Climate and Energy Policies of Key European Member States: The cases of France, Italy and Germany

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Sciences Po Paris
February 2025

Résumé

La nouvelle Commission européenne s'est fixée comme objectif de renforcer l'interconnexion des marchés européens de l'énergie afin d'accroître la sécurité de l'approvisionnement dans l'UE. L'utilisation des énergies renouvelables et l'augmentation de l'efficacité énergétique dans les États membres sont d'autres éléments constitutifs d'un approvisionnement fiable. Ce projet est toutefois confronté aux différents systèmes énergétiques nationaux qui se sont développés et consolidés au fil du temps. La présente analyse examine la structure de l'approvisionnement énergétique, ainsi que les stratégies et les objectifs de développement des énergies renouvelables et de réduction de la consommation d'énergie, à titre d'exemple pour la France, l'Allemagne et l'Italie. Il s'avère que l'harmonisation de la politique énergétique de l'UE et une approche commune pour atteindre les objectifs énergétiques et climatiques offrent de nombreux points de départ pour une coopération approfondie entre les pays.

Abstract

The new European Commission has set itself the goal of integrating the European energy markets more closely to increase the security of supply in the EU. Further building blocks for a secure supply are the use of renewable energies and an increase in energy efficiency in the member states. However, this approach has to align with the different national energy systems, which have developed and become established nationally over time. The present analysis reviews the structure of energy supply, as well as the strategies and objectives for expanding renewable energies and reducing energy consumption, using the three biggest EU economies France, Germany and Italy as examples. It shows that there are numerous starting points for a deepened cooperation between the EU member states through the harmonisation of EU energy policy and a common approach to achieving energy and climate targets.

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Acknowledgements

We would like to thank Linus Mehl for his valuable support in this research.

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1. Introduction

Building on the Strategic Agenda 2024-2029[1] adopted by the European Council on 10 July 2024, the re-confirmed Commission President Ursula von der Leyen presented her political guidelines[2] for the next European Commission on 18 July 2024. Titled "Europe's Choice", the document outlines the planned objectives and initiatives at the European level for the period 2024-2029. The political guidelines put a strong emphasis on reindustrialisation, competitiveness and resilience in a growingly complex and uncertain international environment.

Developing Europe's energy supply and demand is pivotal in this respect. As energy is the backbone for commercial and non-commercial uses, the provision of secure, cheap and clean energy has long been the aim of energy policies in Europe.[3] These dimensions of energy policy have been addressed by the EU Energy Union[4] (2015-2019), putting a focus on energy security and the European Green Deal[5], asking for a full decarbonisation of the EU by 2050. As some 75% of European greenhouse gas emissions are energy-related, it emerges that an energy transition by phasing out the use of fossil fuels is mandatory to achieve this target. Europe's Choice continues these strategies by calibrating energy and climate policies to industrial development. The political guidelines ask for the implementation of the European Green deal while asking for the prioritisation of the energy sector and Europe's energy infrastructure.

In article 194 of the Treaty of the Functioning of the European Union (TFEU), energy is laid down as a shared competence between the European level and Member States. The European level is to ensure the functioning of the energy market, ensure security of energy

[1] https://www.consilium.europa.eu/media/4aldqfl2/2024_557_new-strategic-agenda.pdf

[2] https://commission.europa.eu/document/download/e6cd4328-673c-4e7a-8683-f63ffb2cf648_en?filename=Political%20Guidelines%202024-2029_EN.pdf

[3] Bruch et al. (2024), https://www.sciencedirect.com/science/article/pii/S0301421524002751

[4] https://energy.ec.europa.eu/topics/energy-strategy/energy-union_en

[5] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

supply in the Union, promote energy efficiency and energy saving and the development of new and renewable forms of energy and promote the interconnection of energy networks (Art. 194(1)). Yet, Art. 194(2) confirms the Member States' right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply. This acknowledges the fact that energy systems and energy policy choices have traditionally followed national (geological and technical) conditions and policy choices that aimed at optimising national supply and demand structures.

The vulnerability to energy imports and need to stronger coordinate national energy policies has been highlighted recently by Russia's military invasion of Ukraine and its weaponisation of energy supplies to the EU. As part of its sanctions against Russia, the EU closed major Russian banks from the international bank remittance and payment service from the Society for Worldwide Interbank Financial Telecommunications (SWIFT) but excluded banks responsible for energy-related trade settlements from the sanctions, considering the substantial impact on people's lives and economic activity of a reduction or suspension of resource supplies from Russia. Coal was embargoed in April 2022, crude oil by maritime transport (temporary exemption for imports of crude oil by pipeline) in December 2022, petroleum products in February 2023, and propane gas in December 2023. Although the 14th package of sanctions includes a ban on reloading services for Russian liquified natural gas (LNG) on EU territory for transshipment operations to third countries and a ban on new investments for the completion of LNG projects under construction, the EU has kept some distances from the total embargo of LNG.

To end the EU's dependence on Russian fossil fuels and achieve the decarbonisation objectives for 2050 and 2030, the European Commission presented the REPowerEU Plan in May 2022. The plan is currently implemented. It includes energy savings, diversification of energy supplies, and accelerated roll-out of renewable energy to replace fossil fuels in residential sectors, industry, and power generation.

Between August 2022 and March 2024, the demand for natural gas decreased by 18%, conserving 125 billion cubic meters (bcm) of gas. EU energy ministers agreed on a proposal in March 2024 to extend the target for gas-saving measures, which was initially adopted in 2022 as an emergency by the Regulation on Coordinated Demand Reduction Measures for Gas, to aim for a 15% reduction in gas demand within a year from April 2024 compared with its average gas consumption from April 1, 2017, to March 31, 2022.

As the European level is not allowed to directly interfere in the design and integration of national energy and decarbonisation policies, it has adopted a strategy of "harder soft governance"[6] by setting up a coordination process under the EU Governance Regulation.[7] In this process, Member States have to submit National Energy and Climate Plans (NECPs) that report present and planned policies along the five dimensions of the Energy Union and

[6] Knodt et al. (2020), see https://www.tandfonline.com/doi/full/10.1080/1523908X.2020.1781604

[7] Regulation 2018/1999, see https://eur-lex.europa.eu/eli/reg/2018/1999/oj

estimate the impact of these policies in a 2050 perspective in dedicated long-term scenarios[8]. While the NECPs may offer an effective tool for policy coordination, further energy sector integration will need to consider the existing differences in resource endowment, governance choices and institutions in the EU member states.

The aim of this contribution is to underpin and prepare the discussion on the further integration of EU energy markets and policies by providing a detailed analysis of the cases of France and Italy. Based on – among others – the latest NECPs, latest available Eurostat and European Commission data on the energy sector and the country studies of the International Energy Agency (IEA), this paper reviews (a) governance aspects (actors, structures and coordination mechanisms), (b) national strategies and key policies, (c) focal points of policy action on energy security, energy efficiency and renewable energy deployment.

After a brief presentation on energy supply dependence in the EU (section 2), we proceed by systematically presenting these aspects for France (section 3), followed by Italy (section 4). Section 5 summarises our findings related to further pathways and methods for increased policy alignment in the climate and energy fields.

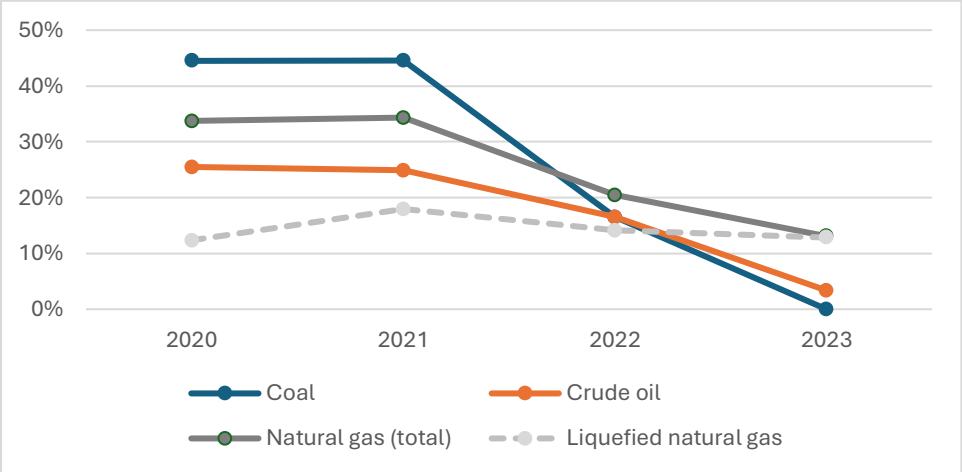
[8] The NECPs differentiate between two scenarios: A WEM scenario, analysing the impact of existing measures and a WAM (with additional measures) scenario, assessing the policy impact of planned policy measures. See Economidou et al. 2022, https://www.sciencedirect.com/science/article/pii/S030142152200444X

2. Import dependence of the EU

Russia's military invasion of Ukraine has highlighted the vulnerability of European Union (EU) countries that depend on Russia for energy supplies. In 2021, the EU relied on imports from Russia for around 35% of its natural gas and 25% of its oil, and 45% of its coal.

As shown in Figure 1, the EU has made efforts to move out of its high dependency on imports of fossil fuels from Russia. The decline in the share of imports of LNG from Russia is not significant, but the EU puts considerable effort into cutting down the total LNG consumption.

Figure 1: Share of EU's Imports from Russia by Type of Fossil Fuels



Data source: https://ec.europa.eu/eurostat/databrowser/bookmark/0aeee361-1ed7-4bb6-a991-30d752d59f0e?lang=en (EUROSTAT)

To end the EU's dependence on Russian fossil fuels and tackle the climate crisis, the European Commission (EC) presented the REPowerEU Plan in May 2022. The plan includes energy savings, diversification of energy supplies, and accelerated roll-out of renewable energy to replace fossil fuels in residential sectors, industry, and power generation. The REPowerEU Plan has assisted the EU in energy conservation, supply diversification, the generation of clean energy, and the smart blending of reforms and investments throughout the last two years. Between August 2022 and March 2024, the demand for natural gas decreased by 18%, conserving 125 billion cubic meters (bcm) of gas. EU energy ministers agreed on a proposal in March 2024 to extend the target for gas-saving measures, which was initially adopted in 2022 as an emergency by the Regulation on Coordinated Demand Reduction Measures for Gas, to aim for a 15% reduction in gas demand within a year from April 2024 compared with its average gas consumption from April 1, 2017, to March 31, 2022.

To meet the 2030 European anergy and climate targets, the EC requires Member States to submit National Energy and Climate Change Plans (NECPs). After the first round of NECPs in 2019, the updated NECPs have been submitted in 2024. The plans were preceded by their draft versions, submitted to the European Commission one year earlier. Note that in the EU,

the 2021 European Climate Act raised the 2030 reduction target to 55%, which the updated versions of the NECPs were supposed to reflect. During the assessment phase of the draft versions, the European Commission noted that many countries fell short of their targets. In the final version, many countries reacted and have adopted higher targets than in the draft version, and the EU as a whole is assessed as being capable of meeting the 40% reduction target for 2030.

Table 1: History of the EU's Target towards the Reduction of GHG Emissions

	Cancun Agreements	INDC	NDC
Base year	1990	1990	1990
Target year	2020	2030	2030
GHG reduction target	-20% (-30% under the conditions set out by the European Council of December 2009)	-40%	-55%

Source: Author's summary based on reference[9]

We proceed to present the national energy profiles and policies as outlined in national strategies. This can serve as a basis for an in-depth understanding of the similarities and asymmetries of national energy and strategy choices in three major EU economies.

[9] UNFCCC "submission by Latvia and the European commission on behalf of the European Union and its member states 2015", UNFCCC "Expression of willingness to be associated with the Copenhagen Accord and submission of the quantified economy-wide emission reduction target for 2020", European Commission "Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people" （Brussels, 17.9.2020COM (2020) 562 final）

3. France

France's economy has doubled in the past three decades, with a GDP increase from USD 1.27 trillion in 1990 to USD 2.65 trillion in 2020.[10] The International Energy Agency summarises the French energy policy as follows: "France has a very low-carbon electricity mix owing to its large nuclear fleet, the second largest after the United States. As an early leader in setting out an ambitious energy transition, France legislated a net-zero emissions target for 2050 in its 2019 Energy and Climate Act and aims at reducing by 55% its greenhouse gas emissions by 2030. A national low-carbon strategy with 5-year carbon budgets and a multiannual plan for energy investments implement the long-term target. Acknowledging the need to maintain electricity security in the longer term and a low-carbon footprint, France invests in efficiency, six new nuclear power plants and renewable energy, notably offshore wind, while enhancing flexible power system operation."[11]

In its latest climate adaptation plan of 2024[12], the government outlined that France would suffer devastating climate effects. Parallel analysis by the World Bank likewise projected major negative impacts, such as agricultural droughts that last 35% longer and heatwaves that occur 80% more frequently and last 1,461% longer than they do now. Coastal communities, including 140,000 houses in the Languedoc-Roussillon region alone, are at risk of being damaged and submerged by rising sea levels. GDP losses could amount to as much as €30 billion by 2050.[13]

3.1. Political institutions and key players

The French institutional landscape is shaped largely by the national government, but supported by regional, and local levels of government. As of November 2024, the Minister of the Ecological Transition, Energy, Climate and Risk Prevention prepares and implements the Government's policy in the areas of sustainable development, environment, energy, energy efficiency, the fight against air pollution, the protection of nature and biodiversity, water and the prevention of natural and technological risks and industrial safety as well as the promotion of sustainable management of rare resources.[14] In international relations on climate, energy, terrestrial and marine biodiversity, the environment, risk prevention and the circular economy, the Minister represents the Prime Minister, responsible for ecological and energy planning in European and international negotiations, in consultation with the Minister for Europe and Foreign Affairs, and ensures the implementation of the agreements concluded. Further, the

[10] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=FR

[11] https://www.iea.org/countries/france

[12] https://www.adaptation-changement-climatique.gouv.fr/comprendre/strategie/plan-national-dadaptation0

[13] https://www.g20climaterisks.org/france/

[14] https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000050330340

Minister shares responsibility for energy research, development, and demonstration (RD&D) with the Ministry of Higher Education, Research, and Innovation.

The High Council on Climate (Haut conseil pour le Climat) is a French independent body involved in providing advice and recommendations to the French government on the policies aimed at reducing national GHG emissions.[15] The French Council of Energy (Conseil supérieur de l'énergie, CSE) plays the role of the World Energy Council French National Committee, whose members are spearheading French private sectors with an interest in scientific, technical, and industrial participation in global energy issues.[16] The French Agency for Ecological Transition (ADEME) supports and mobilizes all stakeholders through advice, financial support, territory certifications, publication of guides, and training to accelerate the ecological transition.[17] The ADEME has 17 regional departments and three territorial representations in metropolitan France and overseas, which provide a wide range of support adapted to local issues and implement holistic approaches to be consistent with territorial public policies, especially with the Recovery and Ecological Transition Contracts (CRTE). The French Energy Regulatory Commission (CRE) is an independent authority responsible for providing the smooth operation of the French energy markets to benefit consumers.[18] The CRE's primary mission includes ensuring the smooth operation of retail markets, as well as setting regulated electricity and natural gas sales tariffs. RTE is the French transmission operator, in charge of transmission infrastructure, but also places its expertise at the disposal of decision-makers (public authorities, players involved in the power system, institutions, etc.) by providing documents that cover forecasts, estimates and analyses of the French power system.

Regions implement climate and energy transition goals under regional plans for spatial planning, sustainable development, and equality, based on the Energy Transition for Green Growth Act of 2015. These plans include sub-regional climate-air-energy plans and are coordinated by local authorities. Regions support citizen projects, manage public transportation, waste, water, and often hold concessions for heating, gas, and electricity distribution networks.

3.2. Natural resources profile

Present energy production and consumption patterns

Total energy supply (TES) includes all the energy produced in or imported to a country, minus that which is exported or stored. It represents all the energy required to supply end users in the country.[19] In 2023, 40% of TES came from nuclear power, which was followed by imported

[15] https://www.hautconseilclimat.fr/en/about/

[16] https://www.worldenergy.org/world-energy-community/members/entry/france

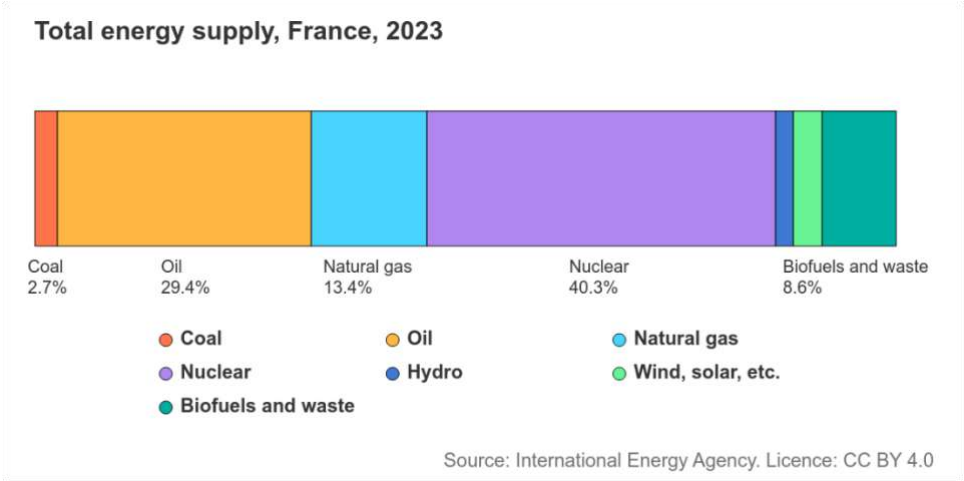
[17] https://www.ademe.fr/en/our-missions/support-and-mobilise/

[18] https://www.cre.fr/en.html

[19] https://www.iea.org/countries/france/energy-mix

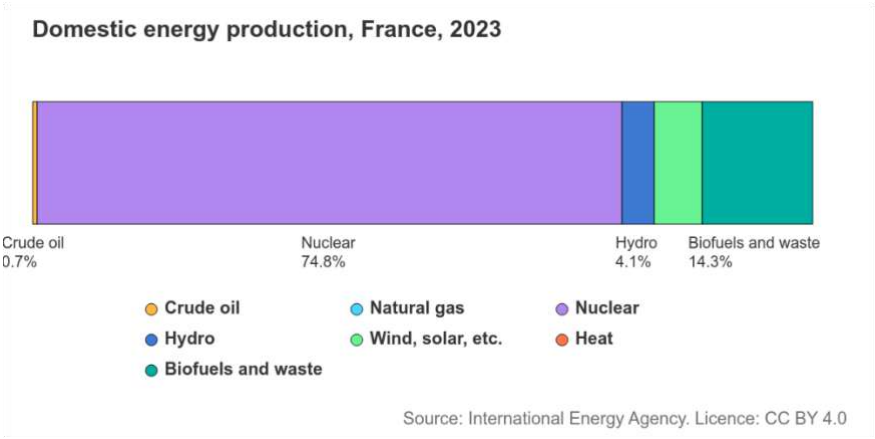
oil (30%), natural gas (13%), and bioenergy produced domestically (8.6%), see Figure 3. Net energy imports are 47.2% of TES. In 2021, 22% of imports came from Russian natural gas, or 13.4 billion cubic meters. France received 7.1 billion cubic meters of LNG from Russia in 2022. Gazprom stopped delivering gas through pipelines in August 2022. In January and March of 2023, France imported over 1.3 billion cubic meters of Russian LNG.[20]

Figure 2: Total energy supply of France, 2023



In 2023, approximately half of France's TES was produced domestically. Nuclear energy makes up 75% of the country's energy production, followed by bioenergy (15%), and other renewable energy sources, which include hydropower (3.8%) in 2022 (see Figure 3).

