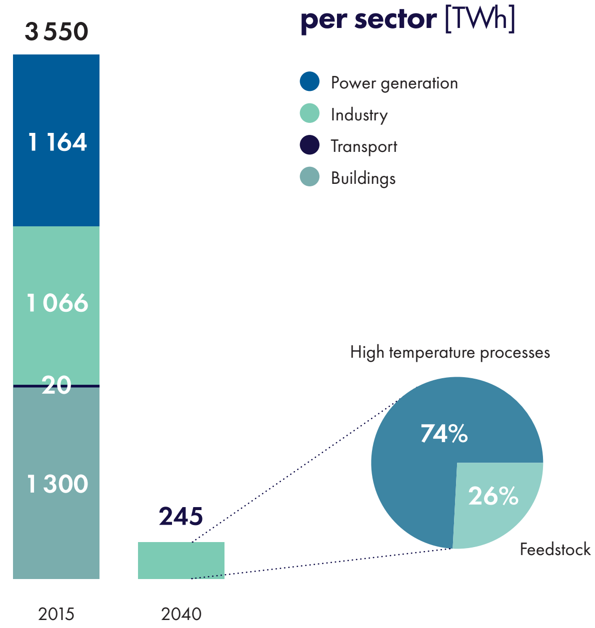
Additional policies and measures, especially in the transport sector, can accelerate the electrification of the vehicle fleet currently on the road and support modal shift. The incorporation of the shipping and intra-EU aviation emissions in the ETS can incentivise the fuel switch in these sectors.
This report will not cover complementary policy measures that might be required in those sectors but this chapter will focus on the necessary policy innovations to reduce the gas demand effectively.

A structural gas phase-down is a major opportunity to enhance the EU's energy security. The adopted EU climate and energy laws for 2030 could lead to a 31% reduction[35] in gas demand by 2030. We know that additional energy savings plans can further reduce gas demand: the Emergency Legislation, for instance, adopted to reduce gas demand resulted in a 19.2% cut or 41.5 billion cubic metres (bcm) reduction between August 2022 and January 2023[36], compared to the average of the previous five years. In this period, lower heating by households and reductions by industry each accounted for around half of the total achievement. Only small savings occurred in the power sector due to low availability of hydropower and lower nuclear capacity.

The Visionary Scenario envisages gas to be structurally phased out of power by 2037. By 2040, the share for gas use in buildings would be phased out in line with policy proposals and its use for industry reduced from 27.4% today to 8.9%. **However, there are currently no policies in place that actually incentivise a well-managed gas demand reduction in any of these sectors.** The Commission suggests[37] national roadmaps for phasing out the use of fossil fuels in heating and cooling by 2040. According to the proposal for the Energy Performance of Buildings Directive (EPBD), EU countries should include these roadmaps in their National Energy and Climate Plans (NECPs). Leaving the demand reduction measures and incentives to national level risk assessment could create a patchwork of policies across the Single Market.

A smarter way to design demand reduction policies across sectors should be explored over the coming years. According to the Visionary Scenario, the gas demand in 2040 would be reduced drastically:

Figure 8.
Fossil gas demand per sector [TWh]



Power

The Group of Seven (G7) have agreed to predominantly decarbonise electricity by 2035, given it makes economic sense to reduce emissions in power first. Within the European Union, however, there are no policies that guarantee that France, Germany and Italy will meet this commitment. The renewable energy target of 42.5% by 2030 is a measure to substitute gas without effectively regulating its full decline. The agreed linear reduction factor in the ETS will lead to no new allowances entering the market after 2038, meaning the power and industrial emissions covered should reach net-zero in 2039 accordingly. However, the current policy design does not provide incentives for a cost-effective phase-out of coal and gas in the power sector as early as 2037. Complementary measures are set out in chapter 4.

An orderly gas phase-out trajectory is the only way to regulate the decarbonisation of the power sector. A very marginal amount of gas might be used 'as a last resort' in the sector to allow for demand flexibility in case of emergency situations, such as limited stored power that could not be discharged to the grid. However, this should not distract from the political signal of a fully decarbonised power system in 2037. This would also allow for effective cross-border planning to ensure sufficient power supply across EU countries and solidarity measures in case countries face shortages.

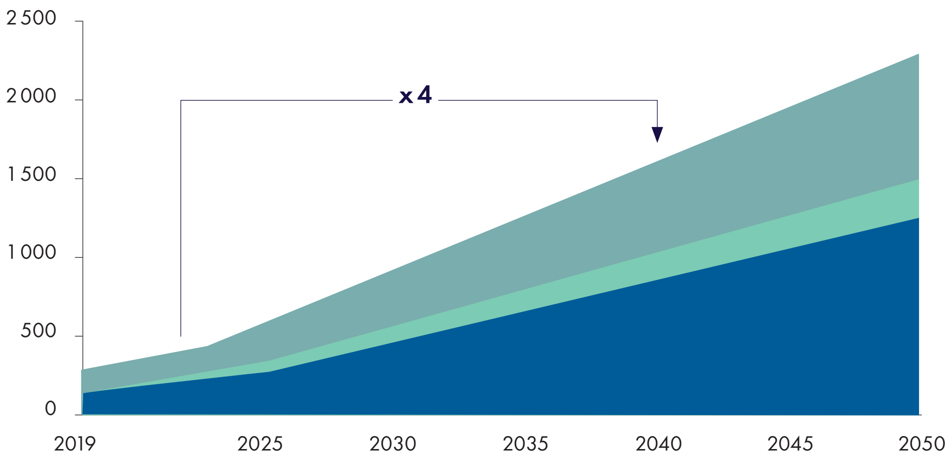


Figure 9.
Visionary Scenario Installation of new renewable capacities [GW]

