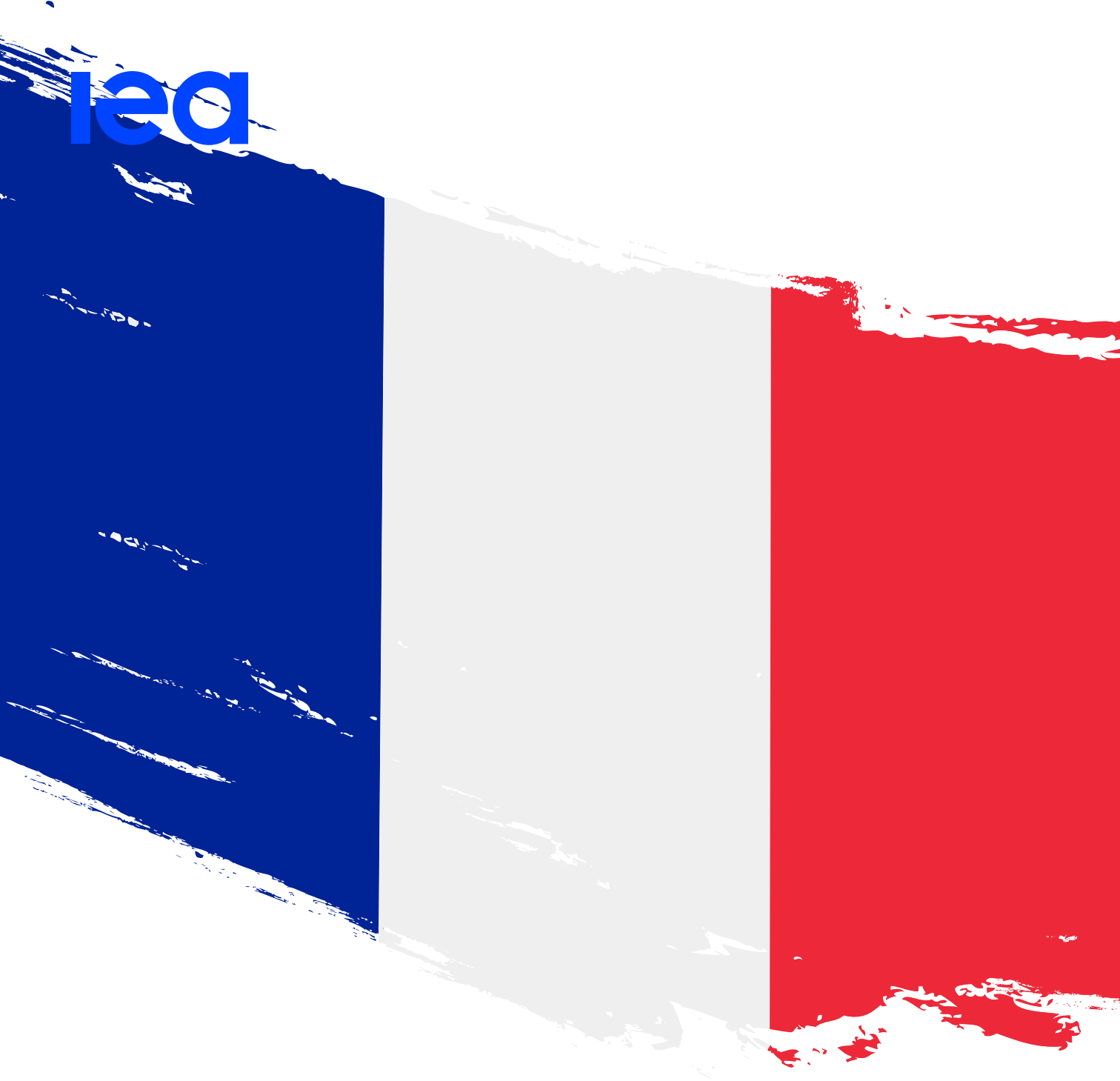

France 2021

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 30 member countries, 8 association countries and beyond.

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Foreword

The International Energy Agency (IEA) has conducted energy policy reviews of its member countries since 1976. This peer review process supports energy policy development and encourages the exchange of international best practices. By seeing what has worked – or not – in the real world, these reviews help to identify policies that can deliver concrete results.

As a member of the IEA for almost three decades, France has been instrumental in guiding international efforts to accelerate clean energy transitions. France has demonstrated important leadership in global climate negotiations, notably with the landmark Paris Agreement in 2015 and in promoting green finance.

I also highly value the strong engagement with IEA activities that we are seeing from France's Minister for Ecological Transition, Barbara Pompili, and her staff at the Ministry. This close cooperation was evident in the preparation of this report as well as for a recent joint study the IEA published with France's transmission system operator, RTE, which examined how power systems could operate with very high shares of variable renewables.

France was among the first countries in the world to adopt an energy transition framework with a National Low-Carbon Strategy and a 10-year investment plan for the energy sector. In 2019, France enacted into law its goal of reaching net zero emissions by 2050. However, France is behind schedule on its energy transition targets, despite important reforms being underway. While its power sector emits relatively low quantities of carbon, its overall energy consumption is dominated by fossil fuels, resulting in rising emissions, notably from transport.

France's nuclear fleet is ageing and maintaining its low-carbon power generation will require timely decisions about the future electricity mix along with an acceleration of clean energy investments. France's economic recovery plan ("Plan Relance") and "France 2030" investment plan have earmarked unprecedented levels of funding for sustainable mobility, building retrofits, hydrogen, nuclear power and other technologies. To guide progress in these areas, the government needs to refresh its 2016 national energy research strategy.

France has considerable work ahead on the road to net zero. It needs to focus on implementation, reviewing progress to date, and increasing co-ordination across the government. As the European Union implements its 55% emissions reduction target, France will need to increase its 2030 targets for emissions reductions, share of renewables and sector-by-sector energy efficiency. I strongly believe this report can help France advance its energy and climate goals while ensuring fairness, energy security and economic growth. The IEA will continue to work closely with France as it moves ahead with its transition.

Dr. Fatih Birol

Executive Director

International Energy Agency

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1. Executive summary

France has been an early thought leader of the global energy transition. As host of the COP21 and the Paris Agreement, France is widely seen as a frontrunner in the energy transition by the international community.

France benefits from decarbonised electricity and the lowest per capita emissions of advanced economies thanks to the role of nuclear energy, which accounted for 71% of its power mix in 2019, and the role of hydro power (10%).

France's decarbonisation framework, anchored in the Energy Transition Law of 2015, builds on the National Low-Carbon Strategy for 2050 (Stratégie Nationale Bas-Carbone, SNBC), with targets for the reduction of fossil fuel use and emissions by sectors under three five-year carbon budgets out to 2034. In the energy sector, actions are implemented by two successive five-year energy investment plans (*la programmation pluriannuelle de l'énergie*, PPE). Building on the SNBC and the PPE, regions are implementing their own climate and energy transition goals under the regional plans for spatial planning, sustainable development and equality. At the local level, municipalities are working on their climate air and energy plans.

In 2021, France is not yet on track to reach its targets for energy efficiency, renewable energy or emissions reductions, that were agreed in 2015. France should be able to catch up in the coming years, if the important reforms which are under way are implemented across the energy sector. As foreseen in the PPE, a significant acceleration in investment in the clean energy transition is needed to achieve France's energy and climate targets by 2030. Commendably, the government adopted a historic Recovery Plan to fight the COVID-19 pandemic, which in addition to the PPE funding, offers important green funding dedicated to the energy transition. The next five to ten years are critical and France will need to focus on the implementation of its energy policy priorities towards a sustainable, secure and just transition.

Increased climate focus

Since the International Energy Agency's (IEA) last review of France's energy policies in 2015, the government has taken significant actions to strengthen domestic climate action on the road the net zero. The 2019 Energy and Climate Law legislated carbon neutrality by 2050 and a tighter emissions reduction pathway (an 85% reduction by 2050 compared to 1990 levels). In 2020, the government updated the SNBC and the PPE towards the goal of carbon neutrality by 2050.

The government has increased awareness of the need for climate action and has worked to strengthen its governance. The High Climate Council was created in 2019. The prime minister was tasked with co-ordinating climate action across government based on

sector roadmaps. The Citizens' Convention provided a range of recommendations for speeding up climate action by 2030, including at the regional and local levels, which are also reflected in the 2021 Climate and Resilience Law. France has made progress in strengthening building codes, labelling and the application of energy audits for enterprises and has enhanced measures to support improved efficiency of the mobility system. A strong focus on renovation, the just transition and clean mobility is emerging with additional funding provided under the historic green funding under the French Recovery Plan from the COVID-19 pandemic. In October 2021, France announced a EUR 30 bln investment plan for 2030, which targets French industrial development in the energy, automotive and space sectors, including EUR 8 bln dedicated to energy technology investment in the decarbonisation of industry, in hydrogen and small modular reactors; EUR 4 bln for electric and plug-in hybrid vehicles.

Slow progress of France's energy transition

Despite this laudable progress in upgrading its energy transition framework, France is lagging behind with implementation. France has not reached its 2020 targets on energy efficiency and renewable energy. And its 2030 emissions targets, adopted in 2015, remain unchanged; the second carbon budget was revised upwards in 2020, lowering the effort required up to 2023.

In the area of energy efficiency, final energy consumption was 145.5 million tonnes of oil equivalent (Mtoe) in 2019, much above the 2020 target of 130 Mtoe. To put France on a net zero pathway and achieve the targeted decline in final energy consumption to 120.9 Mtoe in 2030, pivotal changes in France's economic structure and consumer behaviour, alongside greater digitalisation and electrification, are required.

Over the past decade, wind and solar photovoltaic (PV) electricity generation have increased, driving the share of renewables in electricity generation from 14% in 2010 up to 23.4% in 2020. Hydropower represents half of renewable electricity generation. France aims at a share of 23% renewables in gross final energy consumption by 2020, but had 17.2% in 2019 and 19.1% in 2020 (preliminary data). The gap with the 2023 targets under the PPE is massive: France would need to add 6.4 gigawatts (GW) of wind capacity (i.e. 40% of total cumulative capacity to date) and almost double the solar PV capacity in just three years.

The delivery gap is mainly due to the lack of administrative staff and lengthy permitting procedures, but a range of remarkable reforms was carried to shorten and streamline them, such as the ESSOC Law, PACTE Law and ASAP Law. Results are expected to manifest themselves in the coming years. The retroactive revision of support mechanisms has been chaotic and their implementation takes too long, like for new solar tariffs. Stop-go policies, notably the retroactive cuts on incentives for solar plants built in the period 2006-10, are undermining investors' confidence and increasing the risks and costs of future investment. Offshore wind is taking off slowly, but France remains significantly behind its neighbours in the implementation of an offshore wind strategy and in the pace of deployment.

Moreover, the electric power fleet is ageing and private investments in large-scale capacity additions are not coming forward, amid the lack of long-term visibility of the electricity mix beyond 2035. The SNBC strongly relies on low-carbon electricity, but does not provide

visibility on the sources and technology options for 2035 and beyond. The government postponed the planned reduction in the share of nuclear electricity to 50% from 2025 to 2035. Recommended by the 2015 IEA review, this is a welcome step at the time of climate urgency, which maintains the benefits of low-carbon electricity for France's energy transition. With the support of France's transmission system operator RTE, the government is currently reviewing several 2050 decarbonisation scenarios as input to a timely decision on the long-term electricity mix beyond 2035, which is very much needed. Whichever scenario will be followed, both the role of nuclear and renewable energy will have to be secured. A joint study by the IEA and RTE in 2020 has provided analysis regarding the technical requirements for system operation with high shares of variable renewables in 2050.

France is not on track towards its emissions reduction targets for sectors outside the European Union's (EU) Emissions Trading System (ETS), as transport emissions continue to grow. France has not met its first carbon budget and it remains to be seen if it will meet its second one. In 2020, the IEA expects a 12% reduction in CO_2 emissions from 2019 levels for France, due to the COVID-19 pandemic. However, these trends do not reflect actual emissions reductions and a fast rebound is expected with the recovery of the economy.

France has ambitious targets and incentives, such as the bonus/malus system and conversion bonus to support the switch to electric and plug-in hybrid vehicles. The Mobility Strategy and 2019 Law on Mobility Orientation require all sales of new passenger cars to be zero emission in 2040. The Climate and Resilience Law of 2021 also includes a ban of the sale of the most polluting vehicles from 2030 onwards. Many countries already have more ambitious targets (despite having a much less decarbonised power mix). It is welcome that the new Climate and Resilience Law has moved to a 2030 target. This is a critical signal, as France is likely to miss its target for electric vehicle roll-out and charging infrastructure under the PPE, targeting sales of electric and plug-in hybrid vehicles of 1.2 million by 2023 and 4.8 million by 2028, which requires a strong increase, up from about 671 000 in mid-2021. After Norway, Sweden, the Netherlands and Germany, France is now catching up in Europe's electric mobility market, reaching the level of the United Kingdom, when considering new car registrations.