Figure 3: Domestic energy production 2023

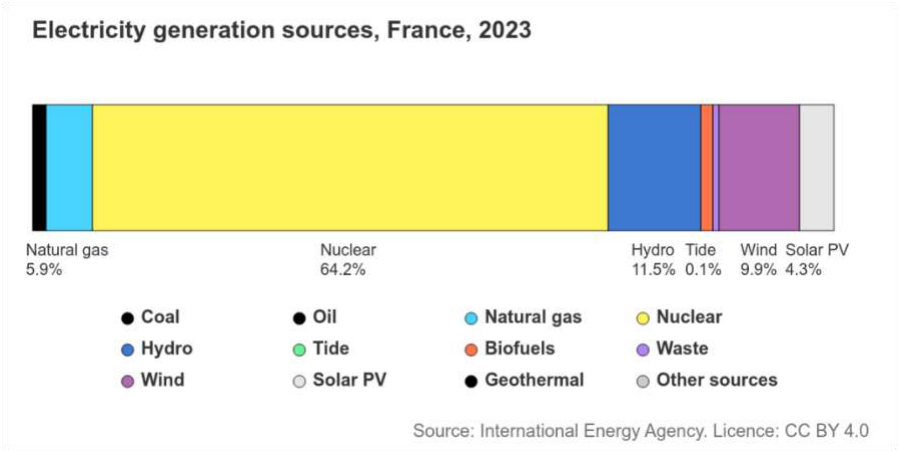


Source: https://www.iea.org/countries/france/energy-mix

[20] https://energy.ec.europa.eu/system/files/2023-06/FR_REPowerEU.pdf

Regarding electricity production, the French production profile shows a clear dominance of nuclear power (64%), followed by hydropower (11.5%) and other renewable energies such as wind and solar (14.2%) in 2023. As such, the electricity generation is largely provided by domestic generation sources (Figure 4)

Figure 4: Electricity generation sources in France 2023



Source: https://www.iea.org/countries/france/electricity

Complementary to these statistics, it is vital to look at the demand side to get a comprehensive overview of the energy system. As the IEA notes: « Total final consumption (TFC) is the energy consumed by end users such as individuals and businesses to heat and cool buildings, to run lights, devices, and appliances, and to power vehicles, machines and factories. It also includes non-energy uses of energy products, such as fossil fuels used to make chemicals. Some of the energy found in primary sources is lost when converting them to useable final products, especially electricity. As a result, the breakdown of final consumption can look very different from that of the primary energy supply. Both are needed to fully understand the energy system. »[21]

On the demand side, oil accounted for 43% of total final consumption, with electricity (25%) and natural gas (18%) coming in second and third. Buildings (residential and commercial sectors) accounted for 40% of TFC, followed by transportation (28%) and industry (20%).

Further domestic potential with renewable energies

Off-shore and on shore *wind energy* exhibit a large potential that remains still untapped. According to the Global Wind Atlas, published with data from the World Bank, France exhibits extensive areas with favourable wind conditions, particularly along the northern coast, including regions such as Brittany and Normandy. These coastal areas are characterised by consistently high wind speeds, making them ideal for wind energy development. Beyond the northern coast, central and northeastern regions also demonstrate strong wind potential,

[21] https://www.iea.org/countries/france/energy-mix

benefiting from elevated plateaus and ridges. Similarly, the southeastern regions, particularly along the Mediterranean coast and near the Alps, show significant wind resources.

Figure 5: Wind energy potential France

Source: https://globalwindatlas.info/area/France

Regarding *solar potential*, World Bank data further reveals that the south of France receives significantly more solar radiation than the north, making it a prime location for solar energy development. The southern regions, particularly the southeast, benefit from higher levels of sunshine, making them more suitable for solar power generation compared to the north. The map indicates that areas marked in red are excluded from solar development due to technical factors, such as insufficient sunlight, or land-use constraints, including agricultural land and nature conservation zones. Despite these exclusions, suitable areas for solar energy development are relatively widespread in the southeast, particularly in regions such as Provence and the Mediterranean coastline, where solar irradiance is among the highest in the country.

Figure 6: Photovoltaic power potential in France

Source: Global Solar Atlas 2.0, Solar resource data: Solargis, https://globalsolaratlas.info/map

3.3. Energy policy objectives and strategies

Overall objectives and targets

French energy policies are influenced by both international and European frameworks. The international framework is primarily based on climate agreements like the Paris Agreement, while the European Union's energy and climate strategies shape the national French energy policy. The EU's Fit for 55 legislative package aims for 55% emission reductions by 2030 and full decarbonisation by 2050. Under the Hollande presidency, France introduced the Energy Transition Act in 2015, aiming to reduce greenhouse gas emissions, cut final energy consumption, and reduce primary energy consumption from fossil fuels. The act also aimed to increase renewable energy share in final energy consumption, with targets for electricity and heat production.

With the Macron presidency starting in 2017, a major legislative shift occurred with the 2019 Energy and Climate Act (Loi energie-climat)[22], which legislated a decrease in fossil fuel consumption by 40% by 2030 compared to 2012 levels and carbon neutrality by 2050 thus increasing ambitions. However, it postponed the 50% nuclear energy target to 2035 to maintain energy security. Following the 2022 Ukrainian crisis, France further revised its energy strategy, withdrawing plans for a significant decrease in nuclear generation capacity and focusing instead on expanding both nuclear and renewable energy. This new approach includes plans to double renewable energy capacity by 2030 and significantly increase it by 2050, aiming for a balanced mix of 50% nuclear and 50% renewables by 2050. While renewable energy expansion remains a priority, the medium-term share of renewables may decline relative to nuclear. The act also focuses on improving energy performance in residential buildings (retrofitting energy-inefficient buildings) by 2050, halving waste production by 2025, reducing energy poverty by ensuring access to energy is proportionate to household income and strengthening the governance and assessment frameworks for climate policies.

While the law initially targeted the closure of all coal-fired power stations by 2022, geopolitical tensions, including the war in Ukraine, led to delays in this timeline. France extended the operation of two coal plants—Saint-Avold and Cordemais—until the end of 2024 to secure energy supplies during winter months. Despite these temporary measures, the government remains committed to fully phasing out coal by 2030. The law also mandates the installation of solar panels on roofs of supermarkets, warehouses, and car parks. Legal procedures for photovoltaic installations and the use of geothermal energy are being streamlined to increase the share of renewable energy in the energy mix to 33% by 2030. Furthermore, the government is supporting the development of hydrogen production and technology, including through the means of nuclear energy.

On 10 February 2022, just before the Russian invasion of Ukraine, President Macron delivered a speech emphasising that the government would commit to reclaiming control over France's energy destiny. In this address, Macron emphasised that decarbonisation, energy security,

[22] https://www.legifrance.gouv.fr/dossierlegislatif/JORFDOLE000038430994/

and energy sovereignty in power generation must rely on multiple strategic approaches, making it unrealistic for France to depend entirely on either nuclear or renewable energy. Instead, the country would pursue both. The President highlighted plans to double the current level of renewable energy by 2030 and continue increasing it through 2050. Special attention would be paid to solar energy, with the goal of reaching over 100 GW by 2050, approximately ten times the present level.

Offshore wind power is another focal area, with a target of 40 GW by 2050 and around 50 units in operation by then. However, the expansion of onshore wind power would slow, in response to opposition from local residents and other restrictions, pushing the goal of doubling its capacity from around 2030 to 2050. Macron also mentioned the importance of other renewable energy sources such as hydropower and bioenergy, as well as replacing natural gas with renewable gas.

In his speech, Macron further outlined several policies, beginning with a 40% reduction in energy consumption by 2050, driven by home renovation projects (such as *MaPrimeRenov*), the transition to new vehicles, and the decarbonisation of industry, particularly through the adoption of hydrogen technologies. Reducing energy demand by means of energy efficiency and energy savings ("sobriété energétique") is another key pillar of French energy strategies. Here, the building sector especially stands out in terms of energy consumption. Regarding the retrofitting of energy-inefficient homes, French law mandates retrofitting homes rated F and G under the EU Energy Performance Certificates (EPCs). Owners of such properties face the following obligations: Since 2021, rent increases for unretrofitted properties are prohibited when tenants change; since 2022, energy performance assessment results must be clearly indicated when selling or renting a property; since 2023, there is an obligation to retrofit or face a ban on renting houses that consume significant amounts of energy. By 2028, rental information must clearly indicate retrofitting requirements, and penalties for non-compliance will be enforced.

SNCB: Energy and climate policy planning

France is embedding its energy policies into strategic multiannual energy and climate policy planning with an ultimate horizon of 2050. For this, France has developed and by now performed two updates of a National Low Carbon Strategy (Stragégie national bas-carbon, SNBC) and a Multi-Year Energy Program (Programmation pluriannuelle de l'énergie, PPE). Relevant plans based on these two strategies have also been developed, such as the Clean Mobility Development Strategy, Air Pollutant Emission Reduction Plan, National Strategy for Energy Research, the National Strategy for Biomass Utilisation and a National Adaptation Strategy. At the regional level, energy efficiency plans are mandatory for regions, which complement the regional climate, air, and energy programs (Le schéma régional du climat, de l'air et de l'énergie, SRCAE) implemented in larger administrative regions consisting of several provinces.

The SNBC, which was introduced by the Energy Transition Law for Green Growth[23] (Loi de transition énergétique pour la croissance verte, LTECV), is France's climate change action plan. It lays forth principles for achieving the transition to a low-carbon, circular, and sustainable economy across all sectors of activity. The SNBC was initially adopted in 2015 and amended in 2018-2019 and 2023/2024 with the goal of attaining carbon neutrality by 2050 (an increase in ambition from the first SNBC, which targeted factor 4, or a 75% decrease in GHG emissions by 2050 compared to 1990). On April 21, 2020, the revised SNBC and carbon budgets for the periods 2019-2023, 2024-2028, and 2029-2033 were established by decree. The present update of the SNBC is under parliamentary scrutiny.

In this way, France responds to its international commitments in the EU framework. Under the Green Deal announced at the end of 2019, the EU raised the 2030 reduction target to 55% of 1990 levels. This target is also reflected in the EU's NDC, updated in 2020. According to the latest NECP published in July 2024, France sets the target of a gross reduction in GHG emissions by at least 50 % in 2030 compared to 1990 (i.e., reaching a target of around 270 MtCO2eq). France reaffirms its target of achieving carbon neutrality in 2050, which was initially set by the Government's Climate Plan published in July 2017 and now enshrined in the law.

France has carbon budgets, defined in the SNBC, which are set based on France's GHG emission reduction target trajectory. These budgets are updated every five years and are adapted if necessary. The SNBC 2 set the 2nd, 3rd, and 4th carbon budgets for 2019-2023, 2024-2028, and 2029-2033, in line with the French climate ambition. The 3rd and 4th budgets will be updated in line with France's new climate ambition, and the 5th budget will be established in 2034-2038 in SNBC 3. The preliminary estimate of the breakdown of carbon budgets by sector, which was carried out by the Directorate General for Energy and Climate (DGEC) is as follows.

[23] https://www.ecologie.gouv.fr/politiques-publiques/loi-transition-energetique-croissance-verte

Table 2: Preliminary SNBC 3's estimate of the distribution of carbon budgets by areas of activity [Source: NECP, 2024]

Average annual emissions (in MtCO2eq)	1990 (reference year)	2024- 2028 (3rd. carbon budget)	2029- 2033 (4rd. carbon budget)
Transport	123	110	83
Buildings	93	51	33
Agriculture	89	71	65
Industry	140	60	42
Production of energy	79	32	26
Waste	15	10	7
LULUCF	-18	-8	-17
Total (including LULUCF)	521	327	239

Key cross-sectoral measures included in the SNBC emphasise reducing the national carbon footprint. For instance, in 2018, the carbon footprint performance stood at 11.2 tCO2 per person, which was 1.8 times the per capita greenhouse gas emissions within the country. Measures also focus on strengthening carbon price signals to stimulate investments in energy transition, promoting climate risk and opportunity judgments for investors, and excluding public investment projects that do not align with energy transition targets. Support for innovative enterprises is essential, particularly in developing and marketing new technologies needed to create a low-carbon society. Urban development is restricted on agricultural land, forests, and other natural environments to prevent long-term increases in greenhouse gas emissions. The strategy also involves information campaigns to promote low-carbon lifestyles and sustainable consumption patterns. Additionally, adaptation to industry changes and the evolving skill sets required for the energy transition is a critical component, with plans to implement necessary human resource development.

PPE: Consumption sectors and energy carriers

The Multi-Year Energy Program (PPE), developed by the French government as part of the 2015 Energy Transformation Act, is intended to be revised on a five-year cycle. The current PPE, published in 2024 is still under parliamentary consideration. It follows up on the previous version that outlines specific goals and measures aimed at advancing a low-carbon energy sector in line with the country's target of carbon neutrality by 2050.

In the **transport sector**, which accounted for more than 40% of total greenhouse gas emissions as of 2015 (the largest share of all sectors), the SNBC sets a target of a 28% reduction in emissions by 2030 compared to 2015, and a 100% reduction by 2050. Measures to achieve this include improving fuel economy to reach 4 l/100 km for new vehicles by 2030 and enhancing the performance of electric vehicles, aiming for 12.5 kWh/100 km by 2050. The

plan calls for zero emissions for all new light vehicles sold by 2040, and for domestic marine transport by 2050. Additionally, 50% of air transport fuel should be converted to biofuels by 2050, in line with efforts to decarbonise vehicle energy use. Infrastructure development, such as installing charging stations for electric vehicles, will support this transition, as will efforts to reduce transport demand through teleworking, car-sharing, and fostering the circular economy. A shift in transport modes will also be promoted, encouraging the use of railways, public transport, and bicycles.

In the **industrial sector**, which contributed 18% of total greenhouse gas emissions in 2015 (with 84% of emissions covered by the EU-ETS), the SNBC sets a target of reducing emissions by 35% by 2030 and by 81% by 2050, compared to 2015. Key measures include supporting businesses in various sectors to develop energy transition roadmaps and offering financial support through both public and private investments. The strategy focuses on reducing or eliminating emissions from industrial processes to achieve a 60% reduction by 2050, with a reliance on carbon capture, utilisation, and storage (CCUS) technologies. Further efforts include promoting electrification (with 70% of industrial energy consumption expected to come from electricity by 2050), increasing the use of biomass and renewable energy, improving energy efficiency through heat recovery, and controlling energy and material demand per product. The promotion of a circular economy will also help manage the demand for raw materials.

In the **residential and commercial sectors**, which accounted for 19% of greenhouse gas emissions in 2015 (or around 28% when including indirect emissions), the target is a 49% reduction by 2030 and complete decarbonisation by 2050. Key measures prioritise eliminating the use of fuel oil and coal for heating in the short term, with the long-term goal of achieving zero greenhouse gas emissions for all energy used in buildings by 2050. Energy efficiency retrofits will be accelerated, with a target of retrofitting 370,000 homes per year after 2022, rising to 700,000 retrofits annually in the long term. For commercial buildings, model energy efficiency retrofits will focus on public facilities, aiming to reduce energy consumption by 40% by 2050. Future environmental regulations will increase the required levels of energy performance and greenhouse gas reductions for new buildings. The strategy also promotes energy savings through the adoption of smart technologies, such as smart meters, to improve energy efficiency at the equipment level.

In the **energy sector**, which accounted for 10% of total greenhouse gas emissions in 2015 (with 74% covered by the EU-ETS), the SNBC sets a target of reducing emissions by 33% by 2030 and achieving complete decarbonisation by 2050. Managing electricity demand will involve improving energy efficiency through the research and development of innovative energy storage technologies, as well as promoting energy-saving practices through the use of smart technologies. Additionally, diversifying and decarbonising the energy mix by promoting the development of renewable energy sources, particularly biomass, and energy recovery, is a central priority.

Several key measures focus on **reducing energy consumption**. These include the end of sales of internal combustion engine vehicles by 2040, improving energy efficiency in both new and existing buildings, and promoting renewable energy use. Additionally, the PPE

emphasises the importance of setting an appropriate carbon price, such as a lower carbon price limit and the potential introduction of a border carbon tax. The continuation and strengthening of the *Certificate of Energy Efficiency and Conservation* (CEE) system is also a crucial component of the plan.

With regard to **renewable electricity development**, the target is to increase the installed capacity from 48.6 million kW at the end of 2017 to 73.5 million kW by the end of 2023 and from 101 to 113 million kW by the end of 2028 through tendering. These targets will be supported by a wide range of measures aimed at fostering renewable energy development. The plan for renewable energy development includes doubling the installed capacity of renewable electricity by 2028, compared to 2017, and increasing renewable heat production by 40-60% by 2028. To support this, the government will allocate EUR 9.7 billion to the biogas industry, aiming to raise biogas consumption to 6-8% of total gas consumption by 2028. Six new tenders for offshore wind power were issued in 2023 to further boost installed capacity. Financial support will also be increased for the hydrogen development industry, and administrative procedures will continue to be simplified to expedite development and reduce costs. The program will encourage citizens and local authorities to invest in renewable electricity projects and promote the large-scale recycling of materials from existing renewable energy facilities reaching the end of their operational life.

Efforts to enhance the performance of existing facilities are also central to the program. In the case of **hydropower**, this will be achieved by installing additional turbines, while mandatory recycling of materials from existing onshore wind facilities began in 2023. The PPE includes a common policy for excavating and removing the base of dismantled wind power facilities, with increased debt guarantees when new technologies are used. For solar power, priority is given to developing ground-mounted, low-cost facilities on urban land and parking lots. The target of introducing 300,000 kW/year of small- and medium-sized roof-mounted solar photovoltaic (PV) systems will be maintained.

In terms of reducing the share of **nuclear energy**, the French Multiannual Energy Plan (PPE) initially outlined the closure of 14 reactors with the goal of reducing the contribution of nuclear to the energy mix from 71% to 50% by 2035. While this plan is still in place, France has updated its strategy in 2024 by planning the construction of six new reactors to maintain its energy security, indicating a more balanced approach to nuclear energy rather than a simple reduction. This new development shows a dual focus on phasing out older reactors while introducing new, more advanced nuclear technologies.

The French government aims to continue the operation of the other existing nuclear power reactors, including beyond the 50-year deadline, as long as safety requirements are met. The goal is to increase the available power of existing reactors and restore the best operational performance levels, with the target of returning to nuclear production of more than 400 TWh by 2030. The industrial programme for the construction of three pairs of new EPR2 reactors is confirmed, with EDF aiming to make its final investment decision in 2025. A possible reinforcement of the nuclear power programme is explored to enable a decision on a second step of at least 13 GW by 2026. The development of small modular reactors and small innovative reactors is encouraged to enable the Nuward project to achieve a first concrete for

a first reference plant in France by 2030. The strategy of treatment and recycling of nuclear fuel is preserved until the 2040s, and facilities are renewed downstream of the nuclear cycle to enable decision-making. A program of investment in nuclear research infrastructures is conducted at the CEA level to maintain research capacity in the nuclear sector. EDF is asked to avoid any risk of saturation of existing infrastructure downstream of the cycle by 2035.

The RTE's analysis, 'Features 2050', reveals that adding low-carbon electricity production through renewable energy sources and maintaining existing nuclear reactors increases the chances of achieving climate targets and is economically efficient. This includes projects such as the Flamanville 3 reactor, wind farms, and photovoltaic projects, as well as restoring the availability of existing nuclear reactors. France aims to restore the availability of existing nuclear reactors by 2030, with the 7 offshore wind farms from 1-3 tenders set to be operational. Additional onshore wind and photovoltaic projects will contribute to increasing decarbonized electricity generation capacity. Between 2030 and 2035, the commissioning of offshore wind farms will complement the existing projects. Post 2035, the deployment of new EPR 2 and small modular nuclear reactors, along with the continued operation of the existing fleet, will strengthen the electricity generation fleet and further develop renewable energies.

The European Commission has further approved a €1.5 billion French program to promote the generation of **sustainable biomethane** and accelerate the transition to a net-zero economy.[24] France has announced a scheme to support the production of sustainable biomethane for natural gas grids. The measure is open to new installations with a projected annual biomethane production of over 25 GWh per year. Beneficiaries will be selected through a competitive bidding process based on the strike price per MWh of biomethane offered. The aid will be granted in the form of two-way contracts for difference (CfD) for 15 years, with the amount determined by the beneficiary's tender offer and the market price of natural gas. Biogas production from bioenergy has evolved from cogeneration to direct, efficient use in grids. Cogeneration is considered preferred for methanizing livestock manure near farms and reducing GHG emissions. The bioGNV production on farms is still possible, especially when biomass is distant from grid connection sites.

Regarding **coal**, France had planned to close its four remaining coal-fired power plants by 2022. While this goal was largely met, temporary reactivations occurred in 2022 and 2023 to address winter energy shortages. However, the full phase-out of coal in the power sector has been extended, with a new target for 2027. Additionally, the plan remains in place to eliminate the use of coal in domestic heating and heat networks by 2025, and to end industrial coal use by 2030, with the exception of the steelmaking sector.

In alignment with France's National Energy and Climate Plan (NECP), these measures support the broader European Union targets for renewable energy development. The European Commission has provided indicators for the amount of renewable energy installed in each country calculated from renewable energy potential and economic growth rates, etc., and the

[24] https://ec.europa.eu/commission/presscorner/detail/en/ip_24_3986

targets presented by France at the time of the draft version were lower than these indicators. In the final version, higher targets were set than in the draft version, with the exception of primary energy consumption, and a value was set for the amount of renewable energy installed that meets the EU indicator.