- RES wind-onshore
- RES wind-offshore
- RES solar pv

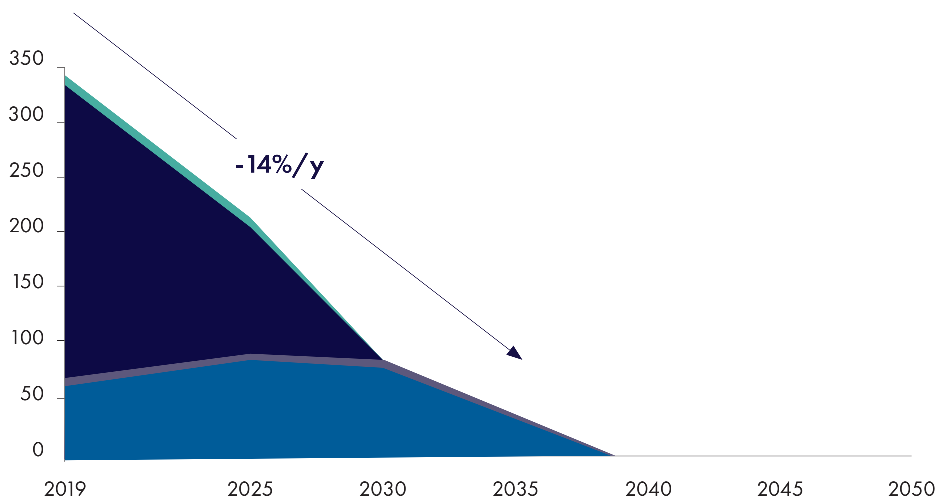


Figure 10.
Fossil fuel phase-out in electricity generation [TWh]

- Waste
- Coal
- Oil
- Gas

Buildings

The Visionary Scenario envisages a gas phase-out in buildings by 2040 in line with the European Commission proposal for the revised Energy Performance of Buildings Directive (EPBD). Given the diversity of heating systems across Europe, EU countries are expected to draft national roadmaps.

Some countries are planning a gas phase-out well ahead of 2040. The Netherlands has put legislation in place to phase out gas in buildings, with an interim target of 1.5 million gas-free homes out of 8 million by 2030. This is accompanied by a ban on new stand-alone fossil fuel boilers by 2026[38] and a national 'Gas-Free Districts Programme'[39] by municipalities to deploy more district heating and heat pumps. Also, France is aiming to end the sale of new gas boilers by 2026. A European plan to support gas phase-out in buildings could help all EU countries align. The following overview of the technology mix of residential heating gives a clear picture of the growth and transition trajectory.

Financial incentives and support, especially for low- and middle-income households, will be vital to ensure the transition is affordable. The Social Climate Fund provides one instrument to support households directly – provided the available amounts are sufficient.

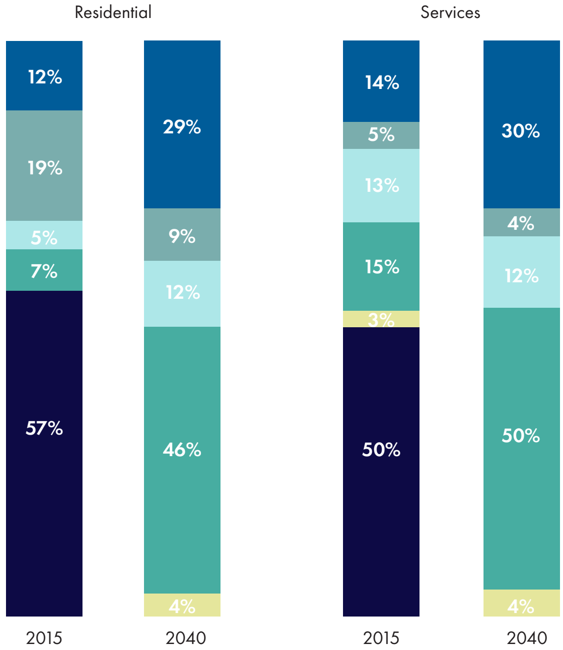


Figure 11.
Technology mix in space heating [%]

- District heating
- Biomass
- Electricity
- Heat pumps
- Solar thermal
- Fossil

Industry

The gas demand reduction that occurred in response to the Russian war in Ukraine is not permanent and prices remain volatile. Some industrial sites had to cease production due to rising energy prices, especially in the paper and glass industries[40]. **Companies therefore have a range of strong incentives to embark on a decarbonisation trajectory, most prominently the expected gas price hikes, scarcity and volatility in combination with the need to reach net-zero in 2039 in line with the ETS.** The gas use in industry would reduce to 8.9% under the Visionary Scenario. The remaining gas would be used by companies not participating in the ETS or as feedstock.

The combination of measures that would drive down the gas demand in industry will be set out in the next chapter.

Barcelona, Spain

CHAPTER 3

Future European industry

The United States' Inflation Reduction Act (IRA) exposed the patchwork approach the EU institutions have taken to drive the transition of European industry. **Whilst the European Commission has published a series of industrial strategies over the last decade, there has never been a meaningful political debate on what the future European industrial base should look like.** The IRA appeals through its simplicity and the anticipated effectiveness of its financial support (500 billion USD in spending and tax breaks). In addition, the strong incentive to 'reshore' manufacturing and to help the US become a market-leader in key technologies has sparked the debate about the need for a response in Europe.

The European carbon market (EU ETS) provides a decarbonisation trajectory that should incentivise industrial sites to invest in energy efficiency, the circular economy and electrification of their processes. **However, an historically low carbon price and the lack of other robust European policies have led to slow progress on the modernisation of the industrial sector.** This leaves the current European industrial base vulnerable to price hikes and supply chain disruptions, meaning a need to transition fast.

The COVID19 pandemic, the Russian war in Ukraine and the energy crisis have exposed vulnerabilities in the European industrial model. The heavy dependence on imported fossil fuels is costing European companies dearly compared to other economies[41]. Energy-intensive industries, whose business models depend on the availability of cheap and abundant energy, have suffered from the volatility of energy prices in recent months and some industrial sites have even had to temporarily stop production. According to the European Commission, which recognises that the era of abundant and cheap fossil fuels is over, this risk is here to stay if no decarbonisation plan is adopted.

The high reliance on China for key net-zero strategic technologies and materials to deliver European decarbonisation also leaves the EU vulnerable. China dominates key transition technologies and controls the supply chain of critical materials for the transition, especially rare earth. Notably, the IRA was primarily designed as a US response to China and an investment plan to create an integrated American value chain for key technologies that help achieve the US' climate targets.

The discussion on the EU's next 'Strategic Agenda' for 2024-2029 is a major opportunity to build a holistic vision and policy framework for European reindustrialisation. The decarbonisation of the current industrial base, the diversification of suppliers as well as growing European domestic net-zero manufacturing and mining are paramount to ensure the success of the European industrial transition. Modelling the pathways to 2040 allows for having the necessary data on technology mixes, including availability of secondary raw materials and imports.
Some initiatives have already been launched by the European Commission to address some of these challenges: for example, the Circular Economy Action Plan (CEAP) which aims to improve the 'reduce-reuse-recycling' principle and the Net-Zero Industry Act that seeks to facilitate the conditions of net-zero technologies manufacturing. The underlying analysis for this report shows that additional measures are the only way to achieve a net-zero emission goal by 2039.