Prioritising implementation

Over the past five years, the government has revised its Energy and Climate Law twice and set a very high number of targets for fuels and sectors. Local and regional authorities have also adopted targets, but these are not necessarily aligned or in step with net zero goals, technology progress, socio-economic analysis or affordability concerns. While many countries are also struggling with similar challenges, notably as they target net zero emissions by 2050, going forward, a very strong focus on accelerating implementation and execution is critical for France.

To date, the government does not yet assess the results and progress of the renewable tenders or the efficiency improvement by sector. There is no framework to track, assess or guide progress towards the many domestic targets besides the medium-term National Energy and Climate Plan, as many policies and targets remain fragmented across government.

Several steps need to be envisaged to make a step change in the implementation of climate policy. The government needs to focus its policies on implementation and adopt tools to achieve faster progress and track, including the results towards the targets, for instance with an annual update of the SNBC and PPE indicators.

The government needs to boost its achievement focus and policy certainty to increase investors' confidence and accelerate affordable private investment at the pace necessary to meet the 2020 and 2030 targets for renewables and sectorial as well as interim sub-targets under the PPE. Any contradicting signals increasing uncertainty, risk and cost of investment should be carefully avoided. Any retroactive measures are particularly harmful in this respect. In the area of energy efficiency and renewables, the public support schemes remain complex, multiple and fragmented and do not yet support large-scale investment. They need to be further simplified for consumers, building on recent examples, like MaPrimeRénov', energy vouchers and solar PV.

To steer implementation in all sectors, the government, led by the prime minister, should ensure the co-ordination, implementation and tracking of progress across all levels of government, alongside an increase in the capacity of the ministries to monitor, guide and deliver policies on the ground. The prime minister should present concrete proposals to speed up and streamline procedures for licensing of renewable energy projects, and strengthen energy taxation (with a focus to phase out remaining indirect fossil fuel subsidies). The government needs to increase its expertise and resource capacity for leveraging higher private investment. This requires transparency, communication and engagement with all stakeholders.

To improve implementation and ensure a just transition, the government should also strengthen its capacity to work with the regions. The regionalisation of the PPE is a welcome step in this regard, provided it is well co-ordinated and utilised with the aim of accelerating implementation.

A regular review of progress is fundamental: the High Council on Climate's annual report and the government's report on the PPE, carried out every two years, are good starting points. To respond to the High Council on Climate, the government should carry out a more systematic annual review of progress. Clear identification and communication of the gaps between policy provisions and real actions are critical for the transparency and accountability of France's clean energy transition.

Clear milestones for net zero and targets for 2030

Among G7 members, France has the lowest value of CO2 emission per capita in absolute terms. It has the least stringent goal in relative terms with a target of a 40% reduction of greenhouse gas emissions by 2030. However, the target has not been strengthened since 2015 and progress will not be made without new policy action. France plans to revise its National Low-Carbon Strategy and the energy plan. This is an opportunity to align with the EU's target of reducing emissions by 55% by 2030 and respond to the EU Green Deal and the related Fit-for-55% package. In doing so, the government should improve the clarity and stability of its targets (reflecting updated energy technology costs and socio-economic analysis), alongside stronger policy consistency, gap analysis and robust implementation tracking.

Moving towards net zero will require that transport, buildings and industry are put on cost-effective pathways towards climate neutrality while maintaining a low-carbon electricity supply. A clean energy technology roadmap underpinning a revised national energy research strategy should accompany the new SNBC/PPE under preparation for 2024 to identify pathways and technology choices, job creation opportunities, and inform investment decisions and track progress. Based on a robust evaluation of clean energy technology pathways for 2030, 2040 and 2050, the PPE will need to be strengthened and identify broad clean energy technology options in annual green budgets under the PPE, including for energy efficiency.

In this context, the government needs to revisit the expected contributions of biomass; carbon capture, utilisation and storage; and decarbonised gases, notably hydrogen, based on the latest technology progress, when updating the SNBC. The PPE, the Programming Plan on Jobs and Competences (PPEC), and the revised National Strategy for Energy Research (SNRE) will need to be aligned.

Policies for the net zero pathway

Robust policies are needed for clean energy investments in modern energy markets in support of a strong energy industry. This includes stable and clear market-based support schemes, which lower risks and support technology scale-up and accelerate deployment. This should be complemented by procedures that deliver the permit as a default and grants and loans that expand green recovery funding. The MaPrimeRénov' is already a very good step towards this delivery-focused design of policies that could quickly reach scale.

Electricity market reforms

Since the IEA's last review in 2015, energy markets in France have seen a rise in competition – in the gas sector thanks to unbundling and the phase-out of regulated prices; and in electricity, with the entry of new suppliers at both the wholesale and the retail level thanks to European wholesale electricity market reforms.

A more competitive electricity retail market is slowly emerging, with a large number of electricity suppliers offering market deals to French consumers, some below regulated tariffs. France maintains regulated tariffs which are offered by Électricité de France (EDF), the incumbent supplier of more than 70% of French residential consumers. The government does not have plans to phase out regulated tariffs for residential consumers and continues seeing benefits of those, as reflected in the assessments made by the French Competition Authority and the Council of State in 2021. However, the government needs to ensure a level playing field among all actors, EDF and new entrants, based on unbundling and fair rules for all market participants. However, the government has said it will review the purpose and use of regulated electricity prices.

A key element in this context are the conditions under which other suppliers can have access to electricity from existing nuclear power plants. A new market regulation for the French electricity market is needed by 2025 with the end of regulated access tariff (ARENH) mechanism, closely integrated with its European neighbours. A timely decision on how the government plans to finance the modernisation of existing generation capacity and new nuclear investment is urgently needed.

New network tariffs were adopted in 2021 and electricity network tariff regulation increasingly empowers prosumers, renewable energy communities and electricity distribution companies to drive the energy transition.

Carbon pricing and energy tax reforms

Carbon price signals remain important for clean energy investments. The EU Green Deal and its Fit-for-55% package are expected to strengthen the carbon price signal under the EU ETS and non-ETS sectors. In the transport and buildings sectors, France already levies a carbon tax as part of its energy taxation at EUR 44 per tonne of CO_2.

However, carbon pricing cannot be done without policies for a just transition, which needs to be a continuous priority for the government. Social acceptance of additional taxes reached a limit, as shown by prolonged protests during 2018-19, when excise taxes on motor fuels and the related carbon component both increased during a period of high oil prices. France has increasingly narrowed the gap between the taxation of diesel and gasoline, which now better reflect the relative carbon footprints of these fuels. Moreover, France is the first country to implement a green budgeting approach, which offers lessons for many EU countries at the time of the energy transition.

There is little room for further tax increases without a new approach to managing the cost of the transition, e.g. by supporting reskilling, employment, and the transition of communities and workers. Any further reform of carbon taxes should be part of a broader energy tax reform. French environmental taxes need to better reflect environmental and social costs. Phasing out fossil fuel subsidies in the form of energy tax exemptions will reduce consumption and emissions and increase efficiency, notably in the transport sector.

Sustainable recovery will be an opportunity

France has a highly skilled energy industry, which can be a backbone for a resilient economic recovery. While nuclear and the oil and gas sectors account for the majority of employment today, the renewables sector, notably wind and solar, has seen dynamic growth in jobs and investments. Under the SNBC, this is projected to accelerate with the creation of 300 000-500 000 new jobs by 2030 and 800 000 by 2050, boosted by investments in transport, buildings and energy.

France's Recovery Plan is a historic plan for accelerating the implementation of energy and climate targets and supporting a people-centred transition. Leading global efforts, France has adopted a very large and also green recovery plan, dedicating more than EUR 30 billion (bln), out of a total of EUR 100 bln, of the funding under the French Recovery Plan to sustainable recovery objectives: to support transport (EUR 20 bln), the renovation of buildings (EUR 6 bln), technology innovation in nuclear (EUR 470 million) and France's hydrogen strategy (EUR 7 bln). This funding comes in addition to the support schemes for renewable energies included in the PPE in 2020 as well. Important innovative investment schemes include the MaPrimeRénov', which supports energy efficiency in buildings across all income classes (and replaces the energy transition tax credit), increases subsidies for the private purchase of electric vehicles and provides additional tax credits for the installation of electric vehicle chargers at home.

To implement the plan successfully and ensure that taxpayers' money is spent wisely, policies for net zero, as outlined above, can leverage projects and catalyse private investments, including in electric mobility, low-carbon residential heating, hydrogen and batteries.

Security of France's clean energy transition

Maintaining a high level of security of supply during the clean energy transition needs to be a priority for the government and an integral part of the country's decarbonisation plans.

The Minister of the Ecological Transition needs to strengthen the oversight on security of the energy transition and bring together the stakeholders necessary for managing possible crises across the energy supply chains and infrastructure. Key questions relate to the short- and medium-term electricity adequacy and the medium-term transition of France's oil and gas infrastructure and related security risks. Besides, the government also needs to increase preparedness to address new threats, stemming from more frequent extreme weather events or cybersecurity risks, but also the availability of critical minerals and metals indispensable for clean energy transitions. The new analysis of critical minerals presented by the government is welcome and should trigger domestic and global actions.

Electricity security will be at the heart of the clean energy transition. It cannot be excluded that ensuring adequacy and reliability may require adjustments in the pacing of the anticipated policy measures, including the schedule of closing nuclear reactors. In the 2019 Energy and Climate Law, France committed to closing its remaining coal-fired power plants in 2022, and depending on the evolution of electricity demand, 14 nuclear reactors, to reach a share of 50% of nuclear in its power mix by 2035, while almost tripling renewable electricity generation.

If the deployment of renewables and related flexibility needs is not ramped up quickly enough through prioritising execution and implementation, the objective of closing 14 nuclear reactors may be difficult to achieve while preserving capacity margins. France has taken leadership in developing demand response across the electricity markets and benefits from a well-interconnected power grid. However, neighbouring countries are also going through deep energy transitions, indirectly also affecting France.

France's aging nuclear fleet will need to be modernised for long-term operation, provided safety is guaranteed, to support a secure and affordable energy transition. Major uncertainty remains around the future of nuclear new build and its long-term contribution to France's emissions reduction objectives. As in all countries entering a transition of the electricity system with the development of higher shares of renewables, power system operations will also require an incremental need for flexibility and diversity during the period of 2021-25, over which adequacy imbalances may occur. RTE will, in particular, need to ensure that sufficient flexibility is available during winter peaks, which should be reflected in the PPE, which already includes targets for demand response. Electricity security will need to be carefully monitored and the flexibility portfolio enlarged, notably by completing the legal framework for energy storage, including hydro, and boosting smart grids and dynamic pricing.

France is making hydrogen a top priority with its national hydrogen strategy that focuses on industry and heavy-duty transport, underpinned by EUR 7 bln in public funding. The

government focuses on developing an industry and French expertise in a new technology. The government should use the opportunities from regional hydrogen hubs across Europe to keep up the important momentum for the development of the technology in France and boost the potential to utilise hydrogen as a new energy carrier and provider of long-term energy storage in the energy system.

France has strengthened gas security with the merger of the gas exchanges in 2018 and the latest reform of gas storage. Maintaining oil and gas security remains a major challenge, as the transition accelerates. France's industry is already investing in biorefining and low-carbon fuel supply chains, based on ambitious targets for biomethane, biogas, hydrogen and second-generation biofuels. The government should accompany the capacity of the industry to adapt and support the affordability of the transition, including by making the best use of existing infrastructures. The planned strategy on oil and gas in the transition is a welcome step. In this context, the government should carefully monitor the impacts of a rapid shift in oil products consumption on the security of supply, including the future of the service station network, notably in rural areas of France.