Overview of France's climate and energy objectives:

- Decarbonisation of Energy: Decarbonise the energy mix while enhancing energy sovereignty, primarily by moving away from fossil fuels
- Carbon Neutrality: Achieve net-zero emissions by 2050, in line with the National Low-Carbon Strategy (SNBC)
- Reduce greenhouse gas emissions by 50% by 2030 compared to 1990 levels.
- Renewable Energy Targets:
    - Increase renewable electricity, particularly wind and solar power
    - Install 54-60 GW of renewable capacity by 2030: Terrestrial wind (33 to 35 GW); Offshore wind (3.6 GW); Hydropower (including STEP) (26.3 GW); Renewable heating and cooling (297 TWh); Biofuels (48 TWh); Biogas (50 TWh)
    - Gas injection of 15% renewable gases by 2030
- Reduction of Fossil Fuels
    - Reduce coal-based energy consumption by 70% by 2030 and 75% by 2035 (compared to 2012)
    - Reduce natural gas-based consumption by 40% by 2030 and 60% by 2035
    - Reduce petroleum product consumption by 50% by 2030 and 70% by 2035
- Energy Efficiency
    - Achieve a 30% reduction in final energy consumption by 2030 compared to 2012
    - Specific focus on improving energy efficiency in buildings and industrial processes
    - Final energy consumption forecast for 2030: 1,381 TWh
    - Primary energy consumption forecast for 2030: 2,239 TWh
- Nuclear Energy: 9.9 GW of new nuclear capacity to be committed by 2026
- Flexibility in Energy Systems: Develop 6.5 GW of demand response flexibility by 2028, with additional flexibility required by 2050
- Carbon Intensity of Energy Used in the Transport Sector:
    - Reduction of greenhouse gas emissions by 14.5% in 2030 and 25% by 2035.
    - Forecast: 48 TWh in 2030 and 90 TWh in 2035.
- Share of Renewable Energy in Buildings: 49% in 2030
- Land Use, Land Use Change and Forestry (LULUCF): LULUCF sink gain of 7 MtCO2 between the average of 2016 to 2018 and 2030

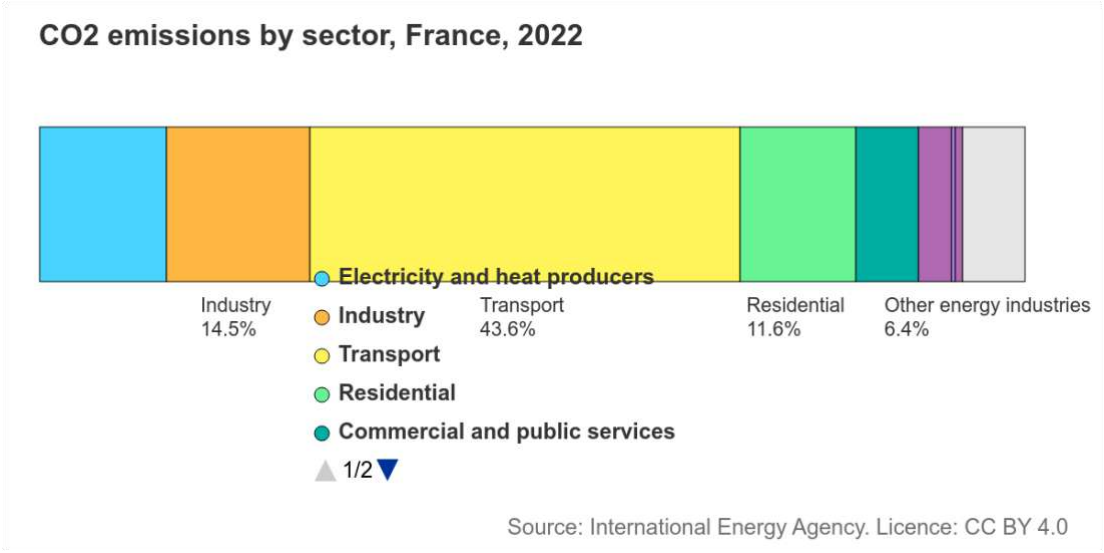
Source: NECP 2024; https://commission.europa.eu/publications/france-final-updated-necp-2021-2030-submitted-2024_en

3.4. Decarbonisation and greenhouse gas emissions

In total, France emitted 282.963 Mt CO2 in 2022, accounting for 0.8% of global emissions related to combustible fuels. This is a reduction of 22% in comparison to the year 2000.[25] The reduction in emissions in France follows a continuous downward pattern. Overall fuel-derived carbon dioxide emissions in France are on a downward trend. Per capita emissions amounted to 4.133 t CO2. Between 2000 and 2022, this is a reduction of 31%.[26]

A sectoral breakdown shows that the transport sector is responsible for some 44% of national carbon emissions, followed by industry and the energy sector (Figure 7).

Figure 7: CO2 emissions by sector



Source: ibid

While the further deployment of renewable energies and the maintenance of nuclear generation is expected to further decrease emissions, the sectoral breakdown explains the French focus to deploy electrification in the transport sector to decrease its carbon emissions.

Decarbonisation Strategies in the Industry Sector

The government's investment plan for 2030 allocates EUR 4.5 billion to decarbonize industries in two areas from 2022 to 2026. It includes EUR 4 billion for the adoption of decarbonisation systems at industrial locations and EUR 500 million to promote the development of industrial decarbonisation solutions through innovation. Since 2019, the government has collaborated with industrial stakeholders to develop roadmaps for decarbonizing industrial sectors. Several sectors have released roadmaps outlining their goals by 2050, with a step point of 2030.

[25] https://www.iea.org/countries/france/emissions

[26] https://www.iea.org/countries/france/emissions

Hydrogen use will be supported by investment, especially through the Important Project of Common European Interest (IPCEI) hydrogen project and tenders for decarbonized electrolytic hydrogen production. Priority support will be given to hydrogen use, and energy savings will be provided through certificates. The carbon market reform aims to boost energy savings and decarbonisation by increasing allowance prices with reduced ETS ceilings and requiring compliance with energy efficiency requirements from 2026.

Emerging CO2 capture technologies require public support to be profitable, despite rising carbon quota costs. A call for tender is being notified to the European Commission to support the installation of CO2 capture units on sites without decarbonisation alternatives. A public consultation on the draft tender specifications was published in June 2024. The French government has concluded bilateral agreements with Denmark and Norway for CO2 export, and plans to develop CO2 transport networks. France will also develop its own CO2 storage capacity through exploration campaigns and injection tests.

Decarbonisation Strategies in the Transport Sector

The measures to reduce CO2 emissions from transport aim to control demand, support modal shift, increase vehicle occupancy rates, increase low-emission vehicles, improve energy efficiency, and encourage biofuel development. Since 2019, these measures have been reinforced through the Mobility Orientation Law and Resilience Climate Law. The SNBC aims to decarbonize vehicles by promoting gradual electrification of passenger and heavy-duty vehicles, maintaining a diversified mix for short and medium term uses. Measures include legislative, regulatory, fiscal, and financial measures, as well as measures for charging infrastructure development, including EU regulations, end-of-sale targets, and incentives for low-emission vehicles.

The French government is collaborating with the automotive sector to accelerate the electrification of the ecosystem, with a goal of producing 2 million electric vehicles annually by 2030 and aiming for 100% electric vehicles in new light vehicle sales by 2035. EU regulations have set emission reduction targets for new car sales since 2009, with a 15% reduction in emissions from 2025 and 37.5% from 2030 onwards. The Climate Resilience Act aims to limit sales of new passenger cars emitting more than 123 gCO2 per WLTP km to 5% by January 2030. National targets for low-emission vehicles (electric or plug-in hybrids) during fleet renewal have been set since 2015, with sub-targets for the share of ultra-low emission vehicles imposed on fleets of more than 20 light vehicles managed by the state and local authorities.

From 2027, the low-emission vehicle target will be 70%, with ultra-low emission vehicles rising to 45% from 2030 at the national level. Local and regional authorities will set the target at 70% and 40%, respectively, from 2030. Private fleets will have a low emission vehicle target of 40% from 2027 and 70% from 2030.

EU Regulation 510/2011 mandated manufacturers to decrease the average emissions of new light commercial vehicles to 175 gCO2 per km between 2014 and 2017. The target was set for

2020, with a further 15% reduction from 2025 and 31% reduction in 2030. Regulation No 2023/851 amended these targets, aiming for 50% reduction in 2030 and 100% reduction in 2035, ending the sale of new thermal motor commercial vehicles. The Climate Resilience Act sets a target to end fossil fuel-primarily used heavy-duty vehicle sales by 2040. Public heavy-goods vehicle fleets must be greened, with 50% of state fleets and 10% of local and regional fleets requiring low-emission vehicles.

The French government aims to reach 400,000 charging points by 2030, while the Energy Transition for Green Growth Act sets a target of 7 million. Budgetary measures promote electric vehicle charging infrastructure deployment. In May 2024, over 130,000 public and 2 million private recharging points were operational for light-duty vehicles in France. The public authority aims to develop 400,000 public terminals by 2030, enabling electric vehicle users to charge their vehicles on roads and near major roads.

The Clean Mobility Development Strategy (SDMP) outlines France's transport sector's goals for the EPP (2030 and 2035) to combat global warming and reduce energy consumption. It aligns with SNBC's mobility objectives and is being developed in consultation with stakeholders in the transport and logistics sector. The SDMP aims to achieve operational decarbonization measures, including sobriety in passenger and freight transport, modal shift towards less carbon modes, and energy issues.

Decarbonisation Strategies in the Building Sector

French legislation mandates an energy audit every four years for large companies with over 250 employees and a balance sheet of over EUR 43 million or turnover of over EUR 50 million. The audit must cover at least 80% of the energy bill to identify energy savings potential. If recommended investments are made, energy savings can lead to up to 30% or even 50% reduction in building-related energy consumption. The Energy Efficiency Directive (EED, 2023/1791) is undergoing transposition work, requiring businesses consuming more than 23.6 GWh annually to implement an energy management system and businesses consuming more than 2.75 GWh annually without an EMS to conduct an energy audit every four years.

The Heat Fund budget will align with the energy strategy's needs, supporting all sectors and district heating network deployment. It will also promote renewable heat projects in France Rénov' and strengthen territorial animation by introducing renewable heat facilitators for community projects and businesses. The budget for energy renovation aid for housing has been increased to 2030, with the MaPrimeRénov' scheme restructured to better support housing needs. The scheme offers two tracks: a MaPrimeRénov' pathway with a trusted third party for large-scale innovation, and an unaccompanied pathway for accelerating decarbonization of heating. Fuel boiler replacement will be prioritized by 2030 to reduce CO2 emissions.

The French government unveiled an action plan to produce 1 million heat pumps by 2027, primarily replacing gas or fuel oil boilers.[27] Legislative simplification will facilitate installation in collective housing, allowing derogation from local urban planning. A center of expertise on heat pumps will be established by 2025 with state financial support. Furthermore, the district heating networks can significantly decarbonize housing, particularly in urban areas. The Chaleur de l'ADEME Fund will evolve until 2030 to support decarbonization, connections per year, and renewable heat and recovery. The number of connections will increase rapidly until 2030.

Decarbonisation Strategies in the Energy Sector

To reduce import dependence and to decarbonise, France uses a large array of energy and climate policy measures. These measures are presented in the country's latest National Energy and Climate Plan of 2024, submitted to the European Commission in the framework of the reporting and planning of European climate and energy policies under the European Green Deal.[28] As stipulated by the EU Governance Regulation, the impact of the policies and measures is assessed by scenario planning, contrasting so-called WEM and WAM scenarios. While the WEM (with existing measures) scenario provides projections of policy impacts on the energy sector, carbon emission and the macroeconomic impacts associated, the WAM scenario (with additional measures) presents a scenario in the case of further additional policy action. In the case of France, the WAM scenario is taken from the modelling undertaken for the updated SNBC and PPE and as such identical to national planning.

Deployment of renewable energies

In 2023, the French government adopted the Law on the Acceleration of Renewable Energy Production (Loi sur l'accélération de la production d'énergie renouvelable, APER).[29] Its Article 15 introduced bottom-up territorial planning from the municipality level, in addition to measures for the simplified revision of planning documents for the reception of renewable energy sources. Especially, the development of offshore wind energy is of strategic interest, but often met by public resistance. The combination of APER and the 2020 Law on Acceleration and Simplification of Public Action (Loi d'accélération et de simplification de l'action publique, ASAP)[30] makes it possible to hold public debates on offshore wind projects at sea façade level – rather than on a project-by-project basis – in the interests of transparency and long-term visibility for the public and the sector. France has set an offshore wind deployment target of 18 GW in operation in 2035. In particular, floating wind is seen as key for contributing to this objective. Capacity was tendered out. The winner of the tender for the floating offshore wind farm project in the south of Brittany was announced on 15 May 2024. With a capacity of 250 MW, it is the world's first commercial floating wind farm to be allocated a purchase tariff.

[27] https://presse.economie.gouv.fr/plan-daction-pour-produire-1-million-de-pompes-a-chaleur-en-france/

[28] https://commission.europa.eu/publications/france-final-updated-necp-2021-2030-submitted-2024_en

[29] https://www.legifrance.gouv.fr/dossierlegislatif/JORFDOLE000046329719/

[30] https://www.actu-environnement.com/blogs/fanny-vellin/362/energie-renouvelable-integration-croissante-acteurs-publics-locaux-709.html

Innovation in this area continues to bring about the transition to industrial scale, with coordination by sea façade and adaptation of port infrastructure.[31]

Support mechanisms for the deployment of renewable energies have evolved over time and are well-established now. In France, there are currently three types of support measures through price guarantees by purchase and supplementation. The applicable period is 12–20 years, depending on the type of power source. Following the revision of the EU state aid rules in 2014, renewable electricity support moved to a competitive process entity. The Feed-in Tariff (FIT) is a system under which all electricity generated is purchased at a fixed price by Electricité de France (EDF) or a regional utility, while the French support system for renewable energy is in transition to Feed-in Premium (FIP) and tendering. The current FIT is limited to some renewable energy sources, mainly small-scale installations. However, the 2021 amendment to the law expands the eligibility limit for roof-mounted solar PV from 100 kW to 500 kW. FITs cover wind, biogas below 500 kW (up to 12 MW outside continental metropolitan areas), hydro and solar power, and geothermal below 12 MW. Based on the 2015 Energy Transformation Act, the FIP system was introduced in 2016.

In principle, renewable energy sources above 500 kW (and some above 12 MW) are not subject to FITs and must sell electricity directly on the wholesale electricity market. However, for designated power sources up to a certain size, in addition to income from electricity purchases on the wholesale electricity market and income on the capacity market, they receive a feed-in premium (FIP) from Electricité de France (EDF) for the difference between the reference price set for each technology and the market price. This enables the company to obtain a price guarantee for the electricity sold on the market. In addition, the company receives an additional premium to compensate for the costs of selling electricity on the market, among other things. The FIP covers wind (onshore facilities with up to six generators not exceeding 3 MW each), biogas (facilities between 500 kW and 12 MW that utilise gas recovered from municipal and industrial wastewater and non-hazardous waste storage facilities) and hydro (<1 MW). Basically, large installations are not eligible for purchase and price guarantees, but in order to procure the power sources needed to meet the renewable energy deployment targets set out in the PPE, the government conducts tenders on an irregular basis through the French Energy Regulatory Commission (CRE). The conditions of the tender, such as power source type and size, are presented in the tender announcement. Facilities that win the tender are eligible for FIP-type support, receiving a premium for the difference between the reference price determined in the tender and the market price.

Energy efficiency

Given the heterogeneity of end uses, France applies a wide array of energy efficiency measures that cover all regulatory categories (legal, fiscal, economic, information, planning, R&D). The 2024 final French NECP lists some 35 measures that cover all sectors of the

[31] https://commission.europa.eu/publications/france-final-updated-necp-2021-2030-submitted-2024_en

economy. Many measures have evolved over time, leading to a mix of well-established and new policies.

In April 2014, France implemented a carbon pricing mechanism by adjusting the domestic consumption tax on fossil fuels to include a carbon tax. The initial tax rate was set at 7 EUR/tCO2, with revenue directed toward tax credits and initiatives aimed at promoting employment and maintaining competitiveness. Under the 2015 Energy Transformation Act, the government announced plans to gradually increase the tax rate to 100 EUR/tCO2 by 2030. However, after the tax rate reached 44.6 EUR/tCO2 in 2018, nationwide protests against this increase led to a suspension of further hikes.

In parallel, the building sector has played a significant role in France's energy efficiency and carbon reduction strategy, given that the residential and commercial sectors account for 44% of the country's energy consumption and 25% of its CO2 emissions. France has been promoting energy efficiency in buildings since 1974 through regulatory frameworks such as the Heat Regulation (RT). In 2020, this regulation was updated and renamed the Environmental Regulation (RE2020), which integrates stricter energy and carbon indicators. The updated framework came into effect in July 2022 and is being applied progressively to residential buildings, offices, schools, and other service sector structures.

The energy saving certificates scheme (CEE) is the key measures to achieve energy savings induced by the energy suppliers. The scheme was introduced in 2006 and has by now entered its fifth phase (2022-2025), with an energy savings target of 2.5 trillion kWh, allocating 30% to energy-poor households. In phase four (2018-2021), 88.1% of CEE certificates were issued based on standardised actions. Additionally, by 2050, all buildings will be renovated to meet "low-energy building" standards, helping to reduce both energy consumption and costs.

Energy conversion tax credits (CITE) transitioned to subsidies for energy efficiency and renewable heat installations (MaPrimeRénov') by 2021, focusing on smaller projects rather than large-scale retrofits. The 2021 Climate Resilience Act supports the EU's target of reducing emissions by 55% below 1990 levels by 2030, addressing energy efficiency and renewable energy while expanding on existing legislation.

"Sobriété Énergetique"

The concept of "sobriété énergétique" in France revolves around reducing energy consumption through simple, collective actions across sectors like households, businesses, and local authorities. This approach targets both environmental benefits and energy security, aiming to decrease dependency on fossil fuels and limit the impact of global energy crises, such as those exacerbated by the war in Ukraine.

Implemented since 2022, France's national plan[32] includes a 10% reduction in energy consumption by 2024, compared to 2019 levels. The plan focuses on several key pillars, notably energy sufficiency and improved energy efficiency. These pillars aim to drastically reduce the country's energy consumption, targeting a 40% reduction in energy use by 2050. Specific initiatives include lowering heating temperatures in public buildings, cutting unnecessary lighting, and encouraging carpooling and remote work.

Responsibility for implementing energy sobriety lies with multiple stakeholders. The national and local authorities are key in planning infrastructure and policies to minimise energy use. For example, authorities promote "soft mobility" (walking, cycling) and regulate energy-hungry public displays. Businesses, under schemes like the Eco-Flux and Decarbon'Action, focus on eco-design and circular economies, while citizens contribute through everyday measures such as reducing heating or using energy-efficient appliances.

Initial results show that these efforts have begun to make an impact. In 2022, primary energy consumption in France fell by 10.2%, partly due to these measures. However, much of this reduction is also attributed to mild winter weather and reduced nuclear output.

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4. Germany

Germany's economy has doubled in the past three decades with GDP increase from USD 1.77 trillion in 1990 to USD 3.89 trillion in 2020.[33] Already now, Germany is witnessing strong climate impacts. Several areas of the country had the worst flooding in almost a millennium this past summer. By 2050, the number of people in Germany who are at risk of flooding would rise by 466% if immediate action is not taken. The frequency of heatwaves is predicted to grow by 80% in Germany as well. By the end of the century, the aggregate effect of these changes will cost Germany €98 billion.[34]

The IEA sums up Germany's energy challenge as follows:

> Germany's Climate Law sets out the framework for reaching net zero emissions by 2045. In order to achieve the ambitious Energiewende by 2030, 80% of all electricity supply will need to come from renewable energy sources (and 100% by 2035) and coal is to be completely phased out. Germany has been an early leader in offshore wind and solar PV and phased out nuclear power in 2023. Major legislative reforms in renewable energy planning and siting support targets of 100-110 GW of onshore wind, 30 GW offshore wind and 200 GW solar, alongside investments in 10 GW of hydrogen by 2030. Under the Energy Efficiency Act, Germany is deploying efforts to reduce energy consumption of about 500 TWh by 2030, corresponding to around one fifth of its energy consumption in 2022.
>
> *Source*: https://www.iea.org/countries/germany

4.1. Political institutions and key players

Energy policy in Germany is the shared responsibility of both the federal government and the Länder. Nonetheless, the primary authority for enacting energy-related laws is the federal government. Through their participation in federal legislation through the Bundesrat, the Länder co-legislate on questions of energy policy. Energy policy, the energy transition, and the federal parts of climate policy are within the purview of the Federal Ministry for Economic Affairs and Climate Action (BMWK). The ministry oversees energy efficiency, emergency preparation for oil, gas and electricity, and policies for the introduction of renewable energy to the market. In addition, institutional energy research, project funding for applied energy research, and energy research policy fall under its purview, in coordination with the ministry of research (BMBF).