Copenhagen,
Denmark

Trends and policy projections for the current industrial base

Energy-intensive industrial emissions have been stable since 2012[42] with only limited reductions due to process efficiency and renewable energy use. With the adopted 2030 policies, industrial emissions could be reduced by 29 % by 2030[43]. Becoming more resilient to gas price hikes and volatility or potential supply shocks is a strong incentive for industry to decarbonise. **Direct electrification, circularity, and green hydrogen are the main facilitators of industry modernisation**.

As figure 12 shows, the potential to reduce emissions through circularity, electrification, process improvements and energy efficiency is significant in the industrial sectors covered by the ETS. This brings benefits in terms of reduced dependence on raw material imports, cost savings in comparison to applying removal technologies and the added advantage of modernising industrial plants.

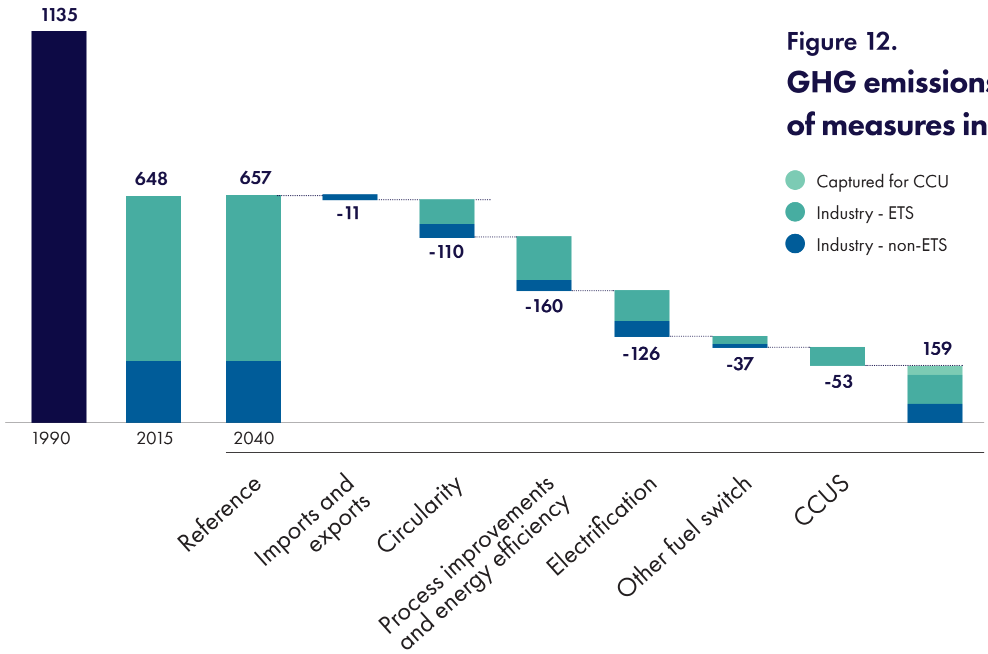


Figure 12.
GHG emissions reduction by type of measures in the industry [MtCO2]

Electrification

The direct and indirect electrification of industrial processes has an untapped potential to make European industry more resilient to gas and coal price volatility and to accelerate decarbonisation of the sector. In the Visionary Scenario, 63% of final energy demand would be electric with both primary and secondary processes[44] electrified. The indirect electrification would be achieved through hydrogen production. Direct and indirect electrification of primary processes would represent 25% of industrial emission reduction, whilst also contributing to another 25% reduction coming from recycling.

Low temperature industrial heat processes could be largely decarbonised by 2035 as most of the technologies are available on the market and could represent a competitive advantage. Heat processes below 100°C account for 40% of industrial gas demand[45]. A large and rapid electrification through industrial heat pumps represent possible 'low hanging fruit' for certain industrial sectors. This is the case for the food, beverage, packaging and textile sectors. Switching to industrial heat pumps and electric cooling systems, especially in the food industry[46], could drive major efficiency gains in the coming years, maximising the use of electricity and heat waste.

Some pilot projects[47] give confidence that high performance heat pumps, reaching temperatures of up to 200°C, will be available on the European market in the coming years. This will allow electrification of more industrial processes. Already today, for medium temperature requirements, heat pumps can be coupled with mechanical vapour recompression or an electric boiler, creating temperatures up to 500°C. Heat pumps, electric boilers and electric cooling systems can play a key role in decarbonising chemical industry processes, which account for one third of the total industrial gas demand in Europe. **Electrifying the chemical industry represents the most important industrial emissions reduction potential in the next decade**. According to Agora Energiewende[48], other technologies such as solar thermal energy (STE) have some potential in Southern Europe.

Some high-temperature industrial processes can also be covered by electrification: cement, lime, glass, steel and chemical. Taking the example of steel, the strong development of circularity would allow electric arc furnaces (EAF) to significantly increase their share of steel production from scrap from 43% today to 68% in 2040. To maximise efficiency, EAFs are mainly used for recycling steel and can reach up to 3500°C. Despite these high temperatures, **the resulting additional electricity demand would remain** limited to 56% more compared to 2015. Substantial efficiency gains could be achieved as scrap-EAFs consume less energy than primary production. Most of the increase in electricity demand would, therefore, come from the remaining primary production of steel, which would almost totally shift to hydrogen (indirect electrification). It would be partly compensated by a small decrease in steel demand.
Under the Visionary Scenario, the electrification of the industry contributes to restoring its global competitiveness by making it less vulnerable to fossil fuel price volatility and geopolitical threats. One of the conditions of this successful industrial electrification will be to ensure industrial plants have access to cheap and reliable electricity from renewable sources.