Key recommendations

The government of France should:

- Increase implementation focus and policy certainty to accelerate private investment to meet energy and climate targets, avoiding any contradicting signals. Adopt regular progress review points for all measures and strengthen implementation capacity across government, co-ordinated by the prime minister.
- Ensure consistency of 2030 targets with the updated National Low-Carbon Strategy and multiannual energy plan, underpinned by new EU ambitions, socio-economic analysis and technology/innovation roadmaps. Introduce clean energy technology budgets to leverage higher private investments.
- Align national and regional targets, policies and regulations; reduce administrative barriers and streamline procedures; and provide for additional action critical to closing delivery gaps and achieving a sustainable, secure and affordable energy mix.
- Building on the green budget approach, scale up the mainstreaming of climate objectives into taxation, government expenditures and regulations across government to improve the cost-effectiveness of the energy transition.
- Clarify the ambitions for the closure and long-term operation of existing and the construction of new nuclear reactors in France, including financing mechanisms to mitigate uncertainties on the path towards net zero to support an affordable, sustainable and secure electricity mix.
- Introduce an energy-system approach across key energy carriers (electricity, decarbonised gases, heat) and networks, including interconnections to neighbouring countries. Facilitate close co-operation between the gas and electricity system operators, industry stakeholders, and regulators. In this context, leverage the national hydrogen strategy for developing a new energy carrier and provider of long-term energy storage.

2. General energy policy

Key data (2020 estimated)

Total energy supply (TES): 217.8 Mtoe (nuclear 42.3%, oil 28.3%, natural gas 16.1%, bioenergy and waste 7.7%, coal 2.5%, hydro 2.5%, wind 1.6%, solar 0.6%, geothermal 0.2%), -7.8% between 2010 and 2019, -10% between 2019 and 2020

TES per capita: 3.2 toe/cap (IEA average: 3.8 toe/cap)

TES per unit of GDP:* 81 toe/USD million PPP (IEA average: 91 toe/USD million PPP)

Energy production: 119.5 Mtoe (nuclear 77.1%, bioenergy and waste 13.2%, hydro 4.5%, wind 2.9%, solar 1.1%, oil 0.6%, geothermal 0.4%), -3.3% between 2010 and 2019, -8.9% between 2019 and 2020

Total final consumption (TFC) (2019): 105.1 Mtoe (residential 39.3%, industry 30.4%, transport 30.3%), -3.9% since 2009

* GDP data are in billion USD 2015 prices and PPP (purchasing power parity).

Note: 2020 data are impacted by the energy demand and supply shock of the COVID-19 pandemic and is a break in historic series.

Country overview

With a territory of 549 087 km^2, France is the largest country in the European Union (EU) and shares borders with Germany, Belgium, Luxemburg, Switzerland, Italy, Monaco, Andorra and Spain. It borders the Mediterranean Sea, the Channel and the North Sea, the Rhine, and the Atlantic Ocean. France has the second-largest maritime area in the world, behind the United States, with 11 million km^2 of exclusive economic zone and around 500 ports. The 12 state seaports handle more than 80% of France's maritime freight traffic.

France is administratively divided into 18 regions: metropolitan France with 13 regions (64.8 million inhabitants) and 96 administrative departments plus 5 overseas territories (2.1 million inhabitants) (Figure 2.1).

France is the second-most populated country in the EU (Eurostat, 2020), with 67 million people in 2020. Around 2 million people live in Paris, the capital city. The population grows by 0.3% per year (INSEE, 2020) and has a relatively high density of 119 inhabitants per km^2 in 2019, compared with the EU average of 34 inhabitants/km^2. Life expectancy is also one of the highest in the world, at 85.6 years for women and 79.7 for men (INSEE, 2020). France is praised for its high standards of living thanks to a well-educated and skilled workforce, high environmental standards, and middle average income inequality (OECD, 2019).

Figure 2.1 Map of France

Political structure

France is a semi-presidential republic, as defined by the Constitution of 4 October 1958 that gave birth to the Fifth Republic. The executive power is held by the head of state (the president) and the government (under the authority of the prime minister). The president is elected for a five-year term and can serve for two consecutive terms if re-elected. The legislative power is in the hands of the Senate (348 senators) and the National Assembly (577 deputies). The next presidential elections are scheduled for 2022.

President Emmanuel Macron was elected on 7 May 2017. He is the founder of the centrist, liberal and pro-European political movement "La République En Marche" (LREM). Edouard Philippe served as his first prime minister until 3 July 2020, when a new government was formed, with Jean Castex as prime minster. Since July 2020, Barbara Pompili is the Minister of the Ecological Transition, in charge of energy matters.

France is committed to active international co-operation within the European Union, the G7 and G20, and the United Nations, among others. It plays a significant economic and diplomatic role, notably in the area of climate change and the United Nations Framework

Convention on Climate Change (UNFCCC) (Paris Agreement and the "Race to Zero"). A founding member of the European Coal and Steel Community, the European Economic Community, and the European Union, France also joined the Organisation for Economic Co-operation and Development (OECD) in its early days in 1961, and the International Energy Agency (IEA) in 1995. During the first half of 2022, France will assume the Presidency of the Council of the European Union.

Economy of France

France is the seventh leading economy in the world, with a gross domestic product (GDP) reaching more than United States dollar (USD) 3.4 trillion in 2019 (OECD, 2021a). In 2019, the unemployment rate was 8.4% (OECD, 2020). France attracts capital thanks to its leading economic and political position in the EU and its developed infrastructures. In 2019, public administration services, defence, education, health and social work accounted for the largest share in GDP (in terms of share of real value added) with 21.9%. The second-largest sector is trade (17.7%), followed by the industry and energy sector (13.5%) (OECD, 2021a). Tourism accounted for 7.4% of GDP in 2018 (CEDEF, 2021). France was the most visited country in the world in 2018, with more than 89 million international tourists.

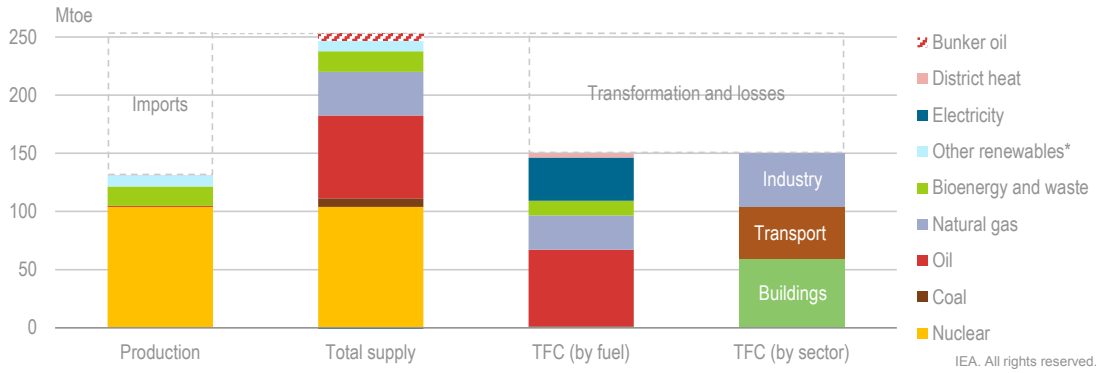
The COVID-19 pandemic strongly hit France, including services, tourism, trade and industry, leading to lockdowns and restrictive sanitary measures that caused an estimated fall in economic activity of 9.1 points of GDP in 2020 (OECD, 2021b). France's key priority has been saving lives while minimising the economic costs of the pandemic. France's GDP is yet expected to recover from the crisis, with an economic growth of 5-6% in 2021 (above world average estimations; IMF, 2020a) and 4% in 2022 depending on the evolution of the pandemic and related containment measures. The policy response to the pandemic has provided strong support for the economy thanks to multiple fiscal, budgetary and investment plans (OECD, 2020), including green stimulus measures.

The 2019 *OECD Economic Survey of France* (OECD, 2019) found that the country's heavy tax burden hampers economic growth and stifles the capacity of the business sector to create new jobs and investment. It also limits the capacity for government to use tax policies to steer behaviour. Social acceptance of additional taxes reached a limit, as shown by prolonged protests during 2018-19, when excise taxes on motor fuels and their related carbon component both increased.

Energy supply and demand

In 2019, France produced about half of its total energy supply (TES) domestically (Figure 2.2). Domestic energy production mainly consists of nuclear energy (79%), bioenergy (13%) and other renewables (including a large role of hydro with 3.7%). Nuclear accounted for 43% of TES in 2019, followed by imported oil (29%), natural gas (15%) and domestically sourced bioenergy (7%). On the demand side, oil still covered 44% of total final consumption (TFC) in 2019, followed by electricity and natural gas. Buildings were responsible for 39% of TFC, followed by transport and industry, each accounting for 30% of TFC.

Figure 2.2 Overview of France's energy production, supply and consumption, 2019



French production secures almost half of total energy supply. Oil, electricity and natural gas account for most of energy consumption. Buildings have the highest energy demand.

* *Other renewables* includes hydro, wind, geothermal and solar.

Notes: *Total supply* includes total energy supply plus international bunker fuel. *Buildings* includes residential and commercial and public services buildings.

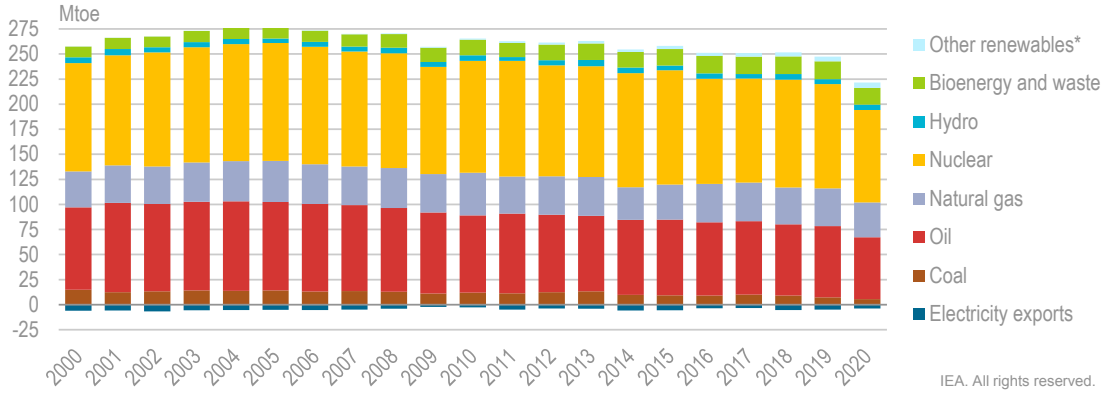
Note: Mtoe = million tonnes of oil equivalent. TFC = total final consumption.

IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Supply

TES was 217.8 million tonnes of oil equivalent (Mtoe) in 2020. It decreased by 8% between 2010 and 2019, and by 10% between 2019 and 2020, as an effect of the COVID-19 pandemic (Figure 2.3). The share of nuclear was stable in the last decade. Oil, the second energy source in TES, accounted for 28% in the same year. Renewables (including bioenergy, hydro, wind, geothermal and solar) increased by 23% from 2010 to 2020, while the supply of coal decreased by 55% and natural gas fell by 18%. The decrease in coal supply reflects a fall in electricity production from coal (-81% in the period 2010-20).

Figure 2.3 Total energy supply in France by source, 2000-20



Between 2010 and 2020, the supply of coal decreased by 55% and natural gas fell by 18%.

* *Other renewables* includes wind (3.0 Mtoe in 2019), solar (1.2 Mtoe), geothermal (0.5 Mtoe) and tide (0.04 Mtoe).

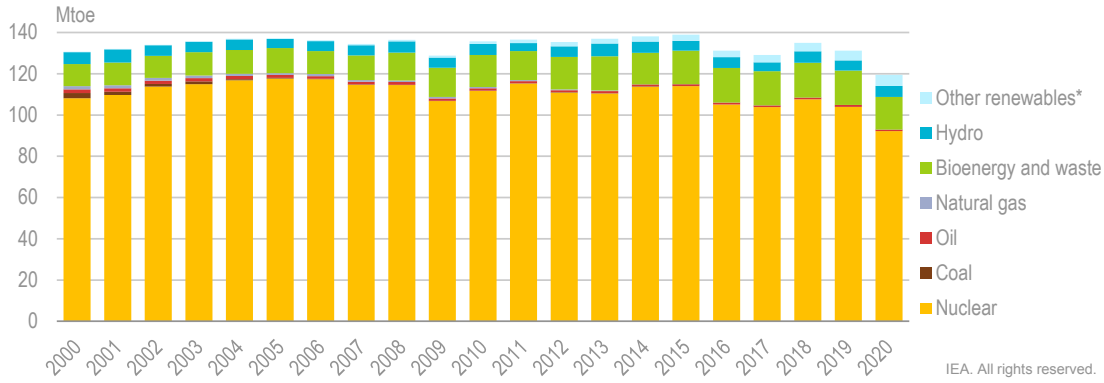
Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Out of 120 Mtoe in 2020, nuclear covered 77% of domestic production, but it decreased by 17% in the period 2010-20. Bioenergy and waste accounted for 13% (a 2% increase in 2010-20) and hydro for 4.5% (a 1% decrease in 2010-20) (Figure 2.4).