Energy conservation in buildings is a topic that is handled by the Federal Ministry for Housing, Urban Development, and Building (BMWSB), conjointly with BMWK. The government's fuel policy and the coordination of the energy transition in the transportation sector are within the

[33] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=DE

[34] https://www.g20climaterisks.org/germany/

purview of the Federal Ministry for Digital and Transport (BMDV). The BMDV has jurisdiction over a wide range of transportation modes, such as air, land, rail, and sea. In addition, it assists in putting the 2013 Mobility and Fuels Strategy into practice and coordinates European transportation policy. The Federal Ministry of Food and Agriculture (BMEL) is primarily in charge of managing the bioenergy industry, which includes biomass and biofuels, in the context of energy. The German Energy Agency (Dena) works on projects that promote energy efficiency and environment-friendly transformation of energy, distribution and use, renewable energies, climate protection and sustainable development together with private sectors and is responsible for providing expertise, consulting and implementing projects.[35] In order to ensure the liberalization and deregulation of markets in the energy sectors, the Federal Network Agency for Electricity, Gas, Telecommunications, Post, and Railway (Bundesnetzagentur, BNetzA) is a federal agency that oversees market regulation and notably grid regulation as a subordinate body to BMWK. Regarding energy, the regulator is in charge of systems integration, network planning, permissions for high-voltage transmission lines, and grid control (third-party access and network costs). In this role, it guarantees competitive pricing for natural gas and electricity, reasonable rates for consumers, and licenses for high-voltage transmission lines. The Bundesnetzagentur is also in charge of regulatory oversight of the trading of wholesale energy. The KfW is the state-owned development bank that provides financial support for the development of renewable energies, such as electricity and heat from the ground, sun, wind and water.[36]

4.2. Potential of natural resource

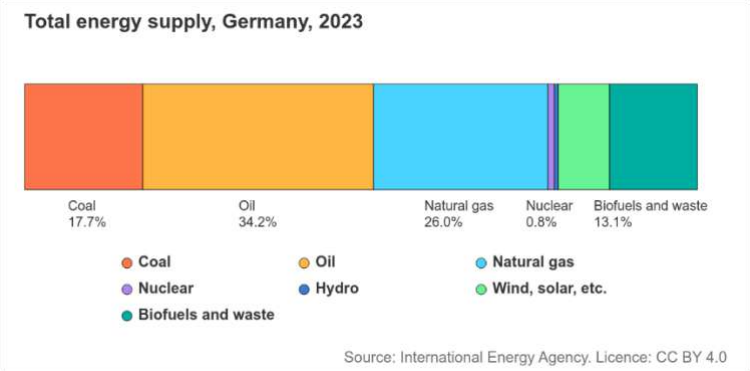
Present energy production and consumption patterns

German TES are dominated by carbon-intensive sources, primarily natural gas, oil and coal. In 2023, fossil fuels contributed some 77% each to the country's TES, followed by various renewable energy sources (Figure 8). Apart from coal, these combustibles are a not available domestically and have to be imported. The strong dependence of the country from Russian gas deliveries before Russia's war of aggression on the Ukraine is by now well-known and analysed. A sizeable portion of all sectors' FEC comes from energy imports from Russia.

[35] https://origin.iea.org/policies/395-national-energy-agency-dena

[36] https://www.kfw.de/inlandsfoerderung/Companies/Energy-and-the-environment/

Figure 8: Total energy supply Germany 2023



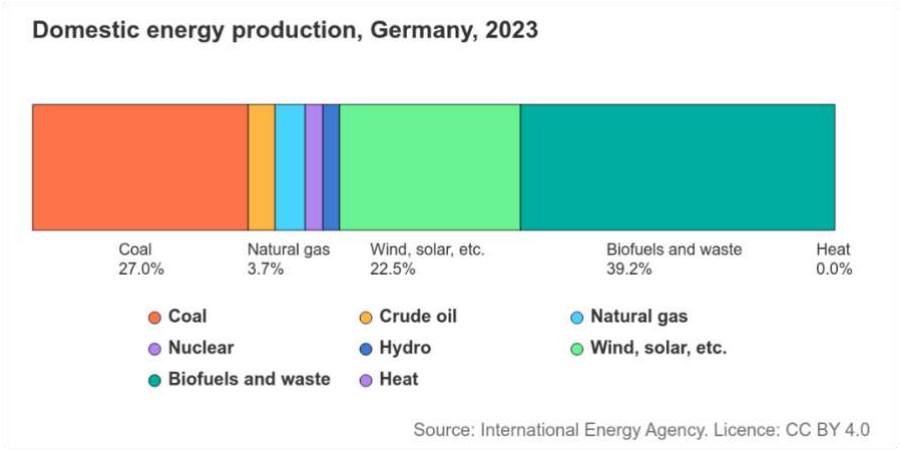
Source: https://www.iea.org/countries/germany/energy-mix

According to the Federal Institute for Geosciences and Natural Resources (BGR), about 98 percent of Germany's primary mineral oil consumption had to be imported in 2022. Russia was by far the largest supplier, delivering 34.1 percent. (U.S. 12.5%, Kazakhstan 9.8%, Norway 9.6%) until the ban of imports. Germany stopped receiving pipeline gas from Russia in late August 2022. According to data from the energy sector group BDEW, Norway was Germany's primary natural gas supplier in 2023, accounting for around 35% of monthly deliveries. The Netherlands came in second with roughly 30%. LNG terminals in nearby nations, where the fuel is regasified and fed into the natural gas pipeline infrastructure, have been another source of supply for Germany. In a concerted attempt to substitute Russian gas, the country built its own floating LNG terminal infrastructure in record time. In 2022, 44.65 million tonnes of hard coal were imported by Germany. Russia (29.2%), the United States (20.8%), and Colombia (16.3%) were its top coal suppliers. Germany stopped importing Russian coal in the summer of 2022 due to an EU ban.[37]

In contrast, biofuels and waste (39.2%), coal (27.0%) and renewable energies (22.5%) constituted the three largest domestic energy sources in 2023 (Figure 9).

[37] https://www.cleanenergywire.org/factsheets/germanys-dependence-imported-fossil-fuels#four

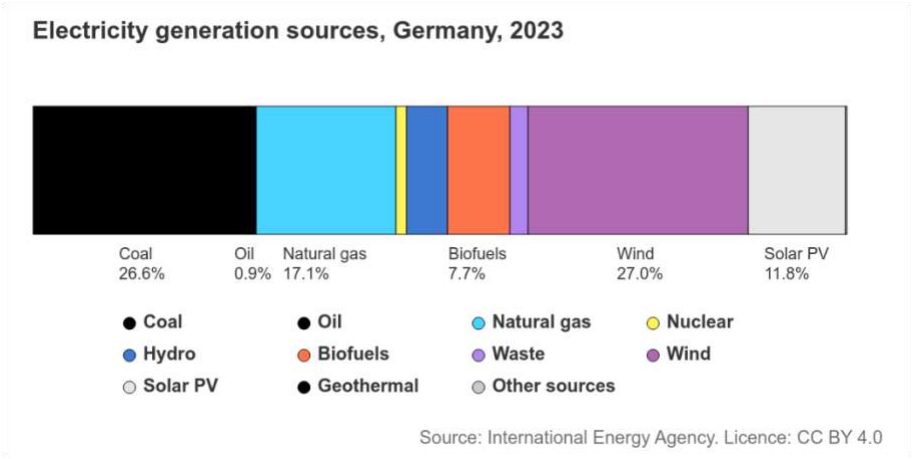
Figure 9: Domestic energy production 2023



Source: https://www.iea.org/countries/germany/energy-mix

The uptake of renewable energies has notably been a success in electricity generation, where renewables by now cover a share of over 50%. Nuclear power has been phased out as production source in line with the German energy concept. However, coal and natural gas still constitute some 43% of generation sources, making the German electricity generation very carbon-intensive (Figure 10). The government pursues a strong electrification strategy in order to switch fossil fuel uses in heating and transport to electricity by promoting electric vehicles and heat pumps.

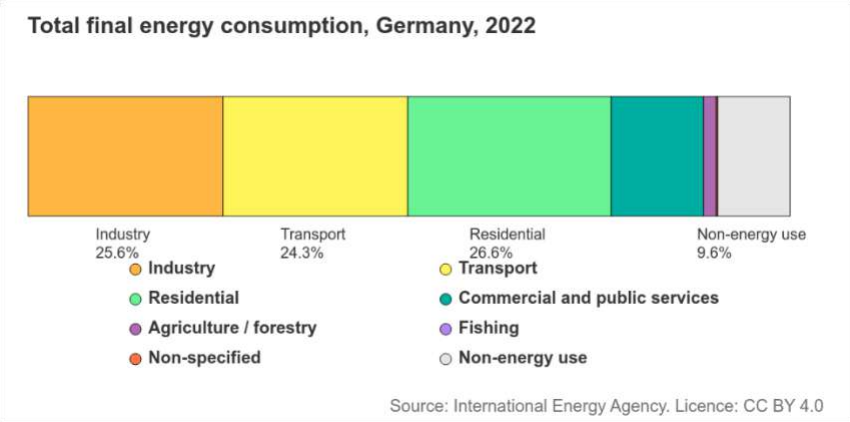
Figure 10: Electricity generation sources in Germany 2023



Source: https://www.iea.org/countries/germany/electricity

When looking at energy consumption patterns, the residential (26.6%) and industry (25.6%) sectors were the two largest energy consumers, followed by transport (24.3%) in 2022 (Figure 11).

Figure 11: Total final energy consumption, Germany

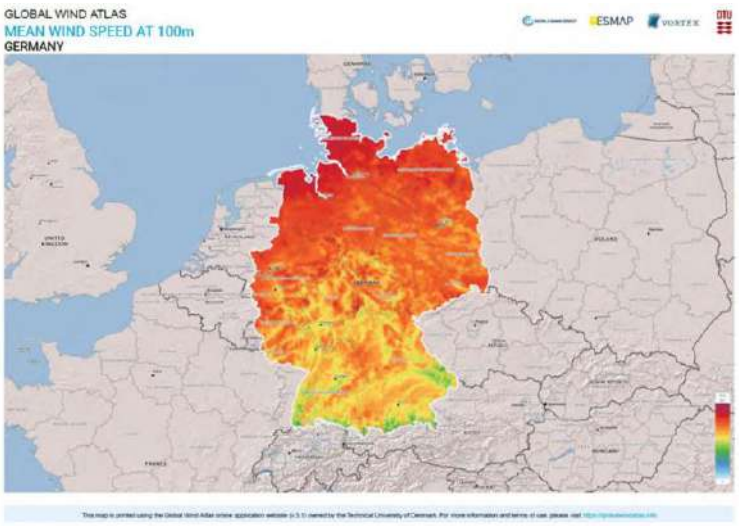


Source: https://www.iea.org/countries/germany/efficiency-demand

Further domestic potential with renewable energies

In Germany, suitable areas with strong **wind conditions** are predominantly concentrated in the northern regions, especially along the North Sea coast. These areas are characterized by high and consistent wind speeds, making them highly favorable for wind energy generation. Notably, regions such as Lower Saxony and Schleswig-Holstein are key hotspots for wind power due to their proximity to the sea, benefiting from both onshore and offshore wind projects. Beyond the coastal zones, parts of northeastern Germany, including Mecklenburg-Western Pomerania, also exhibit good wind potential, driven by open plains and flat landscapes conducive to consistent wind flow. In addition, several inland areas, particularly those with higher elevations such as the Harz Mountains, show moderate wind speeds suitable for wind energy installations.

Figure 12: World Bank Group, GLOBAL WIND ATLAS, Germany 2024



Source: https://globalwindatlas.info/area/Germany

Turning to **solar potential**, the southern regions of Germany, particularly in states such as Bavaria and Baden-Württemberg, receive significantly higher solar radiation compared to the northern parts of the country. These areas are particularly well-suited for solar energy development due to the combination of favorable geographic location and higher average sunshine hours. In addition to Bavaria, other areas with good solar potential include regions in the southwest near the Black Forest and parts of central Germany. The color-coded solar radiation maps for Germany illustrate this variation, with darker regions in the south indicating higher solar irradiance, whereas the northern regions, particularly near the North Sea and Baltic coast, receive less sunshine throughout the year.

Figure 13: Solargis "Global Horizonal Irradiation"

4.3. National targets

The German government set out to make Germany one of the world's most environmentally responsible and energy-efficient economies while preserving competitive energy prices and a high degree of prosperity with its Energy Concept of September 2010 and its energy policy decisions taken in June 2011.[38] The European energy transition, which has set ambitious targets for 2030 and beyond, encompasses the German energy transition. According to these goals, renewable energy is expected to constitute 60% of final energy consumption by 2050, with intermediate targets of 18% in 2020, 30% in 2030, and 45% in 2040. In terms of electricity generation, renewable energy is projected to make up 80% by 2050, with targets of 35% in 2020, 50% in 2030, and 65% in 2040. Additionally, Germany aims for a 50% reduction in primary energy consumption compared to 2008 levels by 2050, with an interim target of a 20% reduction by 2020. The strategy also includes plans for a 25% reduction in electricity consumption by 2050, with a 10% reduction target by 2020.[39]

The evolution of imported hydrogen and hydrogen derivatives are entirely produced from renewable energy sources for the whole period (100% green hydrogen) is shown in Table 3. According to EU statistics, the proportion of renewable energy in gross final energy consumption would increase from 23.5% in 2024 to 38.1% by 2030. In the years that followed, this rise would persist, and the percentage will rise to 73% by 2040. Rapid advancements in the development of renewable technology, particularly in the fields of wind energy and photovoltaics, have been made possible by national acceleration initiatives. The noticeable rise in the number of approvals granted for these technologies in 2023 and 2024 further supports this. By 2030, renewable energy will account for 74.2% of total electricity usage. By 2040, 96% of the electricity generated will come from renewable sources.

Table 3: Renewable energy - Shares in total sector consumption from 2024 to 2050, in % – assuming only green hydrogen imports [Source: NECP, 2024]

	2024	2030	2035	2040	2045	2050
Gross final energy consumption (RED II)	23.5	38.1	57.5	73.0	81.9	88.3
Gross final energy consumption (national statistics)	23.6	38.0	57.0	71.9	80.1	86.1
Electricity (RED II and national statistics)	54.5	74.2	89.6	96.0	95.7	94.5
Onshore wind	21.4	26.2	31.8	33.9	32.5	32.3

[38] https://www.bmwk.de/Redaktion/EN/Publikationen/first-monitoring-report-energy-of-the-future-summary.pdf?__blob=publicationFile&v=1

[39] https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/sechster-monitoring-bericht-zur-energiewende-kurzfassung.pdf?__blob=publicationFile&v=7

Offshore wind	5.6	12.1	16.8	16.7	19.2	19.4
Photovoltaics	15.3	28.6	35.5	40.4	38.8	37.4
Hydropower	3.7	2.9	2.4	2.1	2.0	1.9
Biomass (incl. share of organic waste)	8.4	4.4	3.2	2.9	3.1	3.4
Geothermal energy	0.1	0.1	0.1	0.0	0.0	0.0
Imported green hydrogen	0.0	0.0	0.0	0.0	0.0	0.0
Transport (RED II)	10.2	38.0	71.8	92.7	101.4	108.5
Transport (national statistics)	6.6	16.8	35.8	57.1	68.6	82.9
Biodiesel (incl. HVO and plant oil)	3.5	3.5	2.3	1.1	1.0	0.8
Biogas	0.1	0	0	0	0	0
Renewable energy -electricity	1.7	9.2	23.7	39	49.1	54.3
Green hydrogen/ e-fuels	0	1.4	5.8	12.7	12.8	18.4
Heating and cooling (Eurostat and national statistics)	20.2	30.2	45.4	57	67.6	70.8
Biomass and renewable wastes	14.9	19.4	23.6	27.2	31.1	32.7
Other renewable energies	5.2	9.9	15.9	21.4	25.3	26.6
Hydrogen	0	0.9	5.9	8.4	11.2	11.4

Table 4 provides a description of the sector-specific projection results for reference development.

Table 4: Greenhouse gas emissions by sector, 2024–2050, in Mt CO2- eq. estimated by modelling of 2024 projection data, with-additional-measures (WAM) scenario [Source: NECP, 2024]

	2024	2030	2035	2040	2045	2050
Energy-related emissions	569	362	221	135	95	85
Energy industry	208	95	54	35	35	39

Industry	101	80	55	41	32	30
Transport	148	111	67	32	15	6
Other*	109	73	43	25	12	9
Diffuse emissions	3	3	2	1	1	1
Non-energy-related emissions	108	90	70	64	65	67
Industrial processes	50	38	24	17	17	17
Agriculture	52	50	48	47	47	47
LULUCF	0	-2	-5	-3	-2	0
Waste	5	4	4	3	3	3
Total without LULUCF	677	454	296	202	163	152
Total with LULUCF	677	452	291	199	161	153

Note: Other includes commerce, trade and services; households; agricultural energy; military energy uses.

The Federal Climate Change Act of December 12, 2019 (Bundes-Klimaschutzgesetz - KSG) requires a reduction in greenhouse gas emissions of at least 55% by 2030 compared to 1990 levels. On 29 April 2021, the First Senate of the Federal Constitutional Court ruled that the provisions of the KSG governing national climate targets and annual emission amounts allowed until 2030 are incompatible with fundamental rights because they do not specify sufficient further emission reductions beginning in 2031 and failed to satisfy the obligation imposed by Article 20a of the Basic Law (Grundgesetz - GG) to take climate action. In all other aspects, the constitutional complaints were dismissed.[40] In response to this ruling, On August 31, 2021, an amendment to the KSG went into effect. The amendment makes the country's objective of becoming climate neutral by 2045 legally binding. The target after 2050 is to have negative emissions. (KSG § 3, Paragraph 2.) Germany has established intermediate goals to achieve climate neutrality, including a 65% decrease in greenhouse gas (GHG) emissions by 2030 compared to 1990 levels and an 88% reduction by 2040. (§ 3, para. 1.) The Annexes 2 and 3 provide annual emission amounts for the years 2020-2030 and 2031-2040, respectively.[41]

On September 26, 2021, a parliamentary election was conducted in Germany. The tripartite coalition between the social democrats (SPD) of chancellor Olaf Scholz, the Greens, who

[40] https://www.bundesverfassungsgericht.de/SharedDocs/Pressemitteilungen/EN/2021/bvg21-031.html
[41] https://www.loc.gov/item/global-legal-monitor/2021-09-28/germany-amendment-of-climate-change-act-codifies-climate-neutrality-goal-by-2045/

became the third party, and the Free Democratic Party (FDP), led to an ambitious stance on transition policies. After the break-up of the coalition in 2024, the minority government of SPD and Greens pursued this stance.

The climate change section contains several noteworthy declarations that serve as a major guiding concept for the negotiations and future government action. First, a 'ideal' phase-out of coal by 2030 is envisioned in the coalition statement. The government aims for an ideal scenario of being coal-free by 2030, which is a significant acceleration from the previous target of 2038 set by the Merkel government. This shift underscores a strong commitment to phasing out fossil fuels more rapidly in favor of cleaner energy sources. Additionally, by 2030, the coalition hopes to increase the amount of renewable energy to 80% by fortifying the infrastructure for wind and solar power. The coalition affirms its opposition to nuclear power.[42]

In terms of renewable energies, the coalition has raised the target for the share of electricity generated from renewable sources from 65% to 80%. This adjustment is based on the assumption that total electricity demand in 2030 will range between 680 and 750 terawatt-hours (TWh). To support this ambitious target, the Renewable Energy Act (EEG) will be leveraged to facilitate large-scale renewable energy expansion. Furthermore, the government intends to strengthen subsidized expansion instruments, such as long-term power supply agreements (PPAs) and the European trading of renewable energy power certificates.

The Bundestag has passed a law reducing the cost burden of the Renewable Energy Sources Act levy, allowing electricity consumers to no longer pay the EEG levy starting from 1 July 2022, and requiring electricity suppliers to pass this reduction to end consumers. This funding mechanism will transition from being supported by electricity prices to being funded through the government budget, specifically from the Energy and Climate Fund (EKF) based on emissions trading revenues, starting on January 1, 2023. The government also plans to make solar installations mandatory in new commercial buildings and to regularize the installation of solar panels in new private buildings, with certain exceptions.

To further promote the expansion of solar energy, the government aims to eliminate all obstacles to achieving a target of 200 gigawatts (GW) of solar photovoltaic (PV) installations by 2030. This includes enhancing grid connections, adjusting compensation amounts, and revising tender obligations and caps for large roof-mounted installations. In addition to solar energy, the coalition agreement designates 2% of the country's land area for onshore wind power, securing this allocation under the Federal Building Code.