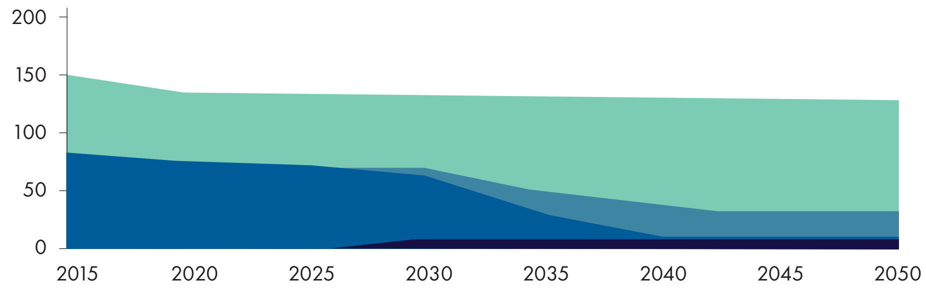


Figure 13.
Steel production by technology [Mt]

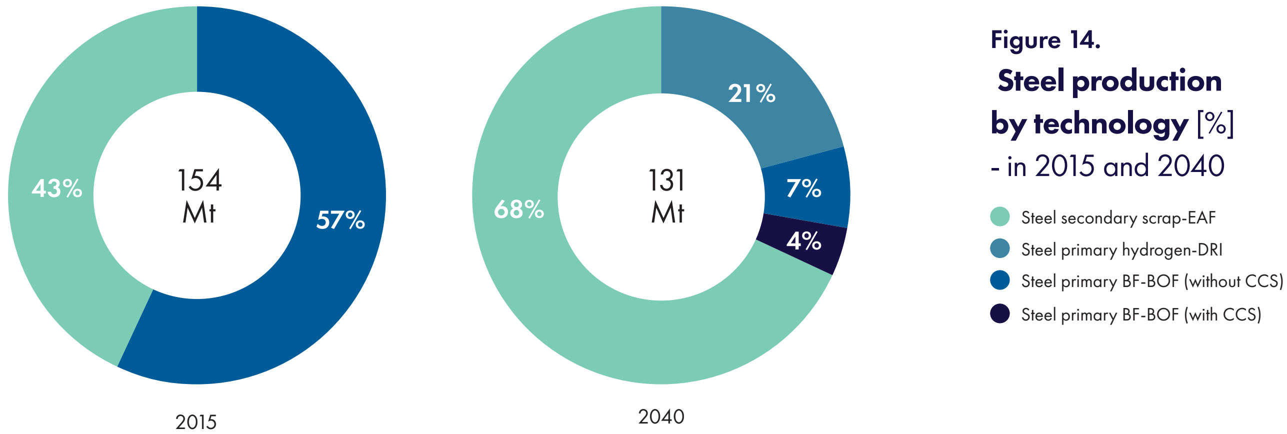


Figure 14.
Steel production by technology [%]
- in 2015 and 2040

Green hydrogen

High temperature industrial processes that are not easily directly electrified will benefit from the targeted use of hydrogen, while green hydrogen allows for the biggest emission reductions. Converting coal-based steel plants (BF-BOF) to green hydrogen steel plants (H2-DRI-EAF) is a key step in the decarbonisation of the sector. Hydrogen could be used both as a feedstock to replace blast furnaces (and thus coal for iron) and as a means of achieving high temperatures. 21% of steel production could be decarbonised through this process. The EU-funded Hybrit pilot project[49] aims to enable the Swedish company SSAB to launch fossil-free steel in 2026. Other steel producers[50] could follow in the coming years, depending on the availability of green hydrogen, such as ArcelorMittal's plants in Bremen or Dunkirk, Voestalpine in Austria or LKAB in Sweden.

However, this requires a significant amount of green hydrogen to be available. Hydrogen production is a relatively inefficient use of electricity, especially when adding the losses from compression, transport and storage to the 30% of the electricity already used by electrolysers that form part of the process. Therefore, as the economy becomes increasingly electrified, **hydrogen end use should be prioritised in sectors that are difficult to electrify** which is the case for some industrial applications. The use of hydrogen in road and rail transport or in heating of buildings risks wasting significant amounts of energy and driving electricity prices up unnecessarily. Direct electrification is the most cost-effective way forward. Indirect electrification can be necessary in some sectors such as the maritime sector or some parts of road freight, but it should be well targeted and deployed with caution given the limited availability of green hydrogen and the security risk associated with it.

In 2040, under the Visionary Scenario, 332 TWh of hydrogen will be needed for the European economy, with 60% of that needed for the production of e-fuels for the aviation and maritime industry. In the analysis, **as of 2035, 100% of the hydrogen is considered green, both for local production and for imports.** Roughly one third of green hydrogen would be imported in the Visionary Scenario, either via dedicated pipelines or shipped as green ammonia. Some discussions are happening between the European Union and third countries like Norway, Morocco or Namibia to secure a future supply of green hydrogen[51]. Available nuclear power capacities can also play a role in producing hydrogen by electrolysis. Some EU countries, such as France, the Netherlands or Poland for instance, plan to build new nuclear power plants with a view to producing decarbonised hydrogen.

Cross-border needs can be taken into consideration to limit costs when planning for hydrogen infrastructure. Recent studies show that some geographical clusters represent a 'no-regrets' option[52] for building hydrogen production, transport and storage infrastructure close to energy-intensive industries. Four main regions have been identified: northern France, Germany, Belgium and the Netherlands; eastern Poland and Lithuania; Bulgaria, Romania and northern Greece; and southern Spain. Developing transport and production infrastructures in these areas is a strategic and cost-effective choice. Establishing a European hydrogen backbone may be more challenging but offers an opportunity to reduce costs by creating economies of scale at the European level[53]. This will require significant planning and investment before 2040, especially as the current gas network and LNG terminals cannot be easily converted into hydrogen infrastructures. Some studies estimate the cost of the European hydrogen backbone at between 43 and 81 billion Euros of investment by 2040[54].

Such projects could be listed as part of a new 'Green Projects of Common Interest' investment initiative. Identifying the needs will allow robust planning of the infrastructure, determine the priorities for hydrogen and avoid future stranded assets.

Circularity

The increased global competition to access raw materials, the recent disruptions of global supply chains and the dominant position of China in material processing has created a new imperative for the circular economy in Europe. The 'reduce-reuse-recycle' principle can achieve a 50% reduction in greenhouse gas emissions in the industrial sector while making European industries more resilient to shocks and reducing dependence on primary raw materials. It also has the potential to create new high-value business models and innovations that will set a global example in the coming years.

Under the Visionary Scenario, by 2040, the share of recycled materials would increase significantly in most energy-intensive industries. For example, 68% of steel, 64% of glass and 66% of paper production would come from recycled materials. **Some companies are already investing in recycling materials to reduce their carbon footprint and limit their dependence on scarce primary raw materials, such as rare earth and critical minerals.** These 'low hanging fruit' also exist in traditional sectors. Saint Gobain, for example[55], aims to achieve 50% of its glass production from recycled glass and cullet by 2025. However, industrial players need predictability in order to invest in technological innovations that improve the circularity of the industrial value chain. Policies can support this development by ensuring favourable market conditions for technologies that contribute to improving the quality of recycled products[56].