France imports all its needs of coal and gas, as the domestic production of coal ended in 2004 with the closure of the La Houve coal mine. Only 1% of oil supply was produced domestically in 2020. The ratio between energy produced domestically and total energy supply was mostly stable between 2010 and 2020.

Figure 2.4 France's energy production by source, 2000-20



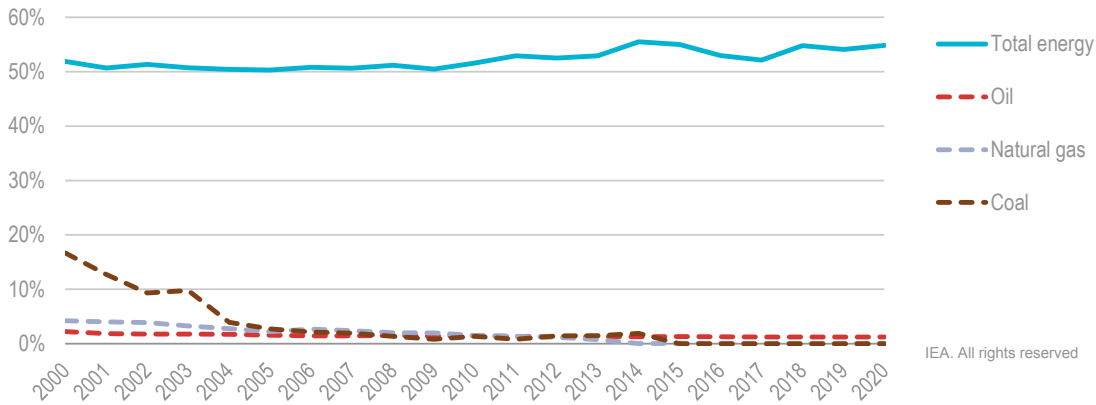
Nuclear is the main energy source of domestic energy production (77%). Bioenergy and waste (13%) comes second, followed by hydro (4.5%).

* *Other renewables* includes wind (3.0 Mtoe in 2019), solar (1.2 Mtoe), geothermal (0.5 Mtoe) and tide (0.04 Mtoe).

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 2.5 Share of total energy supply produced domestically in France by energy source, 2000-20



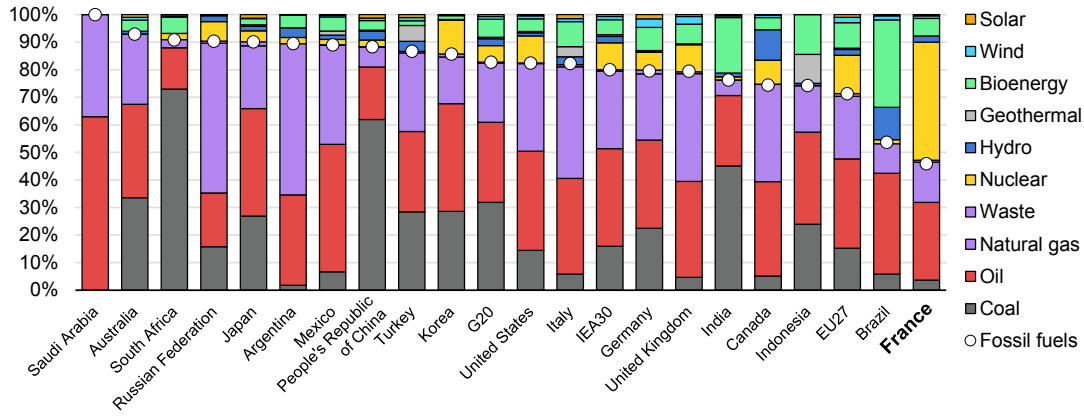
French domestic energy production covers half of its total energy supply. The country relies heavily on imports for its fossil fuels supply.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

France produced 54% of TES in 2019 (Figure 2.4), with domestic energy production consisting mainly of nuclear energy. Domestic coal production was around 20% of coal supply two decades ago. Today, France imports all its coal needs, primarily from Australia and the Russian Federation. Natural gas is entirely imported, mainly from Norway and Russia. Oil is imported from Saudi Arabia, Russia, Kazakhstan, and other countries with a smaller share (see oil section) (Figure 2.5).

France has the lowest share of fossil fuels among G20 countries (Figure 2.6) thanks to the significant share of nuclear in its energy mix.

Figure 2.6 Share of total energy supply by source in G20 countries, 2019



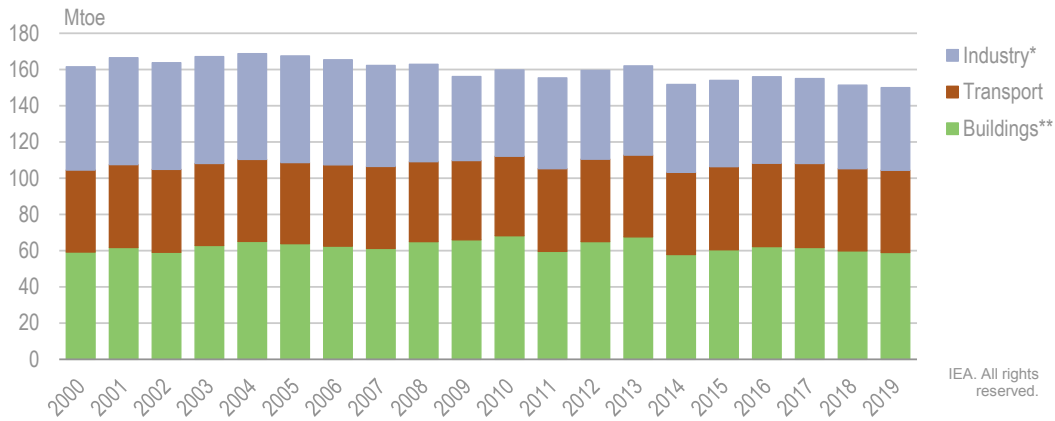
France had the lowest level of fossil fuels in its energy supply among G20 countries.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Demand

TFC in France has slowly decreased, from 160 Mtoe in 2010 to 150 Mtoe in 2019, when it reached its lowest level since 1994. France has witnessed an overall decoupling between the growth of the country's GDP and its final energy consumption (TFC/GDP ratio), despite the population increasing by 4% between 2009 and 2019. France's GDP increased by 15% over the period, while energy intensity of GDP has declined by 16% since 2009 (see Chapter 4). In 2019, energy demand for buildings covered more than a third of TFC (39%) (Figure 2.7). Energy demand for industry and transport was 30% of TFC for each sector. Since 2010, energy demand in buildings saw the sharpest decline, decreasing by 14% (from 68 Mtoe in 2010 to 59 Mtoe in 2019). Over the same period, industry energy consumption fell by 4% (from 48 Mtoe to 46 Mtoe). The only increase was in transport (4%).

Figure 2.7 Total final consumption in France by sector, 2000-19



Total final consumption has been slowly decreasing since 2010, reaching a minimum at 150 Mtoe in 2019, while transport sector demand was still rising.

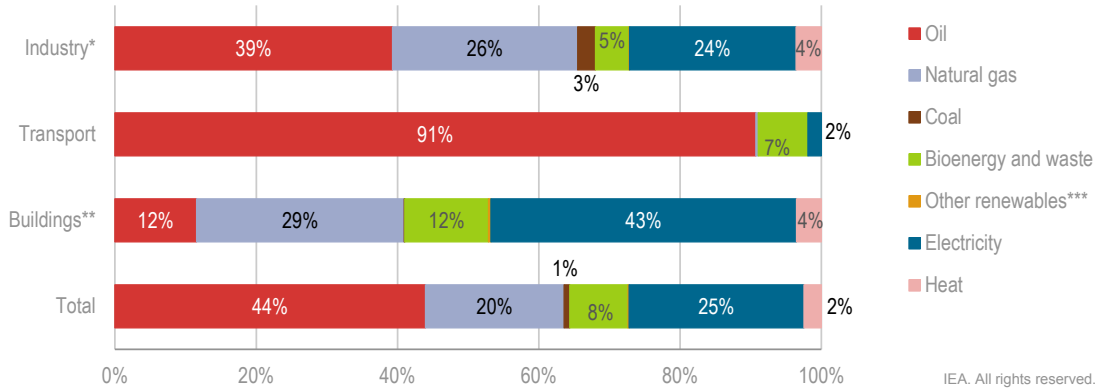
* *Industry* includes non-energy demand.

** *Buildings* includes residential and commercial and public services buildings.

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 2.8 Total final consumption in France per sector and per fuel, 2019



Oil, natural gas and electricity were the main fuels consumed in France in 2019.

* *Industry* includes non-energy demand.

** *Buildings* include residential and commercial and public service buildings.

*** *Other renewables* includes hydro, wind, geothermal and solar.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil covered 44% of energy demand in 2019, mainly in transport and industry (Figure 2.8). Electricity accounted for a quarter of TFC, with the highest share in buildings (43%). Natural gas comes third and is the second-most used energy source in industry and buildings, accounting for more than a quarter in both sectors. Bioenergy and waste also account for an important part (8%), especially in the buildings sector (12%).

Key institutions

The French institutional landscape is shaped by the national, regional and local levels of government.

At the national level, policy making in energy, environment and climate is the competence of the Ministry of the Ecological Transition (MTE). This super-ministry is also in charge of transport, air quality, water, risk management and buildings. Within the ministry, the General Directorate for Energy and Climate develops and implements the policies in energy, climate and air quality. The MTE also directs regional ministerial services in the regions and departments. Its unique cross-disciplinary setting enables the MTE to work together with other ministries not only on climate, biodiversity, clean air, technology and energy taxation, but also on social issues, such as equality. Under the prime minister, the high commissioner for the plan (Haut Commissionaire au Plan) is in charge of planning exercises across government.

In 2018, the High Council on Climate (Haut Conseil pour le Climat) was created, which independently evaluates the government's climate strategy and assesses the effectiveness of the government's policies. It publishes an annual progress report to the government and the parliament, to which the government must officially respond.

When it comes to economic development (notably sustainable recovery) and the competitiveness of French industry, the Ministry for the Economy, Finance and the Recovery is the lead. The Higher Energy Council and the National Consumer Council (Conseil supérieur de l'énergie and Conseil national de la consummation) bring together the main stakeholders in the sector. An important implementing authority for energy efficiency, heat, renewable energy and energy innovation is the French Agency for Ecological Transition (Agence de la transition écologique, ADEME). ADEME implements public policies related to the environment, energy and sustainable development through funding programmes, including for innovation/demonstration, monitoring and evaluations. Regional delegations of ADEME support the territories and the various authorities, including with the development of thermal refurbishment platforms and regional energy efficiency plans which would also involve renewable energy.

The MTE shares the responsibility for energy research, development and demonstration (RD&D) with the Ministry of Higher Education, Research and Innovation. ADEME, the National Research Agency and the Banque Publique d'Investissement (Bpifrance) are the main RD&D funding agencies. The National Alliance for the Coordination of Energy Research is an alliance of all research and training organisations in France in the energy sector, led by the National Centre for Scientific Research, the Alternative Energies and Atomic Energy Commission, and the IFPEN (IFP Énergies nouvelles).

The Energy Regulatory Commission (CRE) regulates the French electricity and gas markets. It is financed by the state, with a EUR 20.9 million budget under the Finance Law. An energy ombudsman provides consumers with information concerning their rights, current legislation and the means of dispute settlement available to them in the event of a conflict.

The French Competition Authority has the power to prevent and sanction anticompetitive practices in any economic sector, including electricity and gas. It must inform the CRE when seized of any matter that would fall under the CRE's jurisdiction. The French

Competition Authority must also notify the CRE of any abuse of a dominant position or any anticompetitive practice in the gas or electricity sectors.

Regions implement climate and energy transition goals under the regional plans for spatial planning, sustainable development and equality (*schémas régionaux d'aménagement, de développement durable et d'égalité des territoires,* SRADDET). Based on the Energy Transition for Green Growth Act of 2015, the SRADDETs include the regional climate-air-energy plans developed at a sub-regional scale (*plans climat-air-énergie territoriaux*, PCAETs). They are co-ordinated by the local authorities in the regions including districts (*intercommunalités*). The regions support citizen's projects or businesses, and are responsible for public transportation, waste and water management at a local scale. They are also often the concession holders of the heating networks, as well as gas and electricity distribution networks.

Energy transition strategy and targets

France has been an early leader in promoting the energy transition, with a cross-sector planning system, anchored in the Energy Transition Law of 2015. Building on the energy strategies and targets of the 2005 POPE Law (Loi n° 2005-781 du 13 juillet 2005 de programmation fixant les orientations de la politique énergétique) and the 2007-10 Grenelle Environment Acts, France has had a decade of experience in building an energy transition framework to green economic growth towards 2030.