On April 6, 2022, the German Federal Government approved the "Easter Package," a comprehensive set of bills aimed at amending several laws and regulations related to energy policy. This significant legislative initiative was presented to the Cabinet of Ministers with the intent to bolster the expansion of renewable energy as a matter of national security and a top

[42] https://old.robert-schuman.eu//en/doc/divers/Traffic_Light_Coalition_Contract_Explained.pdf

public interest priority. Following the government's approval, the German Bundestag and Bundesrat voted on July 7 and July 8, 2022, respectively, on this critical legislative package.[43]

The "Easter Package" comprises key amendments to various laws, including the Renewable Energy Sources Act (RES Act, or EEG), the Offshore Wind Energy Act, the Energy Industry Act, the Federal Requirements Plan Act, the Grid Expansion Acceleration Act and further laws and ordinances in the field of energy legislation. The fundamental tenet of the package is that using renewable energy helps public security and is in the public interest. To further this commitment, the package sets an ambitious target for renewable energy to account for at least 80% of Germany's total electricity consumption by 2030. This new target requires a nearly doubled share of gross electricity consumption covered by renewables, which will be achieved through increased electrification of industrial processes and sector coupling, reducing dependence on gas imports and requiring around 600 TWh of renewable energy. To achieve this goal, the growth rates for onshore wind energy will be increased to 10 GW annually, bringing Germany's installed onshore wind capacity to approximately 115 GW by 2030. Germany's installed solar capacity (rooftop/ ground-mounted/ special solar installations) should reach about 215 GW by 2030 as the expansion rates for solar energy are stepped up to 22 GW/year. According to the coalition agreements, offshore wind energy expansion targets will be significantly increased to at least 30 GW by 2030, at least 40 GW by 2035, and at least 70 GW by 2045. To achieve this considerably quicker rollout, the Offshore Wind Energy Act will be completely amended and the volumes up for auction will be raised. Moreover, the Energy and Climate Fund will replace the EEG surcharge on electricity prices for renewables financing, easing consumer burdens and strengthening sector coupling.

To enhance the deployment of wind power in Germany, a series of strategic measures have been implemented for both onshore and offshore wind energy. Central to these efforts is the Accelerating Onshore Wind Power Expansion Act (WindBG), promulgated in July 2022 and effective from February 1, 2023. The RES Act alone cannot address major onshore wind barriers such as a lack of sites); instead, a different legislative package, known as the "summer package," addresses these issues in a subsequent step that the cabinet will adopt. However, the 2023 RES Act modifies a few crucial aspects to make room for these reforms. For instance, the limit on the size of pilot wind turbines is being lifted, the reference yield model for low-wind sites is being upgraded, and the degression of the maximum value is halted for two years.

Biomass funding will focus on highly flexible peak load power plants, utilizing bioenergy as a storable source to better serve the grid. Auction volumes for biomass will be scaled back, and tenders were set to increase biomethane to 600 MW/year from 2023. Biomass will be used more in areas hard to decarbonize, such as transport and industry. Citizens' energy initiatives will be exempted from auctions for stakeholder diversity, local acceptance, and bureaucracy reduction. Wind and solar projects will be realized without auction participation, but wind

[43] https://www.bmwk.de/Redaktion/EN/Downloads/Energy/0406_ueberblickspapier_osterpaket_en.pdf?__blob=publicationFile&v=5

projects up to 18 MW and solar projects up to 6 MW are restricted due to the European Commission's Guidelines on State aid for climate, environmental protection, and energy.

To facilitate the expansion of solar energy in Germany, several measures have been introduced aimed at increasing capacity and streamlining support for solar installations. Solar energy conditions will be improved through specific measures aimed at different installation types. The deployment corridor, PV expansion targets, and auction volumes will be adjusted, with expansion volume shared equally between roof-top and ground-mounted installations. Remuneration for roof-top installations will be raised, and new installations that feed all their electricity into the grid will receive adequate funding. Self-consumption installations will receive lower subsidies. Ground-mounted installations will have moderate expansion, considering agricultural and nature conservation aspects. New categories of agrivoltaics, floating voltaics, and moor voltaics will be included in regular auctions for ground-mounted photovoltaics. Some agrivoltaic and moor voltaic installations will be granted a bonus to compete.

The revision aims to expedite the awarding of grid connection contracts, streamline planning and approval procedures, and consolidate investigations. It will replace the planning approval procedure for sites under preliminary investigation with a swifter plan adoption procedure, and impose rules on approval and adoption duration. Environmental impact assessments and consultation rights will be merged, and the offshore grid connection contract can be awarded as soon as the site is included in the development plan, resulting in a faster contract award by several years.

Overview of Germany's climate and energy objectives:

- Decarbonization of Energy: Reduce GHG emissions by at least 65% by 2030 (compared to 1990 levels), 88% by 2040 and reach GHG neutrality by 2045
- Reduce greenhouse gas emissions by 50% by 2030 compared to 1990 levels.
- Renewable Energy Targets:
    - Increase the share of renewable energy to at least 42.5% of gross final energy consumption by 2030
    - Target 80% of gross electricity consumption from renewables by 2030 (600 TWh of renewable electricity): Terrestrial wind (115 GW by 2030; 160 GW by 2040); Offshore wind (30 GW by 2030, 40 GW by 2035; 70 GW by 2045); Photovoltaics (215 GW by 2030; 400 GW by 2040); no targets specified for biomass and hydropower
    - Heating and Cooling: 50% of grid-linked renewable heat or unavoidable heat by 2030
- Reduction of Fossil Fuels
    - Gradual reduction of coal-fired electricity generation
    - Coupling of electricity markets to further phase out fossil fuels
- Energy Efficiency
    - Final energy consumption to be reduced by at least 26.5% by 2030 (compared to 2008)
    - Primary energy consumption to be reduced by at least 39.3% by 2030 (compared to 2008)
- Flexibility in Energy Systems:
    - Strengthen flexibility in electricity demand and markets to further integrate renewable energy sources

    - Focus on sector coupling between electricity, heat, and transport
- Carbon Intensity of Energy Used in the Transport Sector:
    - 30% of gross final energy consumption from renewable energy in 2030
    - Targets for electric vehicles (15 million electric vehicles by 2030)
- Share of Renewable Energy in Buildings:
    - 50% of grid-linked renewable heat or unavoidable heat by 2030
    - Improvement of energy efficiency of buildings
- Land Use, Land Use Change and Forestry (LULUCF): LULUCF sink gain of 3.8 MtCO2 by 2030, aiming for a 30.8 Mt sink

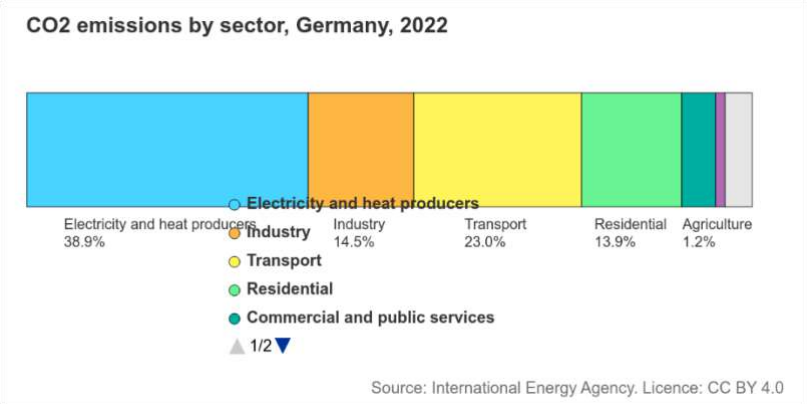
Source: NEPC, https://commission.europa.eu/publications/germany-final-updated-necp-2021-2030-submitted-2024_en

4.4. Decarbonisation and greenhouse gas emissions

Given the carbon intensive-energy production, German CO2 emissions amount to 612.004 Mt CO2 in 2022. They however follow a downward trend, having decreased by 25% in 2022 in comparison to the year 2000. Germany is responsible for a share of 1.8% of global emissions from combustible fuels. Per capita emissions amount to 7.303 tCO2, decreasing by 27% in the period 2000-2007.[44]

A sectorial breakdown shows that electricity and heat production with 38.9% of emissions represent the country's biggest emission source. Carbon emissions peaked in 2007 (368 Mt CO2) and have been reduced to 238 Mt in 2022. In contrast, the other sectors show relatively stable emission trends, though slowly decreasing.

Figure 14: CO2 emissions per sector, Germany 2022



Source: https://www.iea.org/countries/germany/emissions

[44] https://www.iea.org/countries/germany/emissions

Decarbonisation Strategies in the Industry Sector

The Federal Government's "Decarbonisation in Industry" funding programme, launched in 2021, supports energy-intensive industries in developing climate protection technologies, transforming industrial sites. Merging into the Federal Fund for Industry and Climate Action in 2024 expands accessibility to other industrial sectors and SME.

Germany also intends to promote integrated projects throughout the hydrogen value chain, from green hydrogen production to infrastructure and industry use through IPCEI Hydrogen programme. It's jointly funded by the BMWK, Federal Ministry for Digital and Transport (BMDV), and federal states, with 70% federal government funding and 30% state support. The Federal Government is revising the Ordinance for the Awarding of Other Energy Generation Sectors (SoEnergieV) to include financial support for offshore electrolysis technologies for the production of green hydrogen at sea.

The Federal Government is implementing carbon contracts for difference to establish an economic framework for climate-friendly production facilities in energy-intensive industries. These contracts provide industrial companies with price protection and compensate for higher costs during technological transition.

Decarbonisation Strategies in the Transport Sector

The Federal Government is implementing measures to improve the transport sector, including the Fuel Emissions Trading Act (BEHG), CO2 differentiation of truck tolls, EU CO2 emission standards, and GHG quotas. Emission trading for buildings and transport sectors (ETS II) is expected to be in place by 2027.

Germany aims to register at least 15 million fully electric vehicles by 2030. To increase the share of electric vehicles among new registrations and reduce carbon emissions, further measures are needed. These measures aim to reduce the cost differential between electric cars and internal combustion engines, making charging and refueling infrastructure more attractive. The German Motor Vehicle Tax Act has extended company car regulations for battery electric vehicles or plug-in hybrid vehicles until 2030, and the tax exemption for first-time registrations has been extended until 31 December 2025. The Federal Government has also aligned vehicle tax with carbon emissions, with the taxable base tied to CO2 test values per kilometer. The government has also campaigned at the European level for CO2 fleet limits for new passenger cars and light commercial vehicles, allowing internal combustion engine vehicles beyond 2035, provided they are powered exclusively by CO2-neutral fuels.

The Federal Government aims to expand Germany's publicly accessible charging infrastructure to 1 million by 2030. The strategy includes ensuring land availability, empowering local authorities, and integrating charging infrastructure with grid and electricity expansion. The National Charging Infrastructure Coordination Office coordinates the ramp-up of public charging infrastructure at all levels. Funding is a central pillar in supporting the development

of charging infrastructure, with guidelines covering residential buildings, on-site charging, public refueling infrastructure, and solar power.

The National Hydrogen Strategy (NWS) updated in July 2023 aims to double the production capacity of green hydrogen and address climate change mitigation challenges. The transport sector is crucial, with hydrogen and its derivatives expected to be used in industrial, heavy-duty vehicles, aviation, shipping, and military applications by 2030. The strategy includes short, medium, and long-term measures, including hydrogen and fuel cell technologies, Power-to-X fuels, and a triple credit for green hydrogen towards the GHG quota. Measures in the transport sector include establishing hydrogen refuelling points, promoting renewable fuels, and creating a regulatory environment for hydrogen use. A master plan for hydrogen and fuel cell technology in transportation is being developed to advance hydrogen, hydrogen-derived fuels, fuel cell vehicles, and infrastructure.

The Federal Ministry for Digital and Transport supports research and development in hydrogen and fuel cell technology for transport applications, procurement of vehicles, refueling infrastructure, and electrolysis systems for hydrogen production. Since 2016, over €1 billion has been made available for this purpose. The NIP focuses on scaling hydrogen and fuel cell technologies, optimizing the technology, and addressing market gaps. Germany has built one of the most advanced networks in Europe, with nearly 90 hydrogen refueling stations for cars, light commercial vehicles, and waste collection vehicles. The "HyLand – Hydrogen Regions in Germany" programme promotes regional implementation of hydrogen applications in transport. The "Guideline for the Promotion of Alternative Drives in Rail Transport" supports the conversion of rail vehicles to alternative drives and infrastructure development. The Federal Ministry for Digital and Transport supports the establishment of a decentralized hydrogen innovation and technology center in Duisburg, Chemnitz, Pfeffenhausen, and Northern Germany.

Decarbonization Strategies in the Building Sector

The Federal Government has submitted a Long-Term Renovation Strategy (LTRS) to the EU Commission, aiming to achieve long-term climate targets and transform existing buildings into zero-emission ones. The LTRS requires Member States to set out measures and progress indicators to achieve these targets. The EU Buildings Directive, which came into force in May 2024, aims to achieve highly energy efficient and decarbonized buildings by 2050. To achieve these targets, energy demand for heating and cooling must be reduced through efficiency measures and renewable sources increased.

The buildings sector in Germany is implementing key measures to promote energy efficiency. These include federal funding for energy-efficient buildings, tax incentives for renovation, and the Buildings Energy Act (GEG). The GEG requires 65% renewable energy in new heating systems, reducing fossil fuel use. The act is technology-neutral and covers various energy-efficient options like heat pumps, district heating, biomass, and hydrogen. Carbon pricing based on the Fuel Emission Allowance Trading Act improves the competitiveness of greenhouse gas-neutral heating alternatives. The Carbon Dioxide Cost Allocation Act also

incentivizes landlords to renovate their buildings. The Heat Planning Act (WPG), which came into force on 1 January 2024, mandates large-scale heat planning to increase renewable energy share in the heat supply and provide guidance for future heat supply. The Heat Planning Act aims to generate 50% of grid-bound heating from renewable energy sources and unavoidable waste heat by 2030, with binding requirements for minimum renewable energy or waste heat shares, and full decarbonization by 2045.

The Federal Funding for Efficient Buildings (BEG) program aims to increase energy efficiency in residential and non-residential buildings by replacing old fossil-fuel heating systems with renewable energy sources. Funding is available for complete renovations and individual measures, particularly on the building envelope, through low-interest loans from the KfW with repayment bonuses. Since January 2024, subsidies for renewable heat generators can be applied from the KfW. Special funding incentives are available for refurbishment of buildings with poor energy efficiency, serial refurbishment work, and heat pumps that use natural refrigerants. Investment cost subsidies include a basic 30% subsidy for all buildings, an efficiency bonus of 5% for heat pumps using water, soil, or waste water, a 20% climate speed bonus until the end of 2028, and a 30% income bonus for owner-occupiers with up to €40,000 of taxable household income per year.

The "Climate-friendly New Builds" and "Home Ownership for Families" funding programmes aim to promote environmentally friendly buildings. The KFN and WEF programs aim to build buildings with low gas emissions, high energy efficiency, low operating costs, and a high proportion of renewable energy sources. The KFN program is launched in March 2023, while the WEF program was launched in June 2023. A new "Climate-friendly new construction in the low-cost segment" program is planned for 2024 and 2025.

Germany launched a heat pump initiative in 2022, aiming to install 500,000 heat pumps annually from 2024. Stakeholders agreed to further develop heat pumps, use natural refrigerants, and improve existing building framework conditions. The initiative is part of the Building Energy Act and aims to decarbonize the building sector.

Decarbonisation Strategies in the Energy Sector

The Renewable Energy Sources Act (EEG 2023) reform, effective January 1, 2023, aims to increase renewable energy use by 80% of gross electricity consumption by 2030 with various measures. The new principle prioritizes renewable energy over other interests, accelerating planning and approval procedures. The 2020 amendment to the Combined Heat and Power Act (KWKG Act) introduced instruments for switching fuel from coal to gas and increasing renewable energy use in combined heat and power (CHP). The aim was to phase out coal-based power in Germany. The "Immediate Climate Action Programme" aims the reduction in eligible full-load hours, encouraging CHP plants to operate responsively to the electricity market. Additionally, hydrogen compatibility requirements were introduced, preventing lock-in effects.

The Renewable Energy Sources Act focuses on integrating renewable energy sources into electricity grids, with Germany as a large EU Member State aiming to expand transmission systems and modernize existing ones. This presents challenges, as electricity generation requires adequate transport to consumption centers. Direct control of renewable energy growth is being implemented alongside grid-related measures to better synchronize the growth of renewable energy sources with grid expansion. Regional control of renewable energy sources impacts the expansion plans of states, network development planning, and acceptance of renewable growth. Options for regional control include geographic control of generation capacity and reducing cost-intensive curtailments.

Deployment of renewable energies

In August 2014, renewable electricity was replaced by a market premium system, where new generators above a certain size sell electricity directly to the grid operator and receive a premium.[45] With the Renewable Energy Law amendment (EEG2017) in January 2017, new facilities above a certain size will shift to a bidding process to determine eligibility and support level. Successful projects will receive 20-year contracts to sell their produced electricity at the price they bid during the auction process.[46]

The Renewable Energy Law 2023 (EEG 2023) in Germany has introduced significant amendments to advance renewable energy goals, including the establishment of interim target values for onshore wind and solar photovoltaic (PV) energy, and extending additional targets up to 2040. The law also emphasizes offshore wind power, with a distinct target of 30 gigawatts (GW) set for completion by 2030. The Offshore Wind Energy Act of 2023 (WindSeeG) Amendment, included in the Easter Package, complements the EEG 2023 by increasing the target for offshore wind power deployment beyond 2030. The German Bundestag has expanded the authority of the Federal Network Agency to set the maximum bidding price, which can be increased by up to 25%.[47]

Energy efficiency

Germany's energy efficiency measures include mandatory energy audits for companies, in line with the EU Energy Efficiency Directive. Large companies are required to undergo audits every four years under the Energy Services Act (EDL-G), while SMEs can benefit from a subsidy program.[48]Since December 2015, large companies have been required to undergo energy audits every four years under the Energy Services Act (EDL-G), while small and medium-sized enterprises (SMEs) can benefit from a subsidy program designed to facilitate their participation in energy audits through the Upgrading Energy Consulting initiative. In the building sector, energy consumption has been governed by the Energy Conservation Law (EnEG) and the Energy Conservation Decree (EnEV), which have been

[45] https://www.iea.org/policies/5734-2014-amendment-of-the-renewable-energy-sources-act-eeg-2014
[46] https://www.iea.org/policies/6125-2017-amendment-of-the-renewable-energy-sources-act-eeg-2017
[47] https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/12/20221215-bundestag-adopts-energy-price-caps-important-relief-for-consumers.html
[48] https://apps.eurofound.europa.eu/legislationdb/obligation-to-undertake-energy-efficiency-audits/pdf

integrated and updated under the Building Energy Law (GEG), effective since November 2020.[49] This law establishes stringent energy performance requirements for both new and existing buildings and mandates the incorporation of renewable energy sources for heating and cooling.

[49] https://www.bmwk.de/Redaktion/EN/Artikel/Energy/energy-conservation-legislation.html

5. Italy

Italy's economy has grown by 61% in the past three decades with a GDP increase from USD 1.18 trillion in 1990 to USD 1.9 trillion in 2020.[50] As with all Southern European countries, climate change is expected to have a considerable impact on the country. By 2050, Italy would experience an increase in the frequency of agricultural droughts of 35% if nothing urgent is done. Heatwaves are predicted to last 1.461% longer, and the confluence of rising sea levels, coastline erosion, and extreme weather is expected to devastate Italy's economy, which is projected to lose almost 3.7% of its GDP by 2050.[51]

The International Energy Agency (IEA) summarises Italy's energy and climate policy as follows: "Italy aims for carbon neutrality by 2050 and is on track to reach its 2030 targets for emissions reductions and energy efficiency, aiming to reach 30% of renewables in total energy consumption and 55% of renewables in electricity generation. The country has experienced notable growth in the renewable energy sector and has successfully integrated large volumes of variable renewable generation. Natural gas is a major source for electricity and heating, therefore Italy has strengthened its energy security by diversifying natural gas supply, making use of the pipeline and LNG infrastructure that it has built up over the last decade. Reducing overall demand for natural gas through an accelerated shift to alternative energy sources and a stronger focus on energy efficiency, especially in buildings, will not only further strengthen energy security, but also help the country meet its climate targets."[52]

5.1. Political institutions and key players

Italy is a parliamentary republic with a prime minister who leads the government. The president takes a role of the head of state and appoints the prime ministers. Legislative authority in Italy over energy policy is shared between the central government, the regions, and the autonomous provinces. National legislation's guiding principles place restrictions on the regional legislature's authority in this area. The institutional organisation responsible for coordinating national and regional policy in all areas of shared responsibility, including energy, is the State-Region Conference.

Energy and climate policy competences at government level have been consolidated in the Ministry of Ecological Transition (MiTE, Ministério dellaTransizione Ecologica) since 2020. In 2022, the Meloni government renamed MiTe the "Ministry of the Environment and of Energy Security" (MASE, Ministério dell'Ambiente e della Sicurezza Energetica). The goal of the ministry is to improve the consistency of climate and energy policy and incorporate the shift to a low-carbon, green economy into every aspect of the ministry's operations. Nevertheless, as

[50] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=IT

[51] https://www.g20climaterisks.org/italy/

[52] https://www.iea.org/countries/italy

of late 2024, the effective staff and function integration as well as the transfer of the energy competencies from the Ministry of Economic Development to the MASE remained incomplete.[53]

Several Italian ministries have responsibilities related to energy and climate, including those overseeing transport and infrastructure, agriculture, and education, university, and research (Ministero dell'Istruzione e del Merito, MIUR). The Inter-ministerial Committee for Economic Planning and Sustainable Development (Comitato interministeriale per la programmazione economica e lo sviluppo sostenibile, CIPESS), chaired by the Prime Minister, coordinates national policies to meet the Sustainable Development Goals and oversees research and innovation. CIPESS approves the National Research Programme and allocates funding to public research institutions. The Ministry of Education, University and Research and the Ministry of the Environment and Energy Security provide funding for energy research and development projects.