The shift from an economy of goods to an economy of services can also provide new business opportunities in the maintenance and the reparation sectors, to the benefit of local industries and of the consumers.

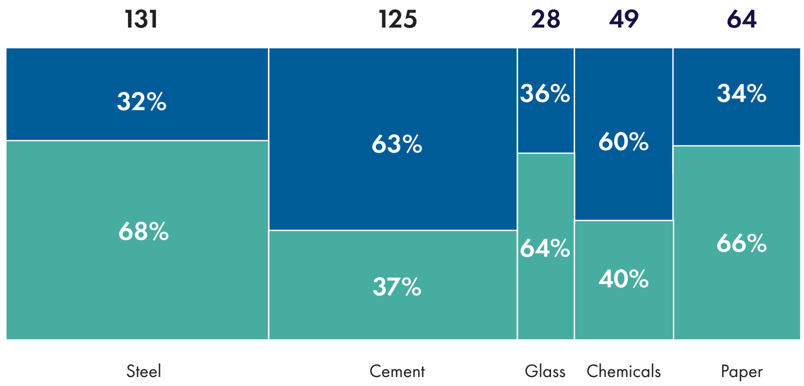


Figure 15.
Share of primary and recycling in 2040 [Mt - %]

- Primary
- Recycling

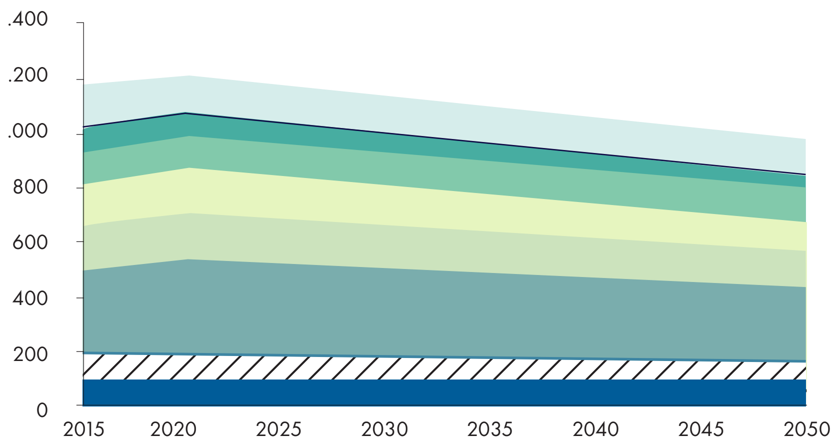


Figure 16.
Evolution of material production [Mt]

- Steel*
- Aluminium
- Non ferrous
- Chemical (Ammonia)
- Chemical (Olefin)
- Biomass (Other)
- Cement
- Ceramic and others
- Glass
- Lime
- Food processing
- Other industries
- Paper
- Wood

The same applies to emerging net-zero industries, where more sustainable standards and efficient use of resources could drive strong innovation and position Europe as a global leader. This is the case in the battery industry, where improving the recyclability of products and setting lower weight standards could significantly reduce their carbon footprint while increasing their value[57].

In addition, **using materials more efficiently and for longer also helps to reduce overall material production.** This could be achieved by using less cement for the same building, producing lighter and smaller vehicles that require less steel, or improving the reparability of products. Efficiency standards could be strengthened at European level to further encourage innovation in this area. Switching to more sustainable alternatives such as clay instead of cement, or wood instead of steel would be another strong driver for a more sustainable and efficient use of industrial production.

Other processes

According to the Visionary Scenario, 85 million tonnes (MT) of CO2 could be captured by 2040 through different technological options[58]:

- **Carbon capture** is mostly applied for industries with high process emissions such as cement. The Visionary Scenario cautiously limits installation of carbon capture modules and applies it sparingly to industries where a full decarbonisation is possible, in order to avoid lock-in effects. In the steel or ammonia industry for example, only existing plants with significant remaining lifetime are considered, while new and modernised plants would switch directly to green hydrogen. 58Mt of CO2 is captured this way in the scenario outline.
-
- **Direct air capture (DAC)** has not been considered due to the high electricity demand, the related uncertainty on prices and the priority given to less energy-intensive decarbonisation processes.
- **Upgrading of biogas to biomethane** is another opportunity to capture CO2. While most of the biogas is currently used to produce electricity or heat, upgrading it to biomethane could bring several benefits. First, it could easily replace natural gas and be used in transmission and distribution infrastructure or end-user equipment without any adaptations. At the same time, the CO2 emissions that result in the upgrading can be captured at a high concentration level, which limits its cost compared to other captured technologies. It can be used either to produce e-fuels (CCU) or stored, leading to a CO2-negative source of energy[59]. In the Visionary Scenario, 27Mt of CO2 are captured through this process, representing 50% of the potential for 35bcm of biogas generation in the EU.
- Permanent natural sequestration could be achieved through other forms of **bioenergy with carbon capture and storage (BECCS)** but the list of concerns is long: emissions can still occur, it requires significant land and water use, it risks damaging biodiversity, and it is still expensive. It is therefore not included as a solution in these scenarios. Bioenergy with carbon capture could be used for e-fuel production but is also not envisaged in this report.

Manufacturing of strategic net-zero technologies

According to the IEA[60], China dominates 60% of mass production of key net-zero strategic technologies and controls the supply chain for several of the key materials for the transition, especially rare earth elements. 25% of EVs and batteries in Europe come from China, as do more than 90% of solar panels. Europe still has a strong share of wind power manufacturing and the heat pump industry, representing 85% and 73% of domestic demand. However, scarcity in the value chain and inflation have weakened the wind industry in Europe, putting the sector at risk, leading to job losses and limiting its potential for expansion to reach higher renewable targets. Rising demand for heat pumps in Europe has led to increased imports from China in recent months. The EU is a net-importer of many strategic net-zero technologies and there is a risk this trend will continue[61]. This high dependence on China exposes the EU to supply risks, bottlenecks or even disruptions in availability of strategic technologies.

Planning the net-zero transition beyond 2030 allows the EU to assess and quantify the volume of net-zero technologies needed for the deployment phase. It can, therefore, be a powerful instrument to develop new manufacturing capacities in Europe. The Critical Raw Materials (CRM) Act and the Net Zero Industrial Act (NZIA) aim to create a European value chain for net-zero technologies, reaching a 40% target for domestic production by 2030.