Reflecting France's international climate change ambitions and leadership at COP21, the Energy Transition for Green Growth Act (Loi relative à la transition énergétique pour la croissance verte) entered into force on 17 August 2015. It was the result of the National Debate on the Energy Transition, an intensive stakeholder consultation that ran from January to July 2013. The national debate discussed four potential transition pathways ("factor4" target which equals a 75% reduction of greenhouse gas emissions by 2050 compared to 1990 levels):

1. DEC – decarbonisation through electrification
2. DIV – diversification and moderate efforts for energy efficiency
3. EFF – strong efforts for energy efficiency and diversification
4. SOB – strong efforts for energy efficiency and sobriety and nuclear phase-out.

No consensus was found on the best pathway to implement. However, a general agreement emerged from the pathway debate that the energy transition should be economically profitable for France and lead to a strong cut in final energy demand and fossil fuel consumption, and that all no-regret options should be taken as soon as possible.

The Energy Transition for Green Growth Act set the basis for emissions reductions (-40% by 2030 from 1990 levels), energy efficiency (with an envisaged reduction of 20% in TFC by 2030 and 50% by 2050 from 2012 levels) and the share of renewable energies (targeting 23% in the gross final consumption by 2020 and 32% by 2030). These targets have remained in place.

At the heart of the French energy transition policy, the National Low-Carbon Strategy for 2050 (Stratégie Nationale Bas-Carbone, SNBC) sets emissions reduction targets by sector and the pathway across three five-year carbon budgets (see Chapter 3). Additional measures are implemented through two successive five-year energy investment plans (*la*

programmation pluriannuelle de l'énergie, PPE) and an economy-wide carbon tax trajectory. Sector roadmaps are under preparation and co-ordinated by the prime minister.

In 2019, France adopted the Energy and Climate Law (Loi n° 2019-1147 du 8 novembre 2019 relative à l'énergie et au climat). The 2019 Energy and Climate Law amended the 2015 law, modifying some of the energy sector targets for the decade up to 2030, as milestones for reaching climate neutrality by 2050 with an 85% reduction in greenhouse gas (GHG) emissions (without land use, land-use change and forestry [LULUCF]) compared to 1990 levels and stressing the ecological and climatic urgency. The following targets have been set:

- the installation of 1 gigawatt (GW) of offshore wind per year by 2024
- a slower reduction of the share of nuclear power production to 50% in the electricity mix by 2035
- a more aggressive reduction of fossil fuel consumption to 40% (from 2012 levels) by 2030 and closing the remaining coal plants by 2022
- a share of 20-40% of decarbonised and renewable hydrogen in France's total hydrogen consumption by 2030
- activating 6.5 GW of demand response by 2028
- providing for an increase in the threshold of maximum generation capacity that Électricité de France (EDF) needs to offer to the market at the regulated access tariff (ARENH) of EUR 42 per megawatt hour (MWh) from 100-150 terawatt hours (TWh)
- ending price regulation for industry by end of 2021 (electricity, gas) and by end of 2023 for households (gas).

In line with the climate neutrality by 2050 goal, the SNBC and the PPE were updated in 2020 with new targets (Table 2.1). The next SNBC and PPE will be adopted in 2024. The energy programming law will be presented in 2023.

The 2021 Climate and Resilience Law (Loi portant lutte contre le dérèglement climatique et renforcement de la resilience face à ses effets dite "Loi Climat et Résilience") was published on 24 August 2021. It prohibits domestic flights for short distances when a train ride of 2.5 hours offers an alternative; and abolishes badly insulated buildings (energy sieves or *passoires thermiques*), with a timeline to prohibit the sale of houses with an energy performance of G (by 2025), F (by 2028) or E (by 2034). The law also includes provisions in favour of subsidies for electric bikes and the objective to reduce air pollution (particulate matter) from biomass heating by 50% from 2020 to 2030 in areas covered by an atmospheric protection plan in France. The law empowers mayors to create low-emission zones in major cities and ban the sale of the most polluting vehicles in 2030, as well as to introduce an environmental footprint score for goods and services consumed in France. The law promotes a greater regionalisation of the next PPE.

Table 2.1 Main targets and policies and measures in the multiannual energy plan 2020

Policy area	2023	2028
Final energy consumption (compared to 2012)	-7.6%	-16.5%
Primary consumption of fossil fuels (compared to 2012)	-20%	-35%
Greenhouse gas emissions from energy combustion (compared to 1990)	-27%	-40%
Renewable heat consumption (compared to 2017)	+25%	+40-60%
Renewable gas production		24-32 TWh
Installed RES-E capacity (compared to 2017)	+50% or 73.5 GW	+100% or 101-113 GW

Note: RES-E = electricity from renewable energy sources. GW = gigawatt. TWh = terawatt hour.

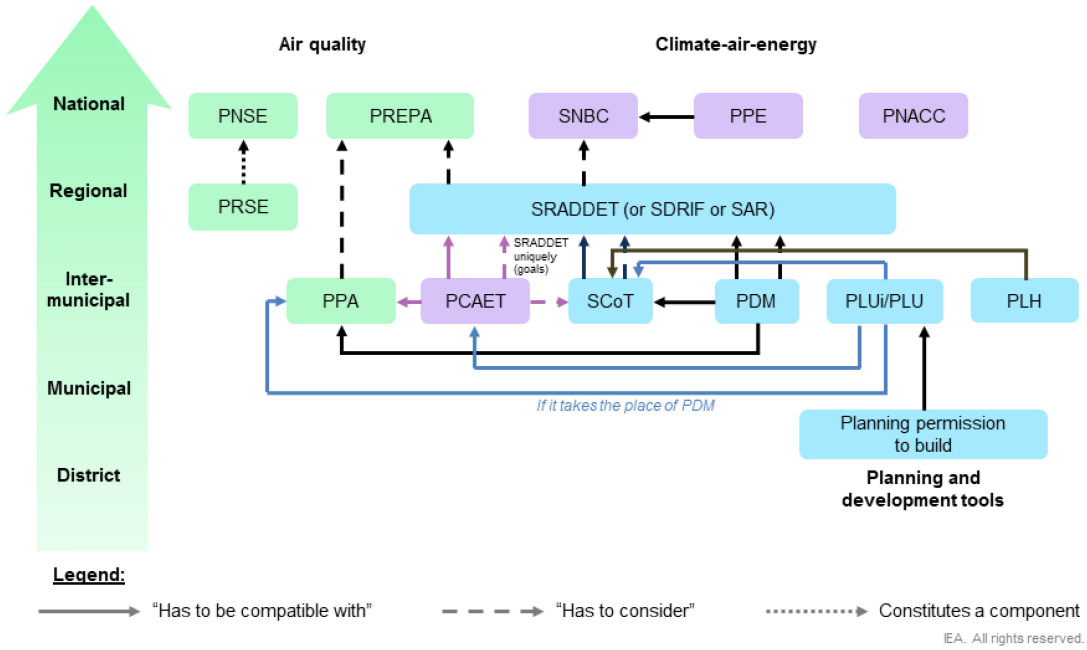
Territorial and regional energy planning

Regions implement their climate and energy transition goals under the SRADDETs. At the sub-regional level, districts (*intercommunalités*), which gather several municipalities, prepare local PCAETs. Regional and local authorities and their respective public establishments have to take the SNBC strategy and its carbon targets into account, in particular through their planning exercises (the SRADDETs and the PCAETs). Targets are updated for every five-year carbon budget (see also Figure 2.9).

By October 2021, around 80% of the SRADDETs (nine schemes) have been approved. The PCAETs were expected to be approved and in place by end of 2018. In 2021, the MTE announced that 224 PCAETs had been adopted. The government works on a common methodology for an indicator framework based on consultation. The framework will allow comparisons between territory plans and interactions and/or flows resulting from connecting activities.

As indicated above, the Climate and Resilience Law of 2021 will add another dimension and strengthen the regionalisation of the PPE to ensure stronger alignment between the above-mentioned national goals of the SNBC and the PPE and the regional plans and targets. The SRADDETs (and the climate-air-energy scheme in the Paris region) must therefore take into account the SNBC and must be compatible with the next PPE (Article 83 of the Climate and Resilience Law). In the 2024 PPE, national renewable targets must be translated into regional targets through a national decree after concertation with regional councils and the concerned stakeholders.

Figure 2.9 National, regional and local plans for the energy transition



Note: PNSE = national environmental health plan. PPA = Atmosphere Protection Plan. PRÉPA = National Plan to Reduce Air Pollutant Emissions. PNACC = National Plan for Adaptation to Climate Change. PPE = Ten-year Energy Investment Plan. SNBC = National Low-Carbon Strategy. SRADDET = regional plan for spatial planning, sustainable development and equality. SDRIF = Master Plan for the Île-de-France Region. SAR = regional development plan. PLH = local housing programme. PLUi/PLU = local intercommunal planning plan. PDM = mobility plan. ScoT = territorial coherence scheme. PRSE = regional health environment plan.

Source: ADEME (2021), A diversity of approaches for a diversity of territories, www.territoires-climat.ademe.fr/ressource/30-9.

EU Climate Law and the role of the National Energy and Climate Plan

In 2020, France presented its final National Energy and Climate Plan (NECP) to the EU under the EU Governance Regulation. By 2023, France will also have to update its NECP in step with the EU net zero ambitions by 2050 and the EU Climate Law.

The EU Climate Law sets into legislation the objective of a climate-neutral EU by 2050, and creates a system for monitoring progress and adjusting national and EU-wide action, if needed. In line with the Paris Agreement, the EU Climate Law provides for a five-year stocktaking process. The NECPs, which are regulated under the EU Governance Regulation, are at the heart of this process. In 2019/20, the first edition of NECPs was adopted for ten years up to 2030. For the first time, by 2023, the European Commission will assess progress. By 30 June 2023, member states are required to provide a draft update of the NECP and by 30 June 2024, the final updated NECP.

EU member states are also required to report on the implementation of their NECPs. The first of such reports (so-called integrated national energy and climate progress reports) is due by 15 March 2023. Any new policies and measures can be included in the progress report.

In July 2021, the European Commission presented a range of proposals to implement the higher emissions reduction ambition with the Fit-for-55% Package, including rules for the reduction of GHG emissions (Effort Sharing Regulation and Emissions Trading System [ETS]) and proposals to revise the Energy Efficiency and Renewable Energy Directives, including their target levels. The updated NECPs (by 2023/24) will have to reflect these increased climate and energy ambitions at EU level, once negotiations are finalised, as well as the results of the national progress reports.

Energy and carbon pricing and taxation

Domestic taxes on the consumption of petroleum products, natural gas and coal (TICPE, TICGN, TICC) include a carbon component and an energy component. There is no carbon component in the TICFE (the tax on final consumption of electricity), as power plants are subject to the EU ETS. The carbon component is included within these domestic taxes on domestic consumption of energy (ITC). The total ITC was planned to increase over time (up to EUR 56 per tonne of carbon dioxide [t CO_2] in 2020, EUR 86/t CO_2 in 2022 and EUR 100/t CO_2 in 2030), yet it has remained at EUR 44.6/t CO_2 since 2018. Introduced in 2014, the carbon component, referred to as the climate energy contribution (CCE), is a method of calculating a part of domestic consumption taxes, proportionally to the CO_2 content of energy products.

The ITC taxation significantly increased the taxes levied on the consumption of coal, heating oil, liquified petroleum gas, gasoline, diesel and natural gas over the period 2014-18. Table 2.2 illustrates the changes in the domestic taxes for some energy products. For instance, the government accelerated the increase of the price of carbon for diesel, from EUR 42.84 in 2014 to EUR 59.4 per 100 litres (L) in 2018, leading to a better balance of diesel and gasoline taxation. The carbon component tax (EUR 44.6/t CO_2) is expected to result in the reduction of 1.2 Mtoe in energy consumption and of 3.3 million tonnes of carbon dioxide equivalent (Mt CO_2) per year. Domestic flights and kerosene consumption are exempt from the ITC.

Though not subject to the carbon component, France levies a tax on final consumption of electricity at the level of EUR 22.5/MWh (since 2016), whose revenues go to the state budget and no longer finance public service charges on energy (CSPE). In addition, the final retail price of electricity includes the fee for network operation and the wholesale price of the energy component. Since 2016, revenues from the public service charges of electricity and gas are no longer used for financing renewable energies in the electricity and gas sector. The support is now no longer financed based on the domestic electricity tax, which goes directly to the state budget. As a result of this reform, changes in the cost of supporting the development of renewable energy (in the gas and electricity sectors) no longer increase the consumers' bill, but are part of the state budget.