The National Sustainable Development Strategy (NSDS) is a multi-level, multi-stakeholder collaboration framework that aims to align national policies with Sustainable Development Goals (SDGs) and ensure their territorial deployment. The governance of the NSDS is defined by reference regulations, including the CIPE Resolution approving the NSDS of 2017 and subsequent amendments. The Ministry of Foreign Affairs and International Cooperation (MAECI) coordinates the external dimension of the Strategy, while the Ministry of Economy and Finance (MEF) ensures alignment with economic-financial planning documents. The Inter-ministerial Committee for Economic Planning and Sustainable Development (CIPESS) approves the Funding Programme for supporting NSDS implementation, and the Ministry of Environment annually provides information to CIPESS about the implementation of NSDS. The Inter-ministerial Committee for Ecological Transition (CITE) approves the three-year review of the NSDS. The NSDS encourages a whole-of-government approach, involving collaborations between MASE, MEF, MAECI, Departments of the Presidency of the Council of Ministers, the National Institute of Statistics (ISTAT), and the Italian Institute for Environmental Protection and Research (ISPRA). Regional and Local governments are at the core of localizing SDGs and developing their own Sustainable Development Strategies, ensuring vertical and horizontal collaboration on sustainable development and policy coherence issues.[54]

The National Agency for New Technologies, Energy and Sustainable Economic Development (L'Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, ENEA) focuses on research, technological innovation, and providing advanced energy and environmental services. Alongside ENEA, Ricerca sul Sistema Energetico (RSE) plays a key role in energy research, development, and innovation. Established in 2022, the Inter-ministerial Committee for Ecological Transition (Comitato interministeriale per la transizione ecologia, CITE) coordinates the ministries' policies to align with ecological transition goals and monitors the implementation of the Ecological Transition Plan. ENEA and the Higher Institute for

[53] https://www.oecd-ilibrary.org/docserver/278dd18f-en.pdf?expires=1721096460&id=id&accname=guest&checksum=B3EFFF4B722BF2D441BA81473F810F2F

[54] https://www.mase.gov.it/pagina/who-main-actors-system-and-governance

Environmental Protection and Research (Istituto Superiore per la Protezione e la Ricerca Ambientale, ISPRA) provide technical and scientific support to these efforts.

The state-owned Gestore dei Sistemi Energetici (GSE) promotes renewable energy in Italy, offers financial support for renewable electricity, and manages energy efficiency incentives. It administers the white certificate scheme, evaluating and certifying energy savings with assistance from ENEA and the Ministry of the Environment and Energy Security.

The Regulatory Authority for Energy, Networks, and Environment (L'Autorità di Regolazione per Energia Reti e Ambiente, ARERA) regulates and supervises the electricity, gas, water, waste, and district heating sectors. It sets tariffs, defines service standards, and ensures compliance with EU regulations. ARERA's operations are funded by contributions from regulated companies, not the state budget. Additionally, the Competition Authority (L'Autorita' Garante della Concorrenza e del Mercato, AGCM) monitors competition in energy markets and prevents anti-competitive behaviour.

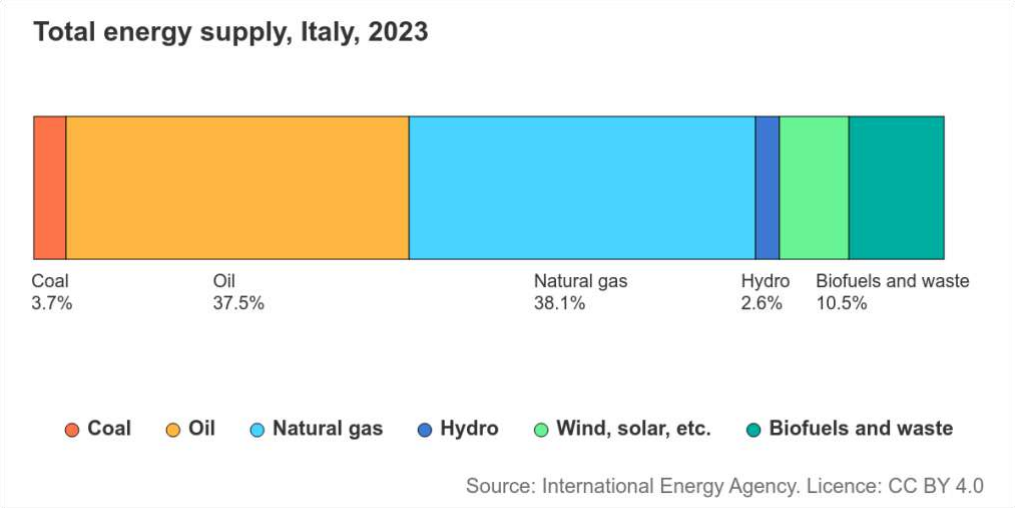
Finally, the Central Energy Stockholding Agency (Organismo Centrale di Stoccaggio Italiano, OCSIT), established in 2014, is responsible for maintaining Italy's emergency fuel reserves.

5.2. Potential of natural resources

Present energy production and consumption patterns

Italy has been a large energy importer for well over a decade. From 2016 to 2021, Italy imported 80% of its total energy supplies (TES), primarily gas and oil. In 2023, natural gas and oil contributed some 38% each to the country's TES, followed by various renewable energy sources (Figure 8). Italy is not a major producer of natural gas or oil. Natural gas imports are vital to Italy. Specifically, it relies heavily on gas imports from Russia, which made for 41% of all its gas imports in 2021. Approximately 23 % of the nation's energy generation in 2021 came from imports of fossil fuels from Russia, ranking second among IEA member nations only behind Hungary. A sizeable portion of all sectors' final energy consumption (FEC) comes from energy imports from Russia.

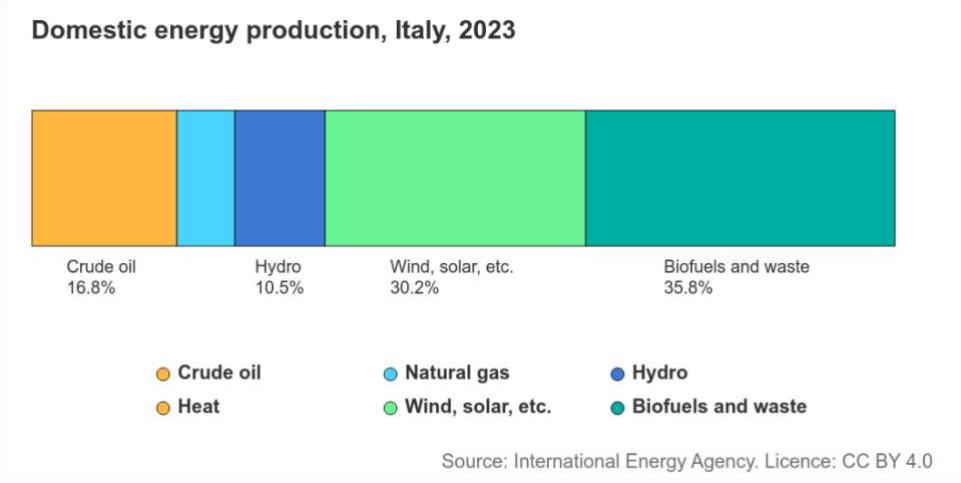
Figure 15: Total energy supply Italy 2023



Source: https://www.iea.org/countries/italy/energy-mix

The majority of domestic production comes from renewable energy sources like wind, solar, hydro, and bioenergy (Figure 9).

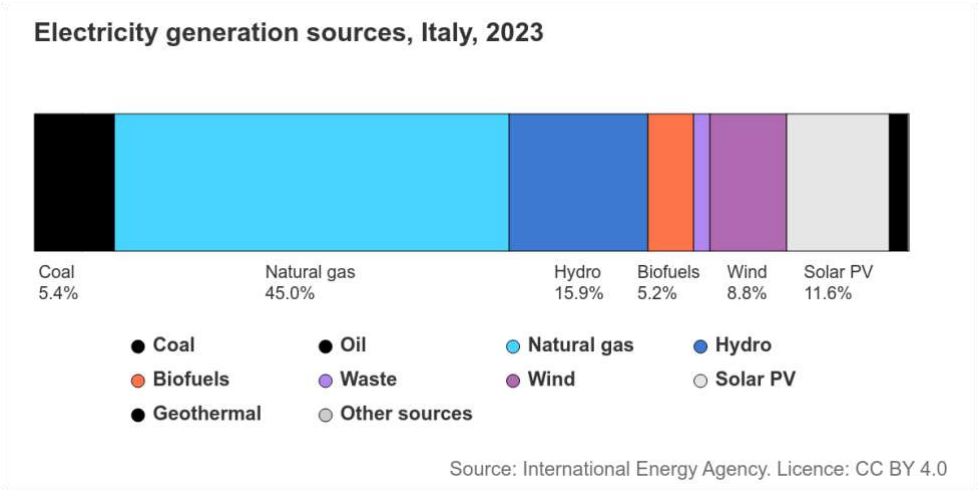
Figure 16: Domestic energy production 2023



Source: https://www.iea.org/countries/italy/energy-mix

Turning to electricity generation, natural gas is the main source of electricity production. In 2021, 50% of the electricity generated came from natural gas, which was the second-highest percentage among IEA nations after Mexico. This share has decreased to 45% in 2023, following efforts to reduce import dependency by the Italian government. Hydropower (16%) and various renewable energy sources such as solar PV (11.6%) and wind energy (8.8%) follow up as generation sources (Figure 10).

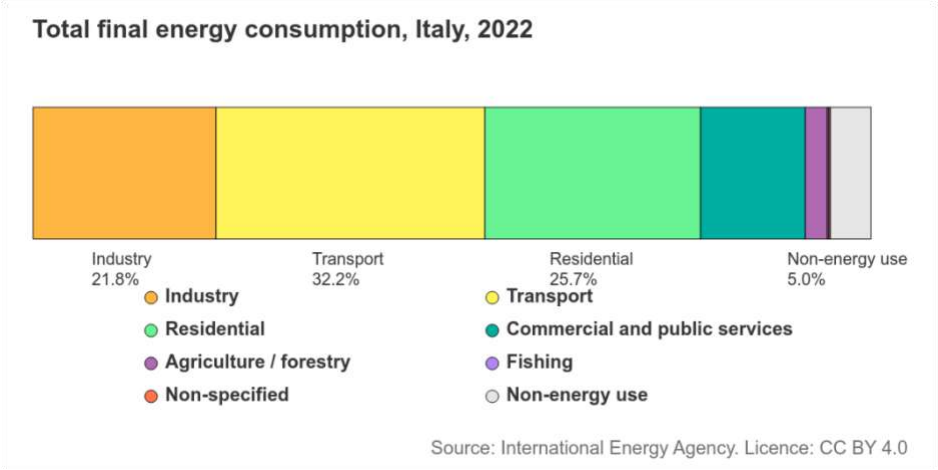
Figure 17: Electricity generation sources in Italy 2023



Source: https://www.iea.org/countries/italy/electricity

On the demand side, in a sectoral breakdown, the transport and the residential sectors were the two largest energy consumers (32.2% and 25.7%, respectively) followed by industry (21.8%) in 2023 (Figure 11).

Figure 18: Total final energy consumption, Italy



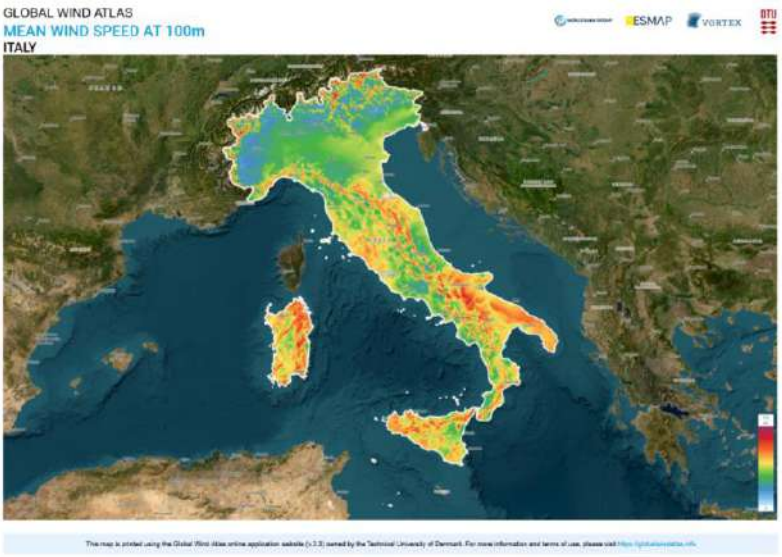
Source: https://www.iea.org/countries/italy/efficiency-demand

Further domestic potential with renewable energies

Italy has considerable **wind energy** potential, particularly in the southern regions and the islands of Sicily and Sardinia, where wind conditions are notably favourable. The country's

geography, with its coastline and high-altitude areas, creates optimal conditions for harnessing wind energy. The southern regions, including Apulia, Calabria, and Campania, benefit from strong, consistent wind patterns due to their proximity to the Mediterranean and the open sea. Similarly, Sicily and Sardinia offer some of the best conditions for wind energy due to their large, unobstructed landscapes and frequent winds, see Figure 12.

Figure 19: Wind potential in Italy 2024



Source: https://globalwindatlas.info/en/area/Italy

Turning to **solar energy**, Italy enjoys significant potential, with the southern regions receiving substantially more solar radiation than the northern parts of the country. This disparity is due to Italy's geographical position, with southern regions like Sicily, Calabria, Apulia, and Sardinia benefiting from longer hours of sunlight and higher solar irradiance (Figure 13). These areas experience more than 1,600–1,800 kWh/m² of solar radiation annually, making them prime locations for solar photovoltaic (PV) installations.

Figure 20: Solar radiation potential in Italy

Source: https://solargis.com/resources/free-maps-and-gis-data?locality=italy

5.3. National targets

Since the decision in the mid-1980s to phase out nuclear power, which was reconfirmed in a public referendum in mid-2011, Italy's energy sector has undergone a major transition. Electricity generation has especially shifted strongly towards natural gas, but also the uptake of renewable energies at large scale.

On 10 November 2017, the Italian Government published the 2017 National Energy Strategy (Strategia Energetica Nazionale, SEN)[55] as a comprehensive energy policy framework aimed at guiding the country's energy transition. The strategy set ambitious targets for CO2 reduction, with the goal of cutting emissions. SEN 2017 focused on several key areas to enhance Italy's energy landscape by 2030, aiming to increase industrial competitiveness, improve the security of energy supply, and protect the European environment, building on the previous strategy published in 2013.

A major focus of the strategy was increasing the share of renewable energy and improving energy efficiency. By 2030, SEN aimed to reduce CO2 emissions in the energy sector by 39% compared to 1990 levels, with a further reduction of 63% targeted by 2050. The strategy also set specific targets for renewable energy deployment, with the aim of achieving 28% renewable energy in the total energy mix by 2030, up from 17.5% in 2015. In the electricity sector,

[55] https://www.mase.gov.it/comunicati/strategia-energetica-nazionale-2017

renewable energy is expected to account for 55% of the supply by 2030, up from 33.5% in 2015, while the heat supply sector targets a 30% share, an increase from 19.2% in 2015. For the transport sector, the goal is 21% renewable energy by 2030, a significant rise from 6.4% in 2015.

Energy efficiency is also a key component of SEN 2017, with a target to reduce final energy consumption by 10 million tonnes of oil equivalent (Mtoe) by 2030 compared to the business-as-usual (BAU) scenario, particularly through changes in the energy mix within non-ETS sectors, including households and transport. Additionally, the strategy outlines a plan for the complete phase-out of coal-fired power generation by 2025, marking a significant step towards decarbonisation.

To ensure a stable energy supply during this transition, the Italian government plans to reform the electricity system, focusing on the development of natural gas generation as a backup for renewable energy. The strategy also aims to narrow the electricity price gap between Italy and the rest of Europe. In 2015, this gap stood at 35 EUR/MWh for households and 25% for companies. Similarly, SEN 2017 targeted a reduction in the natural gas price difference with the Nordic countries, which was 2 EUR/MWh in 2016. The plan also included a reduction in oil consumption by 13.5 Mtoe by 2030, further contributing to Italy's energy independence. Investment in research and development (R&D) for clean energy technologies is a central element of the strategy, with planned R&D investment increasing from 222 Mtoe in 2013 to 444 Mtoe by 2021. Furthermore, SEN 2017 aims to reduce Italy's energy dependence on imports, targeting a 64% dependence rate by 2030, down from 76% in 2015.

Following an alignment with European energy and climate policies, the Italian government updated its national strategy by means of notably the National Energy and Climate Plan (NECP) in 2019. In 2024, in line with the European requirements, an updated NECP has been presented. The Italian 2024 NECP, submitted in July 2024, outlines three key scenarios to project its future energy and climate policies (see Table 1).

The Reference Case represents a baseline scenario where current policies remain unchanged, providing a "business as usual" outlook on energy consumption and emissions trends. In contrast, the Policy Scenario 5 introduces additional measures to meet more ambitious national climate targets, focusing on increased renewable energy use and stricter decarbonisation efforts. Lastly, the Fit for 55 (FF55) REPowerEU Objectives scenario aligns with the EU's overarching climate strategy, which includes a 55% reduction in emissions by 2030 and aims to enhance energy independence, particularly by accelerating the shift from fossil fuels to renewables. This scenario represents the most stringent and ambitious targets in line with EU-wide goals.

Table 1: Scenario cases of the Italian NECP

	Energy statistics	NECP 2024: Reference case	NECP 2024: Policy scenario 5	NECP 2024: FF55 REPowerEU

		2022	2030	2030	2030
Renewable	Share of renewable energy in gross final energy consumption	19%	26%	39.4%	38.7%
	Share of renewable energy in final consumption in the transport fuel sector	8%	15%	34%	29%
	Share of renewable energy in final consumption in the heat and cooling sector	21%	24%	36%	29.6% - 39.1%
Energy efficiency	Primary energy consumption	140 Mtoe	133 Mtoe	123 Mtoe	111 Mtoe
	Final energy consumption	112 Mtoe	111 Mtoe	102 Mtoe	93 Mtoe
	Cumulative annual savings in final consumption through energy efficiency obligation schemes	3.8 Mtoe		73.4 Mtoe	73.4 Mtoe
GHG	GHG reduction vs 2005 for all installations bound by ETS legislation	-45%	-58%	-66%	-62%
	GHG reduction vs 2005 for all ESR sectors	-20%	-29.3%	-40.6%	-43.7%
	GHG emissions and removals from LULUCF	-21 MtCO2eq	-28.4 MtCO2eq	-28.4 MtCO2eq	-35.8 MtCO2eq

Source: https://commission.europa.eu/publications/italy-final-updated-necp-2021-2030-submitted-2024_en

The updated 2024 Italian NECP outlines significant contributions from the transport and residential/commercial sectors toward achieving Italy's climate goals by 2030. The residential and commercial sectors are now expected to save approximately 35 million tCO2e by improving the energy efficiency of existing buildings, primarily through renovations and the

adoption of highly efficient systems such as heat pumps. Meanwhile, the transport sector is projected to save around 46 million tCO2e, largely driven by the promotion of shared and public mobility, reduced energy consumption, and the progressive adoption of low- or zero-emission vehicles. By 2030, Italy aims to have around 6.5 million electrically powered vehicles, including approximately 4.3 million pure electric vehicles (BEVs).

The updated NECP sets a target of 34.2% renewable energy in the transport sector by 2030, which surpasses the 29% target set by the EU's RED III Directive. Additionally, the renewable energy contribution is projected to reach 60% in the electricity sector and 36.5% in the heat and cooling sector. These targets are reinforced by Italy's national legislation under the Renewable Energy Directive (2018/2001), which was implemented through Legislative Decree no. 199 of 8 November 2021, and came into force on 15 December 2021. This legislative framework continues to guide Italy's efforts toward meeting the EU's renewable energy targets by 2030.