A more granular, sector-by-sector approach[62] could ensure that the right policies and investments are implemented to support these emerging sectors. If all conditions are put in place, European industry could thrive on many technologies:

- Companies could be well-positioned to supply the EU market and compete globally with Chinese companies, especially on **wind and heat pump production**. It would be key to grow offshore wind and heat pump manufacturing further and to reinvigorate the onshore wind sector, which faces pressing economic difficulties.
- The EU could also quickly regain market share in the battery value chain. According to studies[63], the European industry could even produce 100% of **li-ion batteries** by 2027 whilst simultaneously improving its environmental standards.
- Redeveloping a European **solar sector** might be more challenging, although it is a major opportunity given the growth of solar installations. It would require significant investments and a business model based on more innovation, as the workforce cost negatively impacts the competitiveness of solar panel manufacturing in Europe.
- Finally, Europe is well placed to lead the development of **electrolysers**, one of the key strategic technologies of the next decade for decarbonising heavy industry. In this instance, European manufacturers, who represent more than 20% of the global market today, will be able to set the standards globally.

In order to achieve this vision, investing in manufacturing capacities will be crucial[64]. This is where Europe lags behind compared to China and the US. Today's EU investment is mainly focused on research and development (R&D) and downstream deployment of net-zero technologies. Only €8 billion would be available from the EU budget for building new net-zero technology factories[65]. According to the European Commission,[66] a minimum additional €92 billion in investment by 2030 should be made instead, with public investment accounting for at least 17-20%. A better estimation of the investment and the manufacturing capacity needs is required beyond 2030 and can inform the design of the next EU budget.

CHAPTER IV

A new chapter of EU policy making

The main political concerns around energy security, industrial competitiveness, cheap electricity, good jobs and resilient supply chains converge around 2040 plans. The analysis has shown that the 2030 laws currently being finalised by the institutions provide a range of trajectories and milestones but are insufficient at EU and national level to achieve a 90% net reduction target. For example, the price signal in both, the current ETS and planned carbon markets for building and transport ('ETS2') might not ensure early action in these sectors or risk being so high that it could be disruptive for low- and middle-income households as well as energy-intensive industries. Both cases prevent a well-managed (and correspondingly just and cost-effective) transition, as well as predictability for companies.

Strategic Perspectives' recommendations focus on complementary measures to ensure a timely implementation for the energy and industry sectors as well as the overall policy structure. We suggest the following:

1. A New Energy Security Architecture,
2. An enabling framework for a competitive industry,
3. A reform of the target and policy framework.

1. A New Energy Security Architecture

The Russian war in Ukraine has shown the importance of greater independence through locally produced zero-emission energy. Ending Europe's heavy dependence on burning coal, gas and oil imported from abroad can be achieved by electrifying large parts of the economy, using renewable energy and energy saving measures. **The Visionary Scenario estimates 4019 TWh of electricity needed by 2040 in order to meet the demand of electrification across sectors.** However, only if electricity is provided through zero emissions sources, can all sectors decarbonise in a cost-efficient way. There is currently no framework that scales up sufficient deployment whilst ensuring that the additional electricity needs are not met by fossil fuels. It will take:

A. A European Zero Emissions Electrification Plan

B. Phasing out fossil fuels with a just transition

C. Affordability of electrified end uses

Warsaw tram, Poland

A. A European Zero Emissions Electrification Plan

The Visionary Scenario analysis clearly demonstrates that complementary measures are needed to guarantee successful electrification. The development of a European Zero Emission Electrification Plan could realise the untapped potential for electrifying parts of the economy and provide economic actors with better predictability of the changes needed. It should include:

- **A clear zero emissions electricity production goal for 2040:** This goal can define the envisaged electricity need for direct and indirect electrification (i.e. through hydrogen), set out that zero-emissions power is expected by 2037 at the latest and encourage national and joint planning to meet the goal. It can also highlight the need for energy storage across the EU.

- **Electrification targets for different sectors:** In the Visionary Scenario, 86% of the car fleet, 46% of the truck fleet, 58% of heating and 63% of industrial energy demand can be directly electrified by 2040. Targets for electrifying heating and industrial energy demand provide predictability for companies whilst effectively reducing the demand for fossil fuels.

- **A binding renewable electricity target for 2040 with safeguards on biomass:** To ensure that the electrification of the economy goes hand-in-hand with the decarbonisation of the power sector, an 80% renewable electricity target can be set with specific boundaries for biomass in the future Renewable Energy Directive. The Visionary Scenario shows that the deployment of 571GW of onshore wind, 195GW of offshore wind and 862GW of solar could lead the race for electrification. Translating this potential into renewable production targets can send a clear signal to the economic players that this takes priority over an increase of biomass use for power.

- **Standards to optimise efficiency of electrified end uses:** To moderate the overall increase of electricity needed, it is vital to optimise the efficiency of electrified end uses. Already as a baseline, the power use of electric technologies is generally much lower than fossil fuel-based alternatives with similar energy services. As electrification progresses, applying the Ecodesign Directive would allow continuous improvement of ecological and efficiency standards for all electrified equipment. It could incentivise smaller and lighter equipment (i.e. batteries). Concrete suggestions could include standards for electricity use in vehicles (per kilometre) and heating systems.

B. Phasing out fossil fuels with a just transition

However, without decarbonising the power sector first, electrification across other sectors will not maximise the potential of emission reductions and cost savings. It will need:

- **A clear phase-out target for coal and gas in electricity through complementary CO2 standards:** Policy-makers can send a strong political signal and enhance energy security and predictability by setting sectoral CO2 standards to prepare a progressive phase-out of coal by 2030 and gas by 2037. This prevents the increased electricity demand from being met by fossil fuels. The Visionary Scenario shows that effective gas demand reduction would then lead to the power mix consisting of 80% renewables, 17% nuclear and 3% solid biowaste. It would also allow for a well-managed transition, supporting the re-skilling of workers and investment in new economic activities in the different regions that will be impacted the most.

- **Encouraging matching just transition plans:** With clear phase-out trajectories and dates set, conversations between trade unions, companies, regional governments and other relevant actors can start on transition plans, reskilling and new jobs.

- **Targeted financial support through EU funds:** A 'stress-test' of the existing financial instruments (i.e. the Modernisation Fund, EU budget) can verify the potential funding gap, regional needs and the necessity of additional EU-level support.

C. Affordability of electrified end uses

- **Maintaining and strengthening the Social Climate Fund beyond 2030:** the upfront investment of an electric vehicle, the renovation of homes and the installation of a heat pump are too high for the average person. The Social Climate Fund has opened the door to a more targeted climate policy supporting low- and middle-income households in getting access to climate-friendly equipment and renovating their homes. The upcoming review of the EU budget could be an opportunity to turn the Social Climate Fund into a strong European social arm in favour of a net zero transition, ensuring a fair distribution of solutions and benefits.