Energy and carbon taxation includes a number of reduced rates for freight (trucks over 7.5 tonnes), buses and coaches, and taxis. It also applies several exemptions (mostly for commercial flights and navigation) or reduced rates of excise on energy products for specific sectors, notably reduced rates for diesel use in agriculture, buildings and off-road transportation and a partial refund of the tax on diesel, natural gas and heavy fuel oil used in agriculture. These amounted to around EUR 2.3 billion (bln) in 2019. The freight of goods alone received refunds of part of the fuel tax rate, at an overall cost of EUR 1.4 bln in 2019.

Table 2.2 Evolution of domestic consumption taxes between 2013 and 2020

	2013	2014 (1 April)	2015	2016	2017	2018	2019	2020
Electricity (no carbon component)	13.5	16.5	19.5	22.5	22.5	22.5	22.5	22.5
Natural gas (households) (EUR/MWh)	Exempt	1.27	2.64	4.34	5.88	8.45	8.45	8.45
Coal (EUR/MWh)	1.19	2.29	4.75	7.21	9.99	14.62	14.62	14.62
Diesel (EUR/L)	0.4284	0.4284	0.4682	0.4981	0.5307	0.5940	0.5940	0.5940
Gasoline E5 (EUR/L)	0.6069	0.6069	0.6241	0.6412	0.6507	0.6829	0.6829	0.6829
Gasoline E10 (EUR/L)	0.6069	0.6069	0.6241	0.6212	0.6307	0.6629	0.6629	0.6629
Heating oil (EUR/L)	0.5660	0.5660	0.7640	0.9630	0.1189	0.1562	0.1562	0.1562
Heavy fuel oil (EUR/kg)	0.1850	0.2190	0.4530	0.6880	0.9540	0.1395	0.1395	0.1395

Note: MWh = megawatt hour. L = litre. Kg = kilogramme.
Source: MTE, 2021

France's taxes on transport fuels (see Chapter 10) are the lowest among IEA countries. However, a few important changes are under way:

- France almost doubled the plane ticket tax in 2019 (for a ticket in economy class, from EUR 1.13 to EUR 2.63 for intra-EU flights, and from EUR 4.51 to EUR 7.51 for extra-EU flights) and earmarked additional revenues (up to EUR 230 million) to support rail infrastructure.
- France increased the tax on road freight carriers (EUR 0.02/L on diesel use) as of January 2020.
- France increased the tax on aviation gasoline used for non-commercial uses in order to reach road rates for gasoline within two years (from EUR 0.45/L, EUR 0.49/L to EUR 0.68/L, EUR 0.69/L) as of January 2021.
- France will limit the reduced electricity tax rate to data centres as of January 2022.
- France will increase taxes on diesel for off-road uses to the level of the on-road rate for diesel (from EUR 0.1882/L to EUR 0.5940/L) as of January 2023.

Green budgeting

In September 2020, France was the first country to conduct a first assessment of the environmental impact of the 2021 Budget Bill, by using the six criteria of the EU taxonomy. The EU Taxonomy Regulation established six environmental objectives: 1) climate change mitigation; 2) climate change adaptation; 3) sustainable use and protection of water and marine resources; 4) the transition to a circular economy; 5) pollution prevention and control; and 6) the protection and restoration of biodiversity and ecosystems (Ministry for the Economy, Finances and the Recovery, 2021).

Around 90% of the EUR 574 bln 2021 budget is considered neutral to the environment (which includes payroll expenditures and social transfers to households). Only EUR 38 bln were assessed as strictly favourable, notably support to renewables (EUR 6.6 bln), expenditures to support the energy transition (energy efficiency bonus, EUR 0.8 bln; reduced value-added tax rate of 5.5% for energy efficiency improvements, EUR 1.2 bln; reduced tax rate on electricity used for public transport, EUR 0.2 bln; official development assistance, EUR 1.9 bln; water agencies' expenditures, EUR 2.2 bln). With around EUR 4.7 bln of mixed impact (mainly related to transport infrastructure, notably new railway infrastructure, which is good for climate but possibly harmful regarding land use and biodiversity), only EUR 10 bln were found unfavourable. These were mainly fiscal expenditures (EUR 7.2 bln), such as exemptions or reduced rates for domestic taxes on the consumption of motor fuels (EUR 5.1 bln), or expenditures to support energy production (using fossil fuels) in areas that are not connected to the national grid (EUR 1.5 bln).

The Budget Bill 2020 promoted a process of further streamlining tax provisions through a new code gathering all taxes on energy as well as other excise duties and sectorial taxes, which will see further revisions in line with the revision of the EU Energy Taxation Directive.

People-centred transition

France is working actively on policies that place the people at the centre of the ecological transition in line with the Sustainable Development Goals (SDGs), notably with regard to gender diversity (SDG 5), sustainable recovery and climate action.

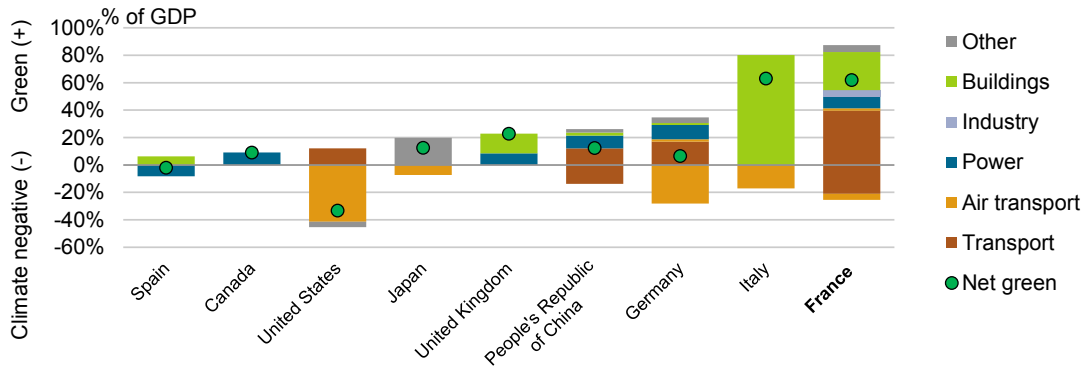
Sustainable recovery

France has a competitive energy industry and the energy sector can be a backbone for a resilient economic recovery and the long-term sustainability of the French economy. While nuclear and the oil and gas sectors account for the lion's share of employment in the energy sector, the renewables sector, notably wind and solar, have seen dynamic growth in jobs and investments. Based on the SNBC and the PPE, around 300 000-500 000 new jobs by 2030 and 800 000 by 2050 are expected to be added, boosted by investments in transport, buildings and energy.

In 2020, the COVID-19 crisis and related lockdowns led to the destruction of demand in transport, notably in aviation, industry and commercial sectors in France, key sectors of the SNBC. In September 2020, the government adopted a EUR 100 bln Recovery Plan. The National Recovery and Resilience Plan outlines the 40% funding share anticipated by the EU's "Recovery and Resilience Facility".

Compared with selected countries, France's Recovery Plan has a strong net green impact in support of an acceleration of clean investments (Figure 2.10). France presented stimulus measures for a green recovery, totalling EUR 30 bln, with a huge focus on transport (rail), buildings (heating, efficiency) and the circular economy, which represents additional funding to existing support schemes in place for the PPE, including renewable electricity and renewable gases (in total EUR 24 bln and EUR 10 bln, respectively). The recovery funding comes in addition to investments planned under the PPE and Finance Law 2020, which provide EUR 24 bln for renewable electricity and EUR 10 bln for renewable gas up to 2028.

Figure 2.10 Recovery plans towards a sustainable transition, France and other IEA countries



Note: Y-axis in percentage of gross domestic product shows climate positive (+) and climate negative (-) investment. Battery energy storage (R&D) investment support counted under transport.

Source: IMF (2020b), *Fiscal Monitor: Policies for Recovery*, https://www.imf.org/en/Publications/FM/Issues/2020/09/30/october-2020-fiscal-monitor.

Rail transport will be upgraded with a view to reduce highway freight transport, in addition to investment in new railroad infrastructure (EUR 1 bln by 2024 and 12 bln in 2025-30). As part of the French Recovery Plan, the government announced a public investment of EUR 7 bln for the hydrogen strategy and an additional stimulus of EUR 6 bln for the renovation of buildings. Specific budgets under the Finance Law 2021 include expanded support for building renovation (MaPrimeRénov' now supports energy efficiency in buildings, rental property and heating across all income classes), higher subsidies for the private purchase of electric vehicles (EVs) and new tax credits for the installation of EV chargers at home.

Citizens' engagement in climate action

In 2018, France experienced major social movements and protests ("gilets jaunes" or yellow vests) and citizens' voice for stronger climate action (climate marches, student strike for the climate). Since then, France has enacted several policies to empower citizens in the climate debate, notably the Citizens' Climate Convention. In the spirit of a just and inclusive ecological transition, the Convention brought together 150 citizens that proposed around 150 new measures to achieve a reduction of at least 40% in GHG emissions by 2030 (compared to 1990 levels). The proposals form part of the Climate Resilience Act of 2021.

As part of the carbon tax freeze, the government adopted new provisions, which offer financial support to consumers, including broader scope for the energy voucher, the subsidy for renovation (MaPrimeRénov'), the car conversion bonus, the heat bonus and a simplified eco-tax. Additional measures were introduced in 2020 under the Recovery Plan.

Gender diversity

Gender equality has been designated a "great cause" of Emmanuel Macron's 2017-22 presidential mandate. Working across government, the president appointed a Secretary of State for Gender Equality.

The MTE implements this policy mandate, including by tracking progress along 15 key indicators, which include access to leadership positions or equality in terms of remuneration and promotion. Within the MTE itself, the gender diversity of the workforce increased from 35% of women in 2009 to 43% in 2019.

France's 2011 Law on Balanced Representation of Women and Men within Administrative and Supervisory Boards put in place a quota, mandatory since 2017, of 40% members of the under-represented sex on the boards of companies with more than 500 employees and whose sales revenues exceed EUR 50 million. Sanctions are planned in case of non-compliance.

The French work code allows companies to take temporary measures specifically targeting women, in terms of recruiting, training and promotion, as a way to improve equal opportunities.

The 2018 Law for the Freedom to Choose One's Professional Future was the driver for mandatory disclosure and data transparency on gender diversity in the energy sector. A "women-men equality index" is mandatory for every company with at least 50 workers since March 2020 and was mandatory from March 2019 for companies with at least 1 000 workers (which covers the energy industry). The index is calculated and published by the companies every year based on five indicators: 1) gap of remuneration between women and men; 2) gap in annual wage increases; 3) gap in terms of career advancement; 4) wage increases after maternity leave; and 5) women represented in the top salary scales.

The French energy industry promotes gender diversity and a positive dynamic can be seen in the sector. The 2019 and 2020 indexes show improvements: EDF went from a score of 80 to 95, ENGIE from 79 to 94 and Total from 85 to 90. EDF targets an increase in the share of women staff to 28% in 2023 (compared to 25% in 2019); and more specifically, 30% of women in its executive committees by 2023, compared to 27% in 2019. ENGIE has the "Fifty-Fifty" project, which targets 50% of women in senior management positions in 2030 (compared to 24% in 2019).

Assessment

As host of the COP21 and the Paris Agreement of 2015, France has stepped up its international and domestic commitments since the IEA's last review in 2015. France is widely seen in the international community as a frontrunner in the energy transition debate.

Since 2015, France has had a robust energy transition framework, with an economy-wide planning system, anchored in the Energy Transition for Green Growth Act. The National Low-Carbon Strategy for 2050, introduced by the Energy Transition for Green Growth Act, is France's roadmap to reduce GHG emissions, which is complemented by the biannual five-year investment plan with measures until 2028. In 2019, France adopted the Energy and Climate Law, which legislated the ambition of climate neutrality by 2050. Over the past five years, the government has adopted an increasing number of targets for fuels and sectors, including at local and regional levels, without them necessarily being aligned or in step with technological progress, socio-economic analysis or affordability concerns. Many countries are struggling with similar challenges.

In 2021, the government will start work on a third update of the SNBC and the PPE for publication in 2024, after the 2022 presidential elections, which will also need to reflect higher ambitions under the EU Green Deal and EU Climate Law, targeting at least a 55% reduction already by 2030. The French government should consolidate its targets as it moves towards implementing its climate neutrality pathway for 2050.