Overview of Italy's climate and energy objectives

- Decarbonisation of Energy:
  - Reduce GHG emissions by 55% by 2030 (compared to 1990 levels) and achieve climate neutrality by 2050
  - Reduce emissions from sectors covered by the Effort Sharing Regulation (transport, residential, waste, agriculture) by 43.7% by 2030 compared to 2005 levels
- Renewable Energy Targets:
  - Increase the share of renewable energy to 39.4% of gross final energy consumption by 2030
  - Ensure 63.4% of electricity consumption is met by renewable sources by 2030
  - Promote renewable energy use in sectors such as heating and cooling, with a goal of 36% renewable energy by 2030
- Reduction of Fossil Fuels
  - Phase out coal-fired electricity generation as part of the broader strategy to decarbonise the electricity sector
- Energy Efficiency
  - Aim to reduce final energy consumption to 93.05 Mtoe by 2030
  - Reduce primary energy consumption to 115 Mtoe by 2030
- Carbon Intensity in the Transport Sector:
  - Increase the share of renewable energy to 29-34% by 2030
  - Promote the use of electric vehicles and other sustainable transport technologies to achieve decarbonisation in the transport sector
- Share of Renewable Energy in Buildings:
  - Achieve a renewable energy share of 40.1% in buildings by 2030
  - Implement energy efficient building practices to further reduce emissions
- Land Use, Land Use Change and Forestry (LULUCF): Target a net carbon sink of more than 35 MtoCO2eq by 2030

Source: NEPC, https://commission.europa.eu/publications/italy-final-updated-necp-2021-2030-submitted-2024_en

5.4. Decarbonisation and greenhouse gas emissions

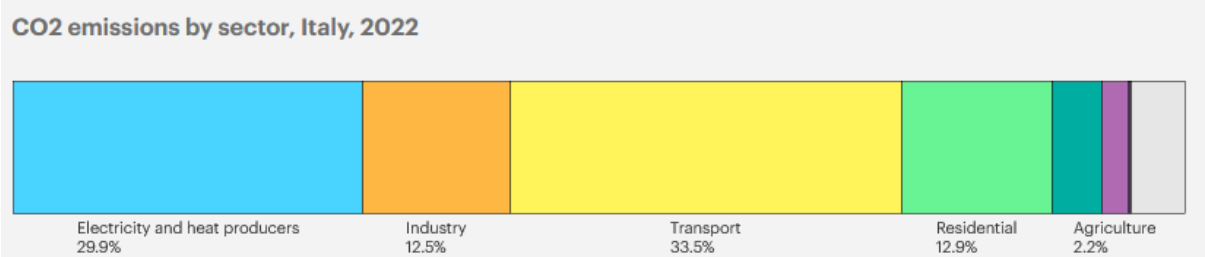
Italy's carbon dioxide emissions peaked in 2005 and have continued to decline since then. In 2020 in particular, emissions were also significantly lower than in 2019, following the economic stagnation caused by COVID, and were 29.6% lower than in 1990.

In total, Italy emitted 310.289Mt CO2 in 2022, accounting for 0.9% of global emissions related to combustible fuels. This is a reduction of 26% in comparison to the year 2000.[56] The reduction in emissions in Italy follows a continuous downward pattern. Overall fuel-derived carbon dioxide emissions in Italy are on a downward trend. Per capita emissions amounted to 5.258 t CO2. Between 2000 and 2022, this is a reduction of 29%.[57]

48% of total carbon emissions are related to oil combustion, and a further 43% for natural gas use, underlining the key decoupling needed from these two energy carriers.

A sectoral breakdown shows that the transport sector is responsible for some 34% of national carbon emissions, followed by electricity and heat production (30%) and the industry sector (13%, see Figure 14).

Figure 21: CO2 emissions by sector



Source: https://www.iea.org/countries/italy/emissions

Notably fuel switches and the deployment of renewable energy sources in electricity production and transport electricity are expected to significantly contribute to further carbon emission savings so as to reach the country's targets for 2030 and 2050 in line with the overall European energy and climate strategies.

Decarbonisation Strategies in the Industry Sector

Italy foresees the capture and storage of carbon dioxide in energy and industrial sectors by 2040 for full decarbonisation by 2050. This decarbonisation is confirmed in Italy's 'Italian Lungo Strategy for the Reduction of Greenhouse Gas Emissions', which identifies pathways to climate neutrality by 2050. Carbon capture and storage (CCS) is identified as a key lever for decarbonisation, aiming to avoid 20-40 Mton of CO2 by 2050.

[56] https://www.iea.org/countries/italy/emissions

[57] https://www.iea.org/countries/italy/emissions

Italy has launched R&D activities on hydrogen, following the National Guidelines for a hydrogen strategy. These activities are structured, focusing on renewable and low-carbon hydrogen production technologies, innovative technologies for hydrogen storage and transport, fuel cells for stationery and mobility applications, and digitalization and integration of electricity/gas networks to improve the resilience and reliability of hydrogen-based infrastructure. Further research and development activities focus on the power to gas approach, developing technologies and systems to support the integration of the electricity grid with the natural gas grid, such as long-term storage and long-distance hydrogen transmission and distribution infrastructure. Higher TRL R&S activities are conducted as part of Mission Innovation, constructing two Hydrogen demo Valleys to test and validate hydrogen supply chain technologies on a pre-commercial scale. The objectives of these activities align with European objectives defined by the Joint Research Programme on Fuel Cells and Hydrogen technologies of EERA and Hydrogen Europe Research.

Italy has joined the International Hydrogen Production and Utilization Initiative to contribute to the decarbonisation of the national economy by supporting the replacement of fossil fuels with hydrogen. Italy participates with six industrial projects and two R&D projects submitted by research organizations. The second IPCEI on Hy2Use hydrogen, approved in September, includes 35 projects from 13 Member States, with a total public support of EUR 5.2 million and a national budget of approximately EUR 500 million. Italy is involved in four projects. The initiative aims to finalize the deployment of renewable hydrogen production systems in specific geographical areas and hydrogen transport infrastructure to build interconnected hydrogen clusters at the European level. The measure provides EUR 1.4 million public funds and EUR 3.6 million private funding, with an expected revenue in operation in 2030.

The Investment aims to incentivize the construction of production plants with a total power of at least 1 GW/year. The investment framework includes three lines of action: implementing projects for electrolyser production under the IPCEI Fund (EUR 0.25 million), further projects for electrolyser production to achieve a 1 GW/year production capacity target by 2026 (EUR 0.1 million), and investment programs for developing the production chain of electrolysers and their components (EUR 0.1 million). Two projects were selected by MASE in June 2022 for electrolyser plants with a total capacity of 800 MW per year by June 2026. The strategy foresees the deployment of at least 10 hydrogen production projects in decommissioned industrial areas, with an average capacity of 1-10 MW each. The Minister for the Ecological Transition invited Regions and Autonomous Provinces to submit expressions of interest in selecting proposals. The aim is the decarbonisation of industrial sites in hard-to-abate sectors (EUR 2 million) through the use of green and renewable hydrogen. The Decree of 21 October 2022 defines the general implementation framework, allocating EUR 1 million to DRI SpA's project and the remaining billion to other sectors. The use of hydrogen should cover at least 10% of fossil sources used before intervention, with a reserve for projects involving hydrogen in more than 90% of fossil sources.

Decarbonisation Strategies in the Transport Sector

In transportation, Italy promotes sustainable mobility with initiatives like the Marebonus[58] and Ferrobonus[59] schemes, which encourage the shift of freight from road to rail or maritime routes. Public transport fleet upgrades and the expansion of electric vehicle charging infrastructure are also emphasised, supporting the reduction of emissions in urban areas. Additionally, the "Cold Ironing" project aims to electrify port quays, allowing ships to connect to shore power rather than using onboard generators, thus reducing local emissions and improving air quality in port cities.[60]

Directive 2014/94/EU on the deployment of alternative fuels infrastructure established a framework for upgrading infrastructure in the EU, requiring Member States to establish national policy frameworks to create markets for alternative fuels and ensure the availability of an adequate number of publicly accessible recharging and refueling points. In 2016, Legislative Decree No n.257/2016 transposed the FASI Directive, introducing measures to promote the development and deployment of e-mobility.

In Italy, there has been a trend of increasing new charging infrastructure (around 41.000 in March 2023), but numbers are not yet able to meet the expected recharging needs in the coming years. To incentivize the deployment of recharging infrastructure for fast and ultra-fast electric vehicles, draft decrees provided for in Mission 2, Component 2, Investment 4.3 of the National Recovery and Resilience Plan were implemented. The decrees define criteria and procedures for granting non-repayable benefits to establish at least 7.500 super-fast charging stations for electric vehicles on extra-urban roads (excluding motorways) and at least 13.755 fast recharging stations in urban centers.

The National Single Platform (PUN) was followed up by Decree No 106 of 16/03/2023 on the procedures for the operation of the national single platform for recharging points for electric vehicles. The UNDP originally provided for in Article 8 of Legislative Decree No 257 of 16 December 2016 implementing Directive 2014/94/EU on the deployment of alternative fuels infrastructure, making it possible to carry out the population census of publicly accessible recharging infrastructure, the associated recharging points, as well as their operators (Charging Point Operators) and e-Mobility Service Providers (E-MPS). This is a necessary element for the deployment of electric vehicles in the country and the development of a market for charging services linked to it, as well as for the effective planning of public and private interventions and investments.

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[58] https://www.portnews.it/en/125-million-euros-for-marebonus/

[59] https://www.railfreight.com/railfreight/2024/10/16/italy-opens-application-for-this-years-subsidies-but-still-hasnt-paid-last-years/?gdpr=deny

[60] https://www.italiadomani.gov.it/content/sogei-ng/it/en/Interventi/riforme/riforme-settoriali/semplificazione-delle-procedure-di-autorizzazione-per-gli-impian.html

The European strategy aims to promote hydrogen production and use in transport through hydrogen refuelling stations (HRS). The NRRP allocated EUR 230 million for the investment, aiming to deploy at least 40 HRS for light and heavy duty vehicles by June 2026. The MIT approved Executive Decree No 144 of 31/3/2023 for the allocation of resources under the NRRP for an investment of EUR 300 million. The funds will be used for renewable hydrogen production, storage, and refuelling facilities, as well as the acquisition of hydrogen-powered trains. The resources will be divided into several regions, including Lombardy Region, Campania Region, Puglia Region, Calabria Region, and Autonomous Region of Sardinia. The funds will be divided into different lines, with the latter allocated entirely to the Region of Puglia and through Ferrovie del Sud Est and Servizi Automobilistica s.r.l., for the Lecce-Gallipoli, Novoli-Gagliano, and Casarano-Gallipoli routes.

Decarbonisation Strategies in the Building Sector

The 'Termico account' is an incentive instrument introduced by the Ministerial Decree of 28 December 2012, amended by the Ministerial Decree of 16 February 2016, to encourage the production of renewable thermal energy and provide public authorities with access to energy efficiency measures for buildings and installations. Public authorities and private entities are encouraged to replace existing winter air conditioning systems with those equipped with heat pumps, electric or gas pumps, using aerothermal, geothermal, or hydrothermal energy. Solar thermal installations are also encouraged for the production of domestic hot water and heat for production processes or injection into district heating and cooling networks. Electric water heaters are replaced with heat pump water heaters, and existing winter air conditioning systems are replaced with hybrid heat pump systems.

In the building sector, tax deductions play a critical role in promoting energy efficiency. Programs like the Superbonus and Ecobonus offer substantial tax credits for retrofitting residential buildings, which has mobilised billions in investment. These programs support improvements such as solar installations, insulation, and high-efficiency heating systems.[61] The Termico Account (conto termico)[62] complements these tax incentives by providing direct financial support for small-scale thermal efficiency projects, especially for public buildings. It has been instrumental in supporting renewable thermal energy installations, including biomass boilers and heat pumps, with eligibility recently extended to new entities like energy communities.

The Bianchi Certificates mechanism, last regulated by the Ministerial Decree of 21 May 2021, mandates electricity and gas distributors with over 50,000 customers to achieve a minimum annual savings of energy through energy efficiency improvement measures and projects. The certificates are negotiable and certify the achievement of energy savings in energy end-use.

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[61] https://iea.blob.core.windows.net/assets/71b328b3-3e5b-4c04-8a22-3ead575b3a9a/Italy_2023_EnergyPolicyReview.pdf

[62] https://www.gse.it/servizi-per-te/efficienza-energetica/conto-termico

The mechanism also promotes renewable energy use for non-electric uses, and is issued for energy savings generated by Cogeneration plants in Upper Rendimento, including renewable installations and district heating networks.

The National Energy Efficiency Fund (FNEE)[63] provides subsidised financing to support energy-saving projects, particularly in public and industrial sectors. This fund aligns with Italy's Recovery and Resilience Plan, facilitating energy-efficient upgrades in municipal buildings and other public infrastructure. Further support comes from the Transition Plans 4.0 and 5.0, which incentivise businesses to adopt energy-saving and digital technologies, promoting self-generation and decarbonisation in industrial processes.[64]

The PREPAC program[65] (Programma di Riqualificazione Energetica della Pubblica Amministrazione Centrale) focuses specifically on improving energy efficiency in central government buildings, aiming to achieve significant savings through structural upgrades. This program is funded under the National Recovery and Resilience Plan and seeks to modernise Italy's public administration buildings by enhancing insulation and installing renewable energy systems.[66] Decree-Law No 34 of 30 April 2019 granted municipalities up to EUR 500 million from the Development and Cohesion Fund (FSC) for investments in energy efficiency and sustainable territorial development for 2019 as a contribution.

Decarbonisation Strategies in the Energy Sector

The electricity sector is set to support the deployment of new installations and upgrade existing ones, with measures based on intervention type, installation size, and technology development. Long-term incentive mechanisms are essential for promoting new installations, as spot markets alone won't achieve decarbonization targets. Legislative Decree 199/2021 provides for auctions for fixed-term contracts for new renewables, referencing quotas per area. Current technologies with significant innovation potential include offshore wind, thermodynamic solar, geothermal thermal energy, ocean energy, and photovoltaic outputs. However, these technologies face high production costs due to raw material costs.

Deployment of Renewable Energies

Italy's renewable energy policy has evolved significantly since the early 2000s, beginning with the Green Power Certificate Scheme introduced in 2002 under a Renewable Portfolio Standard (RPS). This scheme obligated businesses that generated or imported more than 100 GWh of fossil-fuel electricity per year to cover a specified portion of their electricity with renewable sources. Businesses could either generate renewable energy themselves or purchase Green Power Certificates from certified renewable producers. These certificates were awarded for up to 12 years (extended to 15 years post-2008) and allowed companies to meet their renewable

[63] https://www.eib.org/en/projects/all/20130518

[64] https://commission.europa.eu/publications/italy-final-updated-necp-2021-2030-submitted-2024_en

[65] https://www.gse.it/servizi-per-te/efficienza-energetica/prepac

[66] https://commission.europa.eu/publications/italy-final-updated-necp-2021-2030-submitted-2024_en

energy obligations. The required quota started at 2% and rose to 7.55% by 2012, though it was reduced to zero in 2015. The scheme ended in 2020, with the GSE (Gestore dei Servizi Energetici) assuming responsibility for purchasing remaining certificates from renewable energy generators.[67]

In addition to the Green Power Certificate Scheme, Italy launched the Conto Energia program in 2005 specifically for solar photovoltaic (PV) installations. Introduced through the Ministerial Decree of 28 July 2005, this Feed-in Premium (FIP) scheme went through five rounds of modifications, adjusting incentive prices and capacity limits. By 2012, the fifth round transitioned to a Feed-in Tariff (FIT) system. In 2013, Conto Energia ceased to accept new applications after reaching the statutory annual support budget limit of EUR 5.8 billion. For small-scale renewable projects (under 1 MW, or 200 kW for wind), the Tariffa Omnicomprensiva provided FITs from 2008 onwards, covering renewable energy installations other than solar PV. This support offered 15-year buyback agreements with variable prices based on the energy source, ending for new installations in 2012. Both the Conto Energia and Tariffa Omnicomprensiva programs were later integrated into Italy's broader Non-Solar Renewable Energy Purchase Scheme under the Ministerial Decree of 6 July 2012 (DM 6/7 2012).[68]

The Non-Solar Renewable Energy Purchase Scheme, introduced under DM 6/7 2012, supported installations that began operating in January 2013 or later, excluding solar PV projects. This system offered revised support levels and competitive tendering for projects above 5 MW. The Ministerial Decree of 23 June 2016 (DM 23/6 2016) updated the scheme, introducing new support levels and tendering mechanisms. This 2016 framework covered installations operating until 2017 and was succeeded by the Renewable Energy Purchase Scheme of 4 July 2019[69], under which new, fully refurbished, output-enhanced, or otherwise modified installations became eligible for support. This scheme expanded eligibility to include solar PV and introduced two incentive levels: FITs for projects under 250 kW and Contracts for Difference (CfD) for installations above 250 kW. Projects exceeding 1 MW would be selected through competitive tendering, enhancing Italy's strategy for renewable energy market integration and investor stability.[70]

In recent years, Italy has implemented several regulatory and economic policies aimed at fostering new renewable electricity installations and upgrading existing ones. Legislative Decree 199/2021[71] outlines fixed-term contracts awarded through auctions for large renewable installations, while Contracts for Difference (CfDs) and Power Purchase Agreements (PPAs) are available for larger projects to ensure revenue stability. Small-scale installations are encouraged through self-consumption incentives, collective self-consumption configurations,

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[67] https://iea.blob.core.windows.net/assets/71b328b3-3e5b-4c04-8a22-3ead575b3a9a/Italy_2023_EnergyPolicyReview.pdf

[68] ibid

[69] https://www.gazzettaufficiale.it/eli/id/2019/08/09/19A05099/sg

[70] ibid

[71] https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2021-11-08;199

and renewable energy communities, particularly in municipalities with fewer than 5,000 residents. Italy's National Recovery and Resilience Plan (NRRP)[72] provides the framework for grants covering up to 40% of costs for these small-scale projects, with a goal to achieve 5 GW in collective self-consumption capacity by 2027. A digital platform facilitates contract matching for PPAs, simplifying the process for renewable energy producers and consumers.[73]

Italy has also focused on renewable heat solutions, employing tax deductions, a "Thermal Account" program, and white certificates to support renewable-based heating and cooling projects. New buildings must meet renewable energy standards, with private buildings required to obtain 60% of their energy from renewable sources and public buildings required to meet 65%. These standards encourage the integration of renewables in building energy systems.[74]

In transportation, Italy has established ambitious renewable fuel targets, including blending mandates for biofuels and increased quotas for advanced biofuels and biomethane. The Ministry has set renewable fuel integration targets, progressing to a 16% renewable share by 2030. Legislation under the NRRP provides capital funding to support biomethane production infrastructure, aiding biofuel-blending compliance. Advanced renewable fuels, such as sustainable aviation fuels, have specific requirements starting in 2025 to drive decarbonisation across hard-to-electrify transport modes.[75]

Energy Efficiency

Italy has implemented a comprehensive suite of energy efficiency policies to meet the EU's ambitious 2030 energy targets. Central to these policies is the White Certificates (Certificati Bianchi) program, which mandates energy savings by requiring large energy distributors to either directly reduce their energy usage or purchase certificates. These certificates represent energy savings achieved by third parties, and they can be traded to meet compliance requirements. This mechanism incentivises efficiency across industries and has recently been updated to include new project types, such as efficient lighting, hybrid vehicle purchases, and public lighting replacements.[76]

White Certificates in Italy

The Italian White Certificates Scheme, also known as the Energy Efficiency Certificates (EEC) scheme, is a market-based mechanism aimed at promoting energy efficiency. Established in 2005, it obliges electricity and gas distributors with more than 50,000 customers to achieve annual energy savings targets. These targets are set by the Ministry of Ecological Transition (MASE) and are expressed in tons of oil equivalent (toe) of primary energy saved.

[72] https://www.mef.gov.it/en/focus/The-National-Recovery-and-Resilience-Plan-NRRP/

[73] https://commission.europa.eu/publications/italy-final-updated-necp-2021-2030-submitted-2024_en

[74] ibid

[75] ibid

[76] https://www.gse.it/servizi-per-te/efficienza-energetica/certificati-bianchi

The scheme operates by issuing white certificates, each representing one toe of energy savings. Distributors can meet their targets by implementing energy efficiency projects or purchasing certificates from other market participants, such as Energy Service Companies (ESCOs) and other voluntary parties. The certificates can be traded on a dedicated platform managed by the Energy Markets Operator (GME) or through bilateral agreements.

One of the key features of the scheme is its flexibility. Energy savings can be achieved through a wide range of interventions across various sectors, with a significant focus on the industrial sector. Projects can include anything from upgrading lighting systems to more complex industrial processes. The scheme also incentivises voluntary parties by allowing them to sell their certificates to obliged distributors.

The Italian White Certificates Scheme has undergone several updates to improve its effectiveness. For instance, the 2017 decree introduced more stringent targets and measures to address market imbalances, such as price volatility. The price of certificates has fluctuated significantly, reaching over 300 euros per certificate in 2017 due to a shortage in the market.

The scheme is managed by the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) and the GSE, with oversight from the Regulatory Authority for Energy, Networks and Environment (ARERA). It is designed to complement other national and EU energy efficiency policies, contributing significantly to Italy's energy savings targets under the EU Energy Efficiency Directive.

Overall, the Italian White Certificates Scheme is a crucial tool in Italy's strategy to enhance energy efficiency, reduce greenhouse gas emissions, and promote sustainable energy practices. It not only helps in achieving national energy targets but also stimulates the market for energy efficiency services and technologies.