- **Sharing best policy practices between Member States:** a dedicated platform could be created to support governments in designing policies that benefit low- and middle-income households. Good practices already exist across the EU: renovation schemes in the Czech Republic and Ireland, the social leasing of electric vehicles in France or the climate ticket for railways in Spain and Germany are some examples.

Complementary measures at the national level will be needed in terms of grid expansion or modernisation, demand management and flexibility but this cannot be identified through this analysis. A new Energy Security Architecture also relies on a strong reduction of energy use. Beside the standards and efficiency measures identified in the analysis, building renovation is a key driver for reducing the overall energy consumption. A renovation rate of at least 3% of the building stock will be required from 2030 to 2040.

Wind turbines
in Denmark

2. An enabling framework for a competitive industry

A clearer incentive and standard scheme for electrification (direct and indirect), circularity and the scaling up of manufacturing of net-zero technologies are assets for a competitive European industry. **The 2040 horizon allows proper planning of capacities and investments** based on a cost-effective roll-out of net-zero technologies. An effective modernisation strategy will ensure that scarce technologies are used in the right sectors as disproportionate demand from all sectors would make prices spike.

New financial tools for the coming decade can support the modernisation and reindustrialisation. The co-benefits are clear: this can create thousands of quality jobs, improve European cohesion and position European manufacturers as global leaders. If done well, those regions facing multiple transitions at the same time can thrive again.

A. Industrial electrification

Direct and indirect electrification can be supported through:

- **Clear electrification goals for industrial sectors to progressively phase down fossil fuel use:** According to the Visionary Scenario, gas and oil consumption would be phased down to 8.9% and 2.5% of the final energy demand of the sector.
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- **The carbon contract for difference (CCfD) is a good model for quickly electrifying, deploying more circularity and green hydrogen:** It compensates for the high upfront investment and operation cost of climate-friendly technologies for the industrial transformation until they are competitive enough[67]. The German government CCfD for industrial players[68] can be matched by an equivalent European scheme to prevent a fragmentation of the single market. European cohesion is vital to ensure all countries can afford investing in industrial modernisation.
- **The launch of a European Industrial Electrification Alliance:** Such an alliance could support the electrification of a broad range of companies, also those that are not covered by the EU ETS but use low- and medium temperature heat, such as the food industry. This alliance could support innovations in industrial heat pumps and channel investment and provide a platform for industrial players, public authorities and trade unions to exchange views on how to electrify.
- **The establishment of a Green Hydrogen Plan:** Green Hydrogen has the potential to support decarbonisation of some energy-intensive industries such as steel, ammonia and chemical production, or the shipping sector. The plan can identify priority sectors for the use of, at least initially scarce, green hydrogen[69]. The use of hydrogen in road and rail transport or for heating buildings risks wasting significant amounts of energy and unnecessarily driving up the price of a scarce resource. The Vision Scenario estimates around 480 TWh will be used by 2040, with about a third imported. It takes a proper plan of available production capacities, transport and storage infrastructures to ensure that limited domestic production and import capacities match the real needs for the European economy. Allocating new infrastructure in geographical clusters of potential high industrial demand for green hydrogen, as well as carefully selecting partners for green hydrogen imports, represent a 'no-regrets' option[70].

B . Embracing the potential of circularity

Around 50% of emissions in the industrial sector can be reduced through circularity. The Circular Economy Package currently under negotiation provides initial incentives, such as the broadening of the Ecodesign Directive, but falls short of its potential. The enabling framework can be strengthened through:

- **Improving the quality of recycled and secondary raw materials:** Quality assurance is vital to increase their use and market share in the circular economy. It's often at the product design phase that incentives need to start. The agreement on more sustainable and circular batteries[71] can be used as an excellent example to be applied to other products and could lead to international partners replicating EU policies.

- **Setting standards for use of recycled or secondary raw materials:** This can drive up future demand and can incentivise industry to invest in the circular economy. According to our analysis, recycling shares of over 65% for steel, over 70% for aluminium and around 50% for chemicals can be achieved. If done well, the EU can position itself as a global leader of the circular economy and set international standards and best practices. This will reduce the risk associated with possible disruptions on global supply chains and mitigate the pressure on raw materials.

Steelworker

C. Growing demand for green materials

Incentivising the production of green steel, green aluminium, cement and other materials goes hand in hand with creating predictable demand and financial support. Providing companies with reassurance that they will see returns on their investments can happen through a variety of tools which are often complementary:

- **Identifying and creating 'lead markets':** This is key to providing credible estimates about the envisaged demand. For example, if the automotive or wind industry would increase their use of green (or recycled) steel, the foreseen needs can be estimated and provide confidence for steel companies that move their production to green hydrogen. This rewards the first movers and can provide them a competitive advantage at the international level.
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- **Quotas and standards for green material use:** Both quotas for percentage use and standards (for quality, CO2 emissions or local content) of green materials can support the creation of 'lead markets' and ensure predictability of growing demand. The power of the EU's single market means these quotas and standards also apply to imported products, de facto benefitting the European companies that take the lead on innovation and modernisation.

- **Greening public procurement policies with clear net-zero technology deployment targets, additional investments and net-zero standards:** This can contribute to securing a strong market share for climate-friendly industrial products. Public procurement accounts for 14% of European GDP and can be a powerful lever for the decarbonisation of the EU industry. European targets and standards for green public procurement could be introduced to set minimum requirements, given the 'voluntary' approach so far fell short of achieving climate-neutrality consistent procurement. There could be, for example, minimum quotas of green steel or recycled glass in buildings or car fleets, or a minimum percentage of roofs being covered with solar panels on public buildings. Mandatory targets can be accompanied by additional EU financial support to cover the extra cost of greening procurement for regions that cannot afford it[72].

D. Investing in strategic net-zero technologies:

The current financial framework can be complemented or reformed through:

- **Designing new European financial mechanisms to support fresh investment:** Current proposals to support the net-zero industry are largely limited to state aid and the new Strategic Technologies for Europe Platform and don't address the scale of investment required to ensure Europe is able to supply its net-zero technology demand whilst it avoids a two-speed transition. In the short term, a few options could be explored to scale up the EU green industrial base while supporting European cohesion. For example, the use of carbon market revenues by EU countries or the quick deployment of the Innovation Fund to support new manufacturing capacities could be a first step. In the medium term, the European Union could adopt a new financial architecture for the net-zero transition as part of the revision of the next MFF that also targets net-zero manufacturing capacities.