First, France needs to review the alignment of its 2030 national targets with the national climate neutrality goal. France has not upgraded its 2030 target, set in 2015 and stipulating a 40% reduction in GHG emissions by 2030, even though the government adopted the 2050 goal and updated its SNBC and PPE in 2020. In relative terms, France has the least stringent 2030 emissions target among G7 countries, but of course it has the lowest CO_2 emissions in absolute terms. Similarly, the government may wish to review its pledge for ending the sale of new light vehicles using fossil fuels by 2040. Many other countries now have more ambitious transport decarbonisation ambitions; for instance, the United Kingdom's target is 2030. Equally, incentives and roll-out targets need to be aligned. The new Climate and Resilience Law includes a 2030 target, which is a strong signal for the market.

Second, there is little alignment between the national goals and the regional or local targets and objectives. The government does not mandate climate and energy objectives for regional plans; rather, regional plans need to be consistent with national ones. The government works to support the development of the PCAETs and SRADDETs, which includes consultation between national and local government bodies. The Citizens' Climate Convention and the Climate Resilience Law call for stronger links between regional schemes and national goals, with minimum objectives consistent with the PPE for each region, and for the state and regional councils to work together. The role of the High Commissioner for the Plan could be strengthened to improve the consistency of these plans. The national government's initiative to prepare a report for end of 2021 on the contribution of the regional strategy plans to the achievement of national climate objectives is an early opportunity to look for emerging overlaps and gaps across all the regional commitments.

Third, a very strong focus on accelerating implementation and execution is critical and depends on the success of reducing red tape; on the effectiveness of cross-governmental co-ordination; and on progress at the regional, local and city levels. The focus on implementation will also require an increase in human resources dedicated to the transition across all levels of government and better co-ordination. France needs to focus more on the design of robust policies for clean energy investments with stable and more streamlined market-compatible support schemes (e.g. contracts for difference), which lowers risks and supports technology scale-up and accelerates deployment. The government can build on the lessons learnt from other countries in this context and explore opportunities to expand green recovery funding.

Fourth, in the new SNBC, the government needs to update the possible contributions of biomass; carbon capture, utilisation and storage; and decarbonised gases, based on the latest technological progress. For example, the national hydrogen strategy focuses on industry and heavy-duty transport. In its current form, this hydrogen strategy primarily serves as an industrial policy, aimed at developing French expertise in this new technology. However, France has a substantial potential to utilise hydrogen as a new energy carrier and provider of long-term energy storage in its energy system.

The SNBC strongly relies on medium-term priorities of energy sobriety and low-carbon electricity (up to 2035) as the main mitigation measures. However, it does not yet provide for a clear picture for 2040 and the clean energy technology or fuel options by sector. A clean energy technology roadmap could accompany the SNBC/PPE framework to identify pathways and technology choices, job creation opportunities, and inform investment decisions and track progress. The Programming Plan on Jobs and Competences (PPEC) and the National Strategy on Energy Research will need to be aligned with the PPE. The PPE can then set out annual green budgets, including for energy efficiency, even for a longer period.

Fourth, France will need to rebalance its energy policy priorities towards not only a sustainable, but also a secure and just transition. France has a competitive and highly skilled energy industry. The energy sector can be a backbone for a resilient economic recovery. While nuclear and the oil and gas sectors account for the majority of employment today, the renewables sector, notably wind and solar, has seen dynamic growth in jobs and investments. This is projected to accelerate with the creation of 300 000-500 000 new jobs by 2030 and 800 000 by 2050, boosted by investments in transport, buildings and energy. The government encourages gender diversity and the industry is working on the implementation of mandatory targets, with improved results in government and industry.

France made available considerable funds in support of its ambitious transition goals under the French Recovery Plan, with EUR 100 bln in total, out of which around EUR 30 bln is dedicated to sustainable recovery objectives. Specific budgets under the 2021 Finance Law include increased support for building renovation (MaPrimeRénov' now supports energy efficiency in buildings, rental property and heating across all income classes), higher subsidies for the private purchase of EVs and additional tax credits for the installation of EV chargers at home. The Recovery Plan is a historic opportunity for boosting France's industrial competitiveness and accelerating the implementation of medium-term energy and climate targets and supporting a people-centred transition. To implement the plan successfully, the government should continue all efforts to simplify support schemes based on what worked well to leverage large-scale projects, catalyse private investments, including in electric mobility, low-carbon residential heating, hydrogen and batteries.

France is an international leader in climate finance, green finance, green budgeting and taxation. Since 2014, France puts a price on carbon both through the EU ETS and through a national excise duty on the consumption of energy products based on their CO_2 content. The tax increased from EUR 7 to EUR 44.6 per t CO_2 in 2018, but a further increase was discarded amid social unrest. France's prices will be driven by the overall carbon price in the EU, which breached its historic peak of EUR 60 per t CO_2 in 2021. This carbon price will be further strengthened with the planned reforms of the EU ETS, non-ETS, the EU border carbon tax. While this supports investments in clean energy technologies and lowers the carbon footprint of EU imports, the impacts on the just transition will need to be managed.

France's energy and carbon taxation allows exemptions for fossil fuel consumption in various economic sectors, for example domestic air transport, agriculture and road transport, which are eligible for partial reimbursements. France still has opportunities for reducing such indirect fossil fuel subsidies and for integrating climate across its energy taxation and exploring improvements in streamlining, transparency, fairness, stability and

predictability. The annual Green Budget report to parliament, carried out for the first time in 2020, will be an important tool and figures among best practice globally.

Recommendations

The government of France should:

- Revisit 2030 ambitions and consolidate sector and fuel targets to align to net zero and the new EU 2030 emissions reduction target. Identify additional measures and regional efforts to achieve the revised ambitions.
- Strengthen the National Low-Carbon Strategy for 2050 and the two successive five-year energy investment plans by identifying clean energy technology budgets out to 2040 and 2050 to leverage more public and private investments and reflect the opportunities to boost industry development, job creation and the just transition.
- Accelerate the implementation of energy and climate policies by ensuring more stringent co-ordination of the sectoral roadmaps, national and regional plans under the prime minister; with more human resources in ministries and regional bodies; and annual progress reviews of all of the measures against their stated targets.
- Align the carbon budget and the green budget approach and mainstream climate objectives into taxation, government expenditures and regulations across government, reducing overlapping instruments and abolishing exemptions that encourage wasteful fossil fuel consumption.

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3. Climate change

Key data (2019)

GHG emissions with LULUCF:* 412.6 Mt CO_2-eq, -13.7% since 2010, -22.9% since 2000, 21.5% since 1990

GHG emissions without LULUCF:* 443.0 Mt CO_2-eq, -13.7% since 2010, -19.8% since 2000, -19.0% since 1990

Energy-related CO_2 emissions:

CO_2 emissions from fuel combustion (2020 estimated): 258.2 Mt CO_2, -12.1% in 2019-20, -19.4% in 2000-19, -25.2% in 1990-2020

CO_2 emissions by fuel: oil 58.8%, natural gas 28.8%, coal 9.8%, other 2.6%

CO_2 emissions by sector: transport 42.8%, industry 23.9%, buildings 20.9%, electricity and heat generation 12.4%

CO_2 intensity per GDP:** 101 g CO_2/USD (IEA*** 195 g CO_2/USD)

CO_2 intensity per capita: 4.36 t CO_2/capita (IEA*** 8.70 t CO_2/capita)

* Land use, land-use change and forestry (Source: UNFCCC).

** Gross domestic product in 2015 prices and purchasing power parity (PPP).

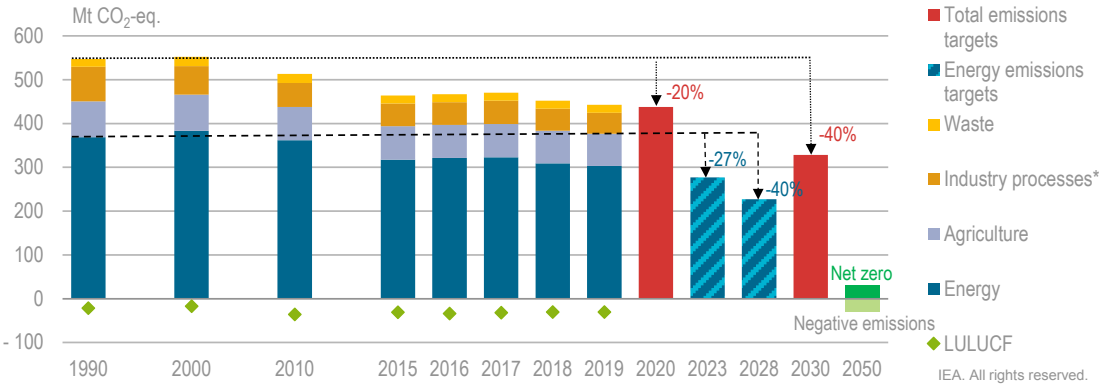
*** Weighted average of provisional data of IEA member countries in 2019.

Overview

As a global thought leader on climate change, France has long-standing ambitions of fully decarbonising its economy. The government has pledged net zero emissions reductions by 2050 under the 2019 Energy and Climate Law and put forward the necessary carbon budgets under the updated National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone, SNBC) and the two successive five-year energy investment plans (*la programmation pluriannuelle de l'énergie* [PPE]). Its goal is to reduce greenhouse gas (GHG) emissions from energy production by 27% in 2023 and by 40% in 2028 compared to the 1990 level. By 2019, France had achieved a reduction of energy-related GHG emissions of 19% compared to 1990. Outside the low-carbon electricity mix, emissions reductions envisaged in the transport, agriculture and buildings sectors are lagging behind and progress has been slow. The creation of the High Council on Climate, the Ecological Defence Council and the Citizens' Convention have increased the awareness of the need for climate action in France, but the needed governance to assess and guide progress towards the targets remain insufficient. During the COVID-19 pandemic, France's emissions decreased by 12% in one year. However, France also risks a rebound in emissions as the economy recovers. It is welcome that the Recovery Plan focuses on boosting investment in the ecological transition.

In 2019, total GHG emissions, excluding emissions from land use, land-use change and forestry (LULUCF), amounted to 443 million tonnes of carbon dioxide equivalent (Mt CO_2-eq.) (Figure 3.1). Energy, but also agriculture, plays a significant role in total GHG emissions. As with other countries, the energy sector is the largest GHG emitter, accounting for 68% of the total in 2019, and has cut its emissions by 18% over the past three decades. Between 2000 and 2020, total GHG emissions decreased by 20%, driven mostly by the energy sector, thanks to the role of nuclear and a 62% increase in renewable electricity generation.

Figure 3.1 Greenhouse gas emissions in France by sector, 1990-2019 and targets



By 2020, total GHG emissions had decreased by 20% compared to 1990. Energy emissions have remained constant since 2015, but will need to decline by 40% by 2028.

* *Industry processes* includes mineral, chemical, metal, manufacturing and construction industries.

Note: Mt CO_2-eq. = million tonnes of carbon dioxide equivalent. LULUCF = land use, land-use change and forestry.

Source: UNFCCC (2020), *France 2020 National Inventory Report*, https://unfccc.int/documents/226401.

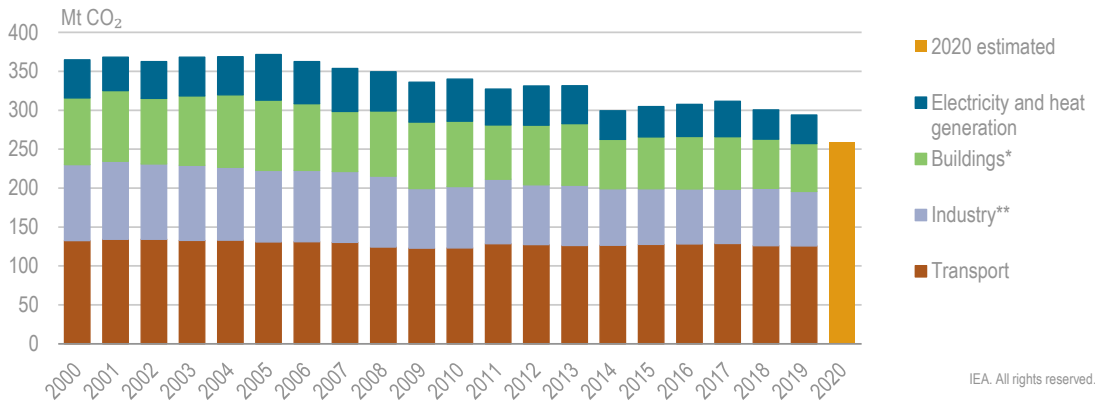
Energy-related CO_2 emissions

France's energy-related CO_2 emissions from fuel combustion stood at 294 Mt CO_2 in 2019, a decrease from 336 Mt CO_2 over the decade since 2009 (Figure 3.2). After a decrease from the buildings sector and electricity generation in 2014, energy-related emissions have remained stable around 300 Mt CO_2 in recent years. Between 2019 and 2020, emissions dropped by 12% to 258 Mt CO_2, as a result of the COVID-19 pandemic.

The largest share of CO_2 emissions in 2019 came from the transport sector at 126 Mt CO_2 (43%), followed by industry at 70 Mt CO_2 (24%), buildings at 62 Mt CO_2 (21%), and electricity and heat generation at 37 Mt CO_2 (12%). While the amount of CO_2 emissions from transport increased by 2% from 2009 to 2019, emissions decreased from electricity generation by 29% and in the buildings sector by 28%.

In terms of fuels, the majority of emissions in 2019 came from oil (59%), reflecting the high reliance on oil in transport, followed by natural gas (29%) and coal (10%) (Figure 3.3). From 2009 to 2019, total emissions from oil consumption fell by 14% due to a downward trend in oil use in the buildings and industry sectors. Emissions from natural gas combustion stabilised at 86 Mt CO_2, driven by energy demand in buildings. Coal emissions gradually declined over the decade.

Figure 3.2 France's energy-related CO_2 emissions per sector, 2000-20



Since a decrease in 2014, energy-related CO_2 emissions have been stable; the decrease in emissions from power generation was compensated for by an increase in transport sector emissions.

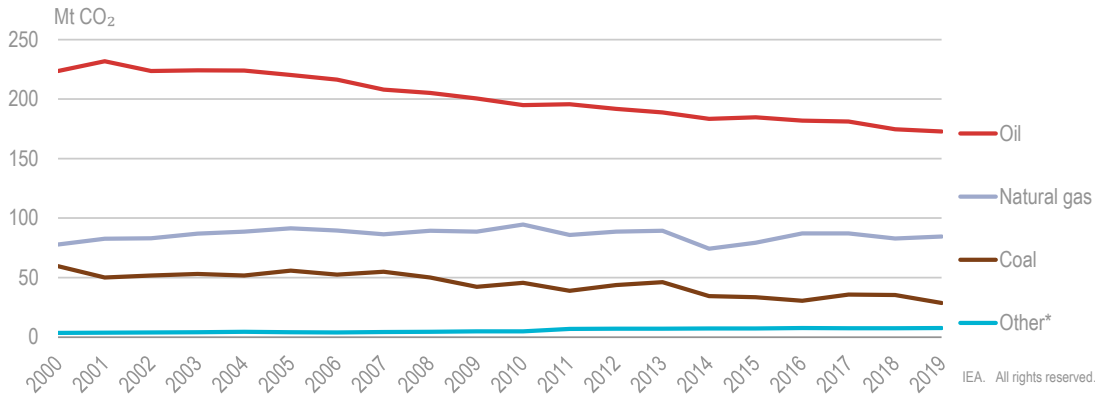
* *Buildings* includes residential, and commercial and public services.

** *Industry* includes CO_2 emissions from the combustion at construction and manufacturing industries, agriculture/forestry, and fishing.

Note: Mt CO_2-eq. = million tonnes of carbon dioxide equivalent.

Source: IEA (2021a), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Figure 3.3 France's energy-related CO_2 emissions by source, 2000-19



Oil and coal emissions have declined while emissions from natural gas have stabilised and are driven by energy consumption in buildings.

* *Other* includes emissions from non-renewable waste.

Note: Mt CO_2-eq. = million tonnes of carbon dioxide equivalent.

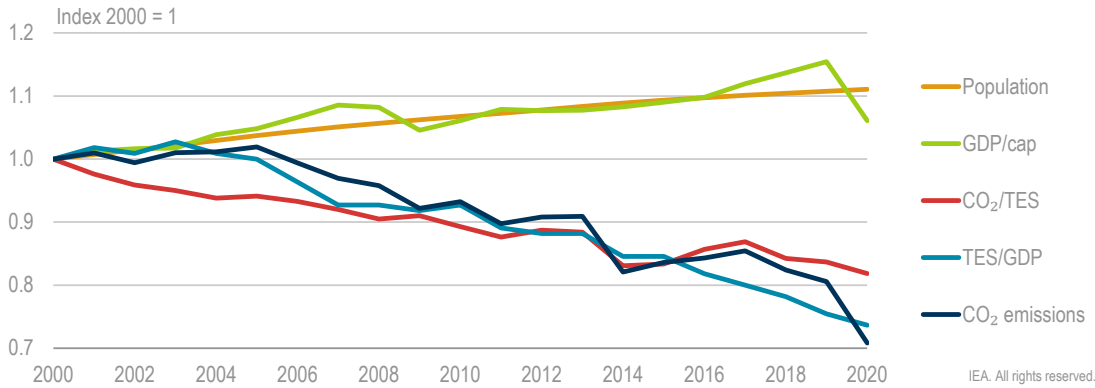
Source: IEA (2021a), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

CO_2 emissions drivers and carbon intensity

France's gross domestic product (GDP) per capita increased by 15% from 2000 to 2019 while the population grew by 11% over the same period (Figure 3.4). Despite the increase in economic activity, energy-related emissions have decreased by 20% since 2000, showing a decoupling of economic growth and energy-related carbon emissions. The

energy intensity of GDP (TES/GDP ratio) decreased by 25% between 2000 and 2019, while the carbon intensity of energy supply (CO_2/TES ratio) only decreased by 16%. Between 2019 and 2020, COVID-19 related lockdowns caused GDP per capita to decrease by 8% and energy-related CO_2 emissions to drop by 12%. However, no structural changes occurred: TES/GDP was stable and CO_2/TES decreased by only 2% (Figure 3.4).

Figure 3.4 Energy-related CO_2 emissions and key drivers in France, 2000-20



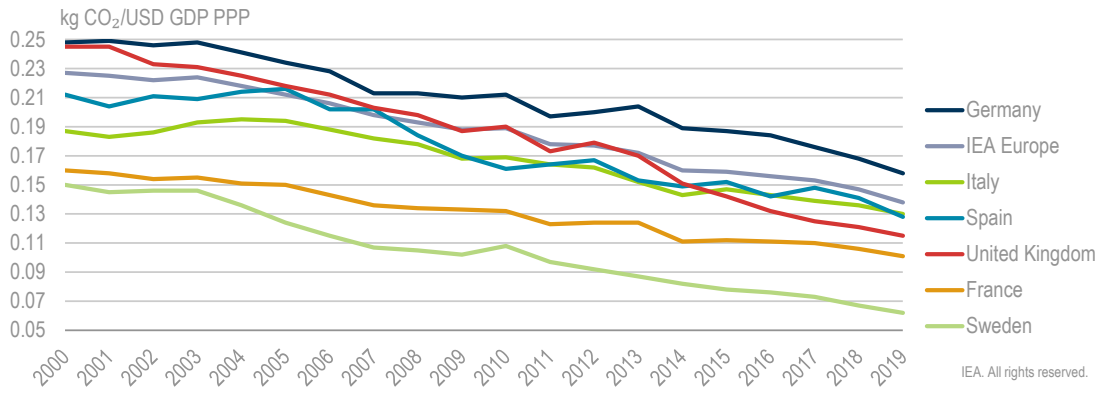
Energy-related CO_2 emissions have been decreasing despite population and economic growth, thanks to a declining carbon intensity of the economy. 2020 saw a drop in emissions due to COVID-19 lockdowns.

* *GDP* refers to real GDP in USD 2015 prices and purchasing power parity (PPP).

Notes: GDP = gross domestic product. TES = total energy supply. *CO_2 emissions* refers to energy-related CO_2 emissions from combustion processes.

Source: IEA (2021a), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Figure 3.5 CO_2 intensity per GDP* in France and IEA countries, 2000-19



The CO_2 intensity of France's economy has steadily fallen since 2000 and is today below the weighted average of European IEA countries.

* GDP data are in billion USD 2015 prices and purchasing power parity (PPP).

** *IEA Europe* is the equivalent of a weighted average of European IEA countries.

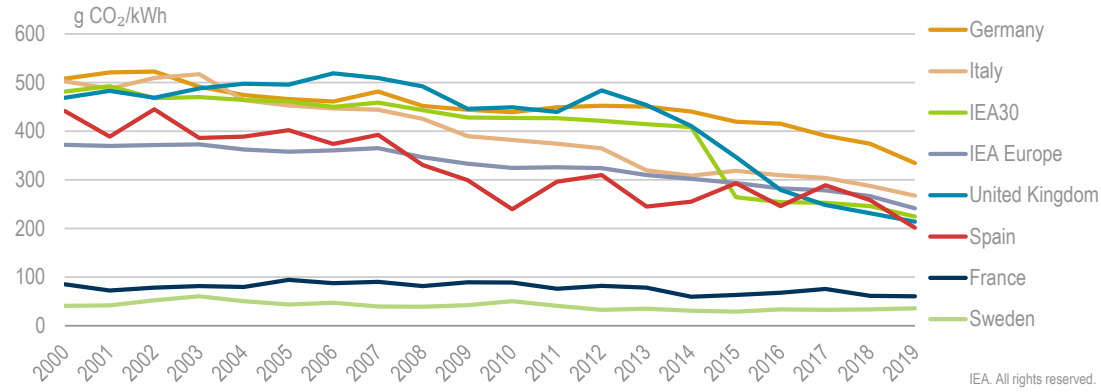
Note: kg CO_2/USD GDP PPP = kilogrammes of carbon dioxide per United States dollar in purchasing power parity.

Source: IEA (2021a), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

In 2019, the carbon intensity of the French economy (measured as the ratio of emissions per unit of GDP) was 0.10 kilogrammes of carbon dioxide (kg CO_2) per United States dollar (USD) in purchasing power parity (PPP) (Figure 3.5). The carbon intensity decreased from 0.16 kg CO_2/USD in 2000 and is lower than the European International Energy Agency (IEA) average of 0.14 kg CO_2/USD.

France is among the global leaders, with a very low-carbon electricity mix. Emissions from electricity and heat generation were 61 grammes of carbon dioxide per kilowatt hour (g CO_2/kWh) in 2019 and saw a 29% decrease compared to 2000 (Figure 3.6), which is largely due to the significant role of nuclear energy. By comparison, Germany's power generation had an intensity 334 g CO_2/kWh in 2019. France is below the weighted IEA Europe average of 242 g CO_2/kWh. France benefits from its low-carbon electricity generation for industrial production, transportation and energy use in the residential sector.

Figure 3.6 CO_2 intensity of electricity and heat generation in France and selected IEA countries, 2000-19



Thanks to the high share of nuclear energy, France's CO_2 intensity of electricity and heat generation remains very low.

* *IEA30* is the equivalent of a weighted average of 30 IEA member countries.

Note: g CO_2/kWh = grammes of carbon dioxide per kilowatt hour.

Source: IEA (2021a), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Emissions reduction targets

An early and global leader of the decarbonisation agenda, France was among the first countries to adopt ambitious GHG emissions reductions targets towards carbon neutrality, an energy and climate planning framework with carbon budgets and an economy-wide carbon tax trajectory.

The 2015 Energy Transition for Green Growth Act (Loi relative à la transition énergétique pour la croissance verte) set out domestic targets of decreasing GHG emissions below 1990 levels by 40% to 2030, confirming the goal of reducing emissions by 75%, or a factor of 4, towards 2050 (as defined in the 2005 POPE Law).

In 2017, the Climate Plan called for ambitious climate action towards climate neutrality in France, notably measures for clean mobility, clean electricity and ending fossil fuel production by leaving oil and gas reserves in the ground (MTE, 2017). Many of the proposed measures were included in the Energy and Climate Law of 2019. The Climate Plan promoted carbon-free electricity; fuel switching; and simplification of procedures for the development of marine, geothermal and other renewable sources. It also pledged to ban hydrocarbon exploration so that by 2040 France no longer produces any oil, gas or coal. The plan supported the increase in the price of carbon with an alignment of taxation between diesel and petrol, the "energy voucher" for low-income households and the end of internal combustion engine (diesel/petrol) sales by 2040.

The 2019 Energy and Climate Law (Loi Énergie et Climat) turned these objectives into law and legislated the goal of achieving carbon neutrality by 2050 in the French Energy Code, which stipulates a reduction of GHG emissions by 85% (excluding LULUCF) by 2050, compared to 1990 levels. The law provided for the law on energy and climate planning process to define the targets under the SNBC and PPE. The 2021 Climate and Resilience Law (Loi Climat et Resilience) was adopted in August 2021 with new climate actions.

France's long-term strategy and carbon budgets