Sources:

https://epatee.eu/sites/default/files/epatee_case_study_italy_white_certificates_ok.pdf

https://energy-evaluation.org/wp-content/uploads/2019/06/2014-berlin-dario-di-santo.pdf

https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2011/2-current-energy-efficiency-policies-on-stage-and-backstage/the-white-certificate-scheme-the-italian-experience-and-proposals-for-improvement/

6. Key fields for policy alignment

6.1 Comparative policy perspectives in low-carbon energy use

The EU is accelerating the implementation of the European Green Deal, the 'Fit for 55' package, and the REPowerEU Plan to address climate and energy challenges. The EU has used the Regulation on the Governance of the Energy Union and Climate Action since 2018 to build a resilient Energy Union fit for future challenges. Previous Sections compile the most up-to-date policies of three key countries in the EU based on their latest National Energy and Climate Plans, which are strategic policy planning tools for Member States to meet the objectives and targets set in the Energy Union and stay on track to achieve climate neutrality and resilience by 2050. The updated plans factor in increased challenges for a more resilient Union, including the consequences of war in Ukraine and reflect the EU's international commitments under the Paris Agreement. The Commission established the Recovery and Resilience Facility (RRF) to build more sustainable and resilient EU economies. With 23 REPowerEU chapters adopted as part of Member States' Recovery and Resilience Plans (RRPs) and 27 revised RRPs, more than 42% (EUR 275 billion) of the total revised RRF allocation will finance investments and reforms supporting the green transition and the REPowerEU plan. Updated NECPs give Member States the right framework to deliver on their commitments and reach the 2030 targets of a net domestic reduction of GHG emissions of at least 55%, a minimum 42.5% share of renewable energy with a view to reaching 45%, and reduce final energy consumption at EU level by 11.7%.[77]

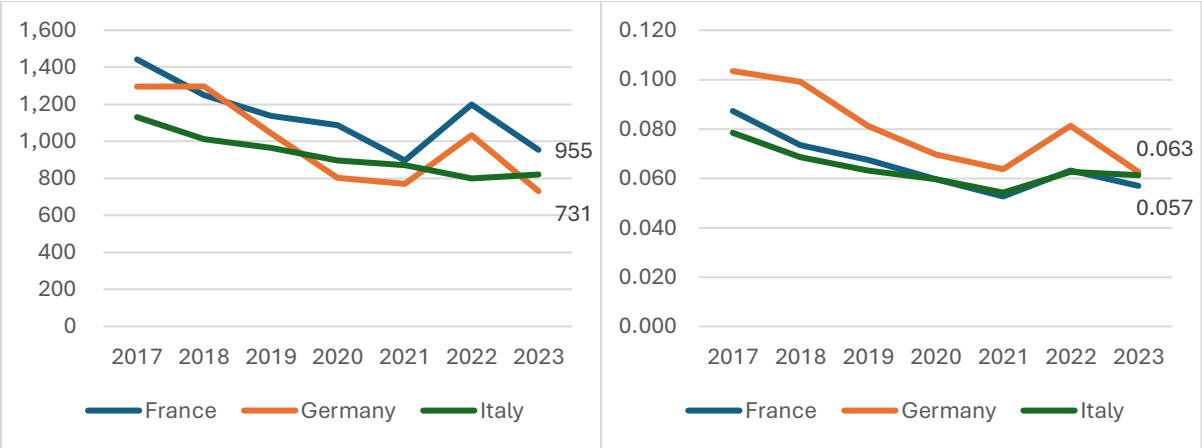
On December 18, 2023, the Commission released its EU-wide evaluation of the revised NECPs, as well as individual assessments and country-specific recommendations for the 21 Member States. According to this EU-wide assessment of the draft updated NECPs, the draft updated NECPs are bringing the EU closer to meeting its 55% GHG emission reduction target by 2030, but there is still a need for additional efforts from Member States to complement EU actions with sufficient policies to close the remaining gap. Furthermore, Member States have set ambitious goals, with a renewable energy share of 38.6% to 39.3% in 2030, which is higher than the 32% in the Renewables Energy Directive (RED II) but lower than the 42.5% binding share set in the revised RED II. In the EU, there has been many efforts to promote the renewable energy in the electricity generation. The increase in electricity generated from renewable energy sources is mostly due to the expansion of two renewable energy sources across the EU: wind power and solar power. In 2022, renewable energy sources accounted for 41.2% of gross electricity consumption in the EU. Wind contributed for more than one-thirds of all renewable-generated electricity at 37.5 %. The solar power accounts for 18.2% and is the fastest-growing energy source from about 1% in 2008. Solar-generated electricity has

[77] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2023%3A796%3AFIN

increased dramatically.[78] Wind and solar power have benefited from lowering costs as technologies have scaled up, making them the most cost-competitive.

Figure 22 (left) Utility-scale solar PV total installed cost trends (USD/kW), and Figure 22 (right) Utility-scale solar PV weighted average cost of electricity (USD/kWh).

Figure 22: Solar PV costs



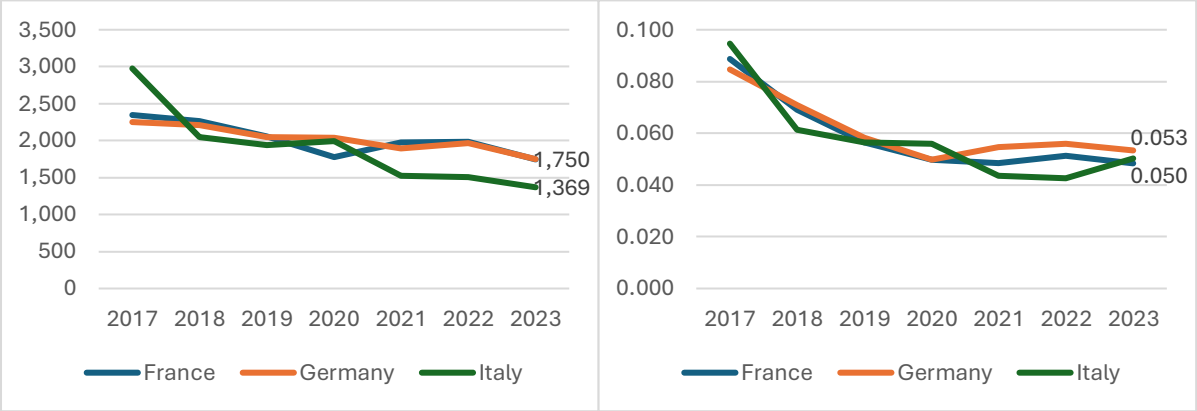
Source: Created based on IRENA Renewable Cost Database

The installed cost of utility-scale PV in major countries has been reduced significantly. France's installed costs are expensive compared to other countries. As of 2023, the cost is 955 USD/kW, down 81% from 2010. Germany's installation costs are lower than in other countries. As of 2023, the cost in Germany was 731 USD/kW, an 76% reduction from 2010. In France, installation costs are the highest, but the utility-scale solar PV weighted average cost of electricity is the cheapest in three countries, reflecting the solar irradiation. In 2023, the cost was 0.057 USD/kWh, down by 87% from 2010. The cost of generating electricity by solar power has been decreasing in all countries.

Figure 23 (left) Onshore wind weighted-average total installed costs (USD/kW), and Figure 23 (right) The weighted average LCOE of commissioned onshore wind projects.

[78] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics#Wind_and_water_provide_most_renewable_electricity.3B_solar_is_the_fastest-growing_energy_source

Figure 23: Onshore wind costs



Source: Created based on IRENA Renewable Cost Database

The installed cost of onshore wind in Italy differs from the downward trend in other countries, with prices continuing to fall until 2023 at 1,369 USD/kW. Although all three countries have the upward trend in the cost of electricity generation by onshore wind since 2021, the levelized cost of electricity (LCOE) of onshore wind has steadily declined over time.

Member States have indicated trajectories for renewable energy technologies up to 2030, with many focusing on renewable electricity generation, particularly for wind and solar power. However, there is still unexplored potential to promote electrolyzer capacity for renewable hydrogen and related products in demand sectors. Nuclear power is also crucial for meeting decarbonization targets and ensuring energy security, with some countries securing alternative fuel supplies. This Section explores the hydrogen and nuclear policy coordination across three countries.

6.2 Cooperation in hydrogen strategies

To avoid the use of Russian natural gas, the urgent response is to expand renewable energy and electricity grids in the EU, and to accelerate the development of technologies and infrastructure for the production and use of green hydrogen. It is difficult to ensure energy security and supply quickly and over the medium to long term by these means alone, and it has called for a temporary increase in the use of nuclear power. The REPowerEU strategy of 2023 states that nuclear power could play a role in Russia's transition away from fossil fuels, and that hydrogen produced from a nuclear power could also play a role in replacing natural gas. On the other hand, the plan also states that in order for nuclear power to play this role, it is important for Member States dependent on Russia for fuel to diversify their sources of supply among the EU's partners. Norway replaced Russia as the EU's largest supplier of natural gas via pipeline, while imports of liquefied natural gas, led by US-produced gas, also increased rapidly. In the first quarter of 2024, the EU's petroleum oil imports came from the United States (17.1%) and Norway (13.6%). Norway supplied nearly half of the natural gas in gaseous form

(46.6%). The United States accounted for nearly half of all imported liquefied natural gas (47.4%).[79]

In 2022, hydrogen accounted for less than 2% of Europe's energy consumption, primarily used for chemical products. The EU aims to develop renewable hydrogen, with the REPowerEU Strategy aiming for 10 million tonnes of production and import by 2030. By 2050, renewable hydrogen will cover 10% of the EU's energy needs, significantly decarbonizing energy-intensive industrial processes and the transport sector. The European hydrogen policy framework, proposed by the Commission in July 2021, includes binding targets for renewable hydrogen uptake in industry and transport by 2030 and a Hydrogen and decarbonised gas market package since 2024. The Recovery and Resiliency Facility for clean energy is an instrument available to EU countries in 2021, supporting investments in hydrogen projects across the value chain. Investment support is provided through IPCEIs on hydrogen.

The European Union (EU) is promoting hydrogen initiatives in various sectors, including the Clean Hydrogen Partnership (2021-2027), the European Clean Hydrogen Alliance, and the Hydrogen Public Funding Compass. The Clean Hydrogen Partnership is a joint public-private initiative supported by Horizon Europe, aiming to accelerate research, development, demonstration, and deployment of hydrogen valleys. The European Clean Hydrogen Alliance, launched in 2020, aims to achieve an ambitious deployment of hydrogen technologies by 2030 by bringing together renewable and low-carbon hydrogen production, demand in industry, transport, and hydrogen transmission and distribution. It launched six roundtables and published a hydrogen project pipeline. The Hydrogen Public Funding Compass is an online guide for stakeholders to identify public funding sources for hydrogen projects.

There has been an increasing amount of cooperation across key countries. Germany, Austria, and Italy have signed a Joint Declaration of Intent (JDOI) to promote the creation of a hydrogen import corridor between the three countries. The SoutH2 Corridor is one of five large-scale pipelines for hydrogen imports, facilitating the import of 10 million tonnes of renewable hydrogen by 2030. The SoutH2 Corridor is crucial for the southern states in Germany and will facilitate the import renewable hydrogen by 2030. The partnership aims to improve energy security for industrial demand clusters and foster the implementation of climate targets in the European Union.[80]

On July 24, 2024, the Federal Cabinet has approved an import strategy for hydrogen and hydrogen derivatives, a crucial part of Germany's hydrogen policy. The strategy outlines a reliable framework for imports, aiming to meet the national demand of 95-130 TWh by 2030. Around 50-70% of this will likely be imported from abroad, with the import share expected to increase after 2030. The demand for hydrogen and hydrogen derivatives could reach 360-500 TWh by 2045.[81] NSW 2023 sets out a number of targets for the German Government to

[79] https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20240701-1

[80] https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2024/05/20240530-germany-austria-and-italy-sign-a-joint-declaration-of-intent-for-the-development-of-the-south2-corridor.html

[81] https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2024/07/20240724-importstrategie-wasserstoff.html

achieve by 2030, including doubling domestic green hydrogen production capacity from 5 GW to 10 GW, expanding hydrogen infrastructure and creating the conditions for a thriving domestic and foreign hydrogen market. As part of this, a policy on importing hydrogen from outside the country is set out. Long-distance pipeline operators have submitted an application for a hydrogen core network, aiming to include crucial infrastructures by 2032. The network, spanning 9,666 km, includes 60% converted pipelines and is expected to cost 19.7 billion euros.[82] The H2med infrastructure project, led by France, Spain, and Portugal, aims to connect the Iberian peninsula's hydrogen networks with those in northern Europe. With Germany's support, the cross-border project is taking steps to establish a European backbone for hydrogen transport, including extending existing and planned infrastructures, including the H2Med pipeline to Germany, and reinforcing the electrical grid within the European Union.[83]

6.3 Nuclear policies in three countries in the middle of hydrogen development

As decarbonization of the industrial sector becomes one of the priority policies, there are high expectations for the use of hydrogen. The three key countries have shown a growing interest in the use of hydrogen and the cross-border projects have been formed to ensure its supply chain. At the same time, as most hydrogen is currently derived from natural gas, there is a need to expand the use of hydrogen derived from non-fossil fuels, green hydrogen. This could be an important area where three countries can harmonize in its definition and scope.

The updated RED defines the rule of EU renewable hydrogen and sets ambitious targets for renewable fuels of non-biological origin (RFNBOs), which defines what percentage of hydrogen used in the industrial sector should be liquid and gaseous fuels of which is derived from renewable sources other than biomass. There was a debate over this target, with some EU countries requesting that not only renewable energy but also hydrogen produced from other non-fossil fuels and low-carbon sources, including nuclear power, be assessed.

This sub-section focuses on the discussions in major EU countries on the definition of hydrogen derived from RFNBOs from the perspective of the coexistence potential of renewable energy and other low-carbon energy sources, including nuclear power, taking into account the energy situation in each country.

The revision of the Renewable Energy Directive sets out the target for the share of renewable energy in final energy consumption in 2030 to 42.5%. Targets have also been strengthened in each sector towards this overall target, with the industrial sector setting a target for the share of RFNBOs in hydrogen used of at least 42% by 2030 and 60% by 2035. Notably, an exemption provision has been established for these targets. If the share of fossil fuel-derived hydrogen

[82] https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2024/20240723_Wasserstoff.html

[83] https://www.elysee.fr/en/emmanuel-macron/2023/01/22/french-german-declaration

consumed is below 23% in 2030 and 20% in 2035, the target for the share of RFNBOs can be reduced by 20 percentage, implying that share of RFNBOs at 22% in 2030 and 40% in 2035.

It can bring another interpretation that in 2030, 42% of the hydrogen in the case without exemptions would need to be produced by RFNBOs, while the remaining 58% would be produced by fossil fuels. On the other hand, with exemption, if hydrogen sourced by fossil fuels can be kept below 23%, the target for the remaining 77% would be 22% by RFNBOs, and 55% could be covered by nuclear and other low-carbon hydrogen including that from biomass. A statement was added to the preamble of the Renewable Energy Directive, setting out the approach on which the above-mentioned exemptions are premised. It states that EU Member States should be able to use a combination of various RFNBOs and other non-fossil energy sources, depending on their national circumstances and energy mix, in order to achieve carbon neutrality in 2050 and decarbonize the industrial sector.

The background to the establishment of the exemptions was a strong request from several EU Member States. Nine countries including France argued that targeting only the expansion of renewable energy and not giving other low-carbon energy sources the same incentives as renewable energy would delay the transition to a hydrogen society, and requested that hydrogen from nuclear energy be treated equally with hydrogen from RFNBOs. These countries are key participants in the European Nuclear Alliance, and many of them are not endowed with renewable energy resources. The potential of renewable energy varies along the geographical situation. Germany, which has completed its nuclear phase-out and is leading the expansion of renewable energy in the EU, and Spain, which is rich in renewable energy resources and plans to build a pipeline to export hydrogen derived from RFNBOs to France and Germany by 2030, were particularly strongly opposed to treating hydrogen of originated from nuclear power equally with that from RFNBOs. In reality, many of the countries that have agreed with an exemption provision in the revised Directive are at an ongoing or planned stage of construction of nuclear power plants. These construction projects are mainly replacing coal-fired power plants or replacing existing reactors, with the electricity being used to maintain electricity supply and to decarbonize heat supply through electrification. In other words, even in nuclear-using countries, few countries may be able to provide the large amount of additional low-carbon electricity needed for the large-scale production of industrial hydrogen by 2035 to cover above 55% of its hydrogen production. France has a low-carbon power portfolio with nuclear power accounting for approximately 70% of its power supply mix. The Plan France 2030 sets a target of producing 700,000 tonnes of renewable or low carbon hydrogen by 2030. The electrolyser capacity target is set at 6.5 GW by 2030. According to France Hydrogène, increasing the utilization rate of the French existing nuclear reactors from an average of 70% in recent years to 80% by 2030 could provide the additional electricity needed to run the entire 6.5 GW of electrolysis capacity.[84] The Italian Government submitted the final NECP document on 1 July 2024. The country's electricity sector requires large amounts of electricity for electrification of final consumption and hydrogen and e-fuel production to decarbonize hard to-abated sectors. The NECP developed scenarios which includes all technologies (including renewables and gas/bioenergy with CCS), where it is also possible to include a share of

[84] https://www.senat.fr/rap/r21-801/r21-80117.html

nuclear generation, which is self-limited to half of the deployable potential. According to the projections, the scale of nuclear and fusion power generation to be introduced from 2035 will be approximately 8 GW (7.6 GW nuclear and 0.4 GW fusion) by 2050, supplying approximately 11% of total domestic electricity demand, and could even reach up to 22% considering the development of the full reactor potential. It points out that the resumption of nuclear power could play an important role where possible following the necessary amendments to the relevant national legislation. Italian MASE launched the National Platform for a Sustainable Nuclear Power which will draw up the Guidelines (actions, resources, investments, and timeframes) necessary for a resumption of nuclear power to Italy.

Nuclear energy is an important option for the decarbonization strategies of some EU Member States with limited renewable energy resources. The existence of commercial applications for the production of low-carbon hydrogen from nuclear power could provide a significant boost to investment in nuclear installations, and the value of nuclear power is now clearly recognized in the EU in order to effectively decarbonize based on national energy circumstances. In the context of promoting the decarbonization of the industrial sector, the recent revision of the Renewable Energy Directive clearly recognizes the potential of nuclear hydrogen to contribute to decarbonization in the form of a visible numerical value of a 20% exemption from the target of the hydrogen sourced from RFNBOs. For the exemption provision to apply, hydrogen must be highly decarbonized by other non-fossil energy sources. In practice it would be difficult to fulfil the condition unless the large-scale deployment of nuclear hydrogen production is envisaged. The exemption provision is therefore seen by some as a boost to the expansion and diffusion of nuclear hydrogen and the expansion of nuclear power generation in anticipation of the electricity supply needed for this. Even if it will be difficult to qualify for the exemption by 2035, it is significant that nuclear power is positioned alongside renewable energy on the EU's decarbonization pathway for the future. Renewable energy is an important instrument for decarbonization. However, it should be noted that the socio-economic burden differs greatly between countries with abundant low-cost renewable energy resources and those without such resources.

7. Options for further policy integration

The energy profiles of the three biggest EU economies underline the different energy choices that prevail throughout the EU. While these choices align to clear and rational national circumstances and strategies, they clearly show that the EU is still far from achieving a single energy market. Yet, the analysis shows that despite the differences, the countries align around various principles and topics, which can be used as the basis for further European integration.

First and foremost, this concerns an alignment of objectives: France and Italy – just like all other EU countries – align on the overall policy objectives to safeguard energy supply, guarantee competitive energy prices and use clean energy sources to reduce carbon emissions and environmental impacts of the energy system. Furthermore, the blending of energy and climate policies is a reality found in all EU countries. With the strong impact of EU legislation, the fields of renewable energies and energy efficiency open up two areas of cooperation, in line with Art. 194 TFEU. This concerns the commercial side as well as the political, by exchanging good practices on business models as well as on policy design. The European strategy of aligning policies and fostering cooperation by the means of the NECPs can thus contribute to further policy convergence.

While jointly developing these areas is a necessary condition for lowering import dependence, it is by no means sufficient. Further integration will be needed in other areas to fully reap the benefits of a single energy market. This notably concerns internal market integration of the electricity and gas markets. Here market design, market rules and regulatory oversight demand for further harmonisation, but is proving difficult to implement across all 27 Member States. Next, the EU is well advised to leverage its buying power – as advanced by the 2024 reports produced by Enrico Letta and Mario Draghi – to act jointly on the global markets for hydrocarbons but also for the development of clean hydrogen. While the Energy Union and the European Green Deal, including RePowerEU, have already identified the critical aspects, such as common purchasing of gas, these elements need to be swiftly put into practice to support the EU in an increasingly unstable global environment.