- **Developing Green Projects of Common Interest:** Channelling European and national funding into concrete cross-border projects and speeding up financing procedures are an opportunity to back a more integrated vision of the net-zero transition. Based on a strong analysis of the current missing infrastructures and industrial capacities Europe will need to achieve climate neutrality, they could create synergies between the Connecting Europe Facility (CEF) and Important Projects of Common European Interest (IPCEI) approaches. Ensuring consistency and proper planning on industrial projects, cross-border needs and infrastructure will be crucial to secure a cost-effective transition. Examples include the installation of joint offshore wind parks, the upgrade of the European electricity grid, better railway connections, an electrification alliance or the development of green hydrogen projects in strategic locations.

E. Reindustrialising regions

As the net-zero transition accelerates, ensuring that all regions have fair access to and benefit from climate-friendly solutions is crucial to maintaining European cohesion. Otherwise, the EU risks a two-speed transition where only the richest regions and Member States with greater fiscal capacity will benefit. Our suggestions include:

- **Dedicated European funding schemes:** Such schemes could be used to support the establishment of industrial sites in regions facing multiple structural changes. Anticipating the structural changes within European territory and identifying regions that are and will be affected by multiple transition challenges, such as decline of coal mining, change in steel production and car manufacturing, can be part of the 2040 planning exercise. It will maximise the creation of quality jobs and distribute the industrial benefits across the EU. As part of the cohesion policy, new criteria could be developed to better target those regions in future industrial investments.

- **Establishing 'structural change platforms':** Based on the example of the 'Initiative for coal regions in transition', structural change platforms could be set in those regions in order to establish a dialogue between investors, businesses, trade unions and public authorities on the industrial base. This would help identify levers to support reindustrialisation and better channel European funding whilst ensuring quality, future-proof jobs remain in or return to the regions.


European Parliament
building in Brussels, Belgium

3. A reform of the target and policy framework

The major questions for the future climate structure revolve around the definition of the future target, how target achievement can be ensured at the national level and how to deal with carbon removal. The current 2030 policy framework outlines some decarbonisation trajectories for the next decade but does not ensure a fair and effective policy architecture:

A. Create transparent, interactive target definition:

- **Setting a net-emission reduction target with three separate sub-targets for emission reduction, technological and natural carbon removals:** This would ensure progress across emission reductions and removals. It will allow better monitoring of emissions reduction and an immediate course-correction if the EU is off-track on one of them.
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- **Accountability mechanism:** Given the different types of removals, developing an appropriate accountability mechanism that verifies different types of removals will be needed as the EU approaches its climate neutrality goal. Removing carbon from the atmosphere can be permanent and non-permanent, depending on the method (i.e., forests or DAC). Appropriate comparability schemes are the only method to ensure environmental integrity. This could lay the groundwork for future net-negative governance systems.

B. Ensure EU-wide delivery on targets:

- **National economy-wide targets: :** National targets are an effective and transparent way to incentivise governments to develop comprehensive domestic net-zero transition plans and implementation policies. At European level, it allows for monitoring and verifying emissions reductions. Many countries already have economy-wide targets for 2030 and climate neutrality targets. A new method can be identified to establish differentiated, fair, cost-effective and stringent targets for countries toward climate neutrality. Some countries such as Austria, Denmark, Finland, Germany and Sweden already planned to reach climate neutrality before 2050. A regular assessment can help to keep the 27 countries on track to achieve the overall goal of climate neutrality by 2050 at the latest and verify annual progress. This system will open the door to a more effective national assessment of decarbonisation trajectories.

- **A Natural Carbon Sink Fund:** This new fund can support countries that are most vulnerable to climate impacts and have limited fiscal capacity to restore and grow their natural carbon sink. For example, natural carbon sinks in southern and south-eastern Europe are rapidly declining due to forest fires and droughts. This reduces their potential to capture carbon and provide ecosystem services. The exact structure to promote ecological land use activities needs to be developed but could be based on ETS revenues or the Modernisation Fund example.

ANNEXE

Methodology and pathways

The analytical team

Since 2011, CLIMACT has developed tools and methodologies which support governments and stakeholders in the development of low carbon pathways. These tools and methodologies are used on a daily basis by administration officials, companies and NGOs.

For this project, the following CLIMACT experts were involved: Julien Pestiaux, Simon Lalieu, Julien Defauw, Dimitri Krings, Adrien Lefebvre, Colin Stoquart, Thomas Gilon, Maïté Jonas, Vincent Matton and Michel Cornet.

The Pathways Explorer

The Pathways Explorer (www.pathwaysexplorer.org) is a step-by-step solution supporting organisations and equipping them with a robust analytical foundation, enabling the development of energy transition scenarios based on credible and transparent assumptions.

Behind the process is an open-source web-based tool which enables the exploration of possible futures and assesses the implications and trade-offs of their choices.

Simulations can be performed in real time, offering a direct understanding of the key levers of the low carbon transition.

The exploration scope encompasses the energy system and its dynamics, all GHG emissions, and the associated resources and socio-economic impacts.

It provides credible analysis:

- Results aligned with official emissions and energy reporting,
- Pathways specified with above 150 levers, and thousands of data points, and
- More than 100 graphs and hundreds of KPIs available for each pathway.

There are many ways to analyse the GHG emissions trajectories with the Pathways Explorer:

- Developing low-carbon scenarios, exploring cross-sectoral dynamics,
- Converting existing targets into concrete sectoral measures and reproducing existing country scenarios (National Energy and Climate Plans, Long Term Strategies),
- Tracking progress compared to EU or national targets,
- Exploring the cost implications and monitor the link between recovery plans, funding opportunities and concrete implementation plans, and
- Exploring other non-monetary implications (e.g., resources like land and materials, air pollution, minerals, water and jobs).

Dresden, Germany

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4. There is a minor difference with the 2030 legislation: the legislation partially excludes international aviation outside the EU, while our modelling includes it all.
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6. The indicative target for 2035 is extracted as an intermediary point of the respective emission trajectories.
7. Includes biogenic CO2 from the upgrade of biogas to biomethane (assuming 60% of biogas upgrade to biomethane for scenario -95% (27.6Mt), 50% for scenario -90%(23Mt) and 40% for scenario -85%(18.4Mt). Please note that this is not visible in the online webtool.
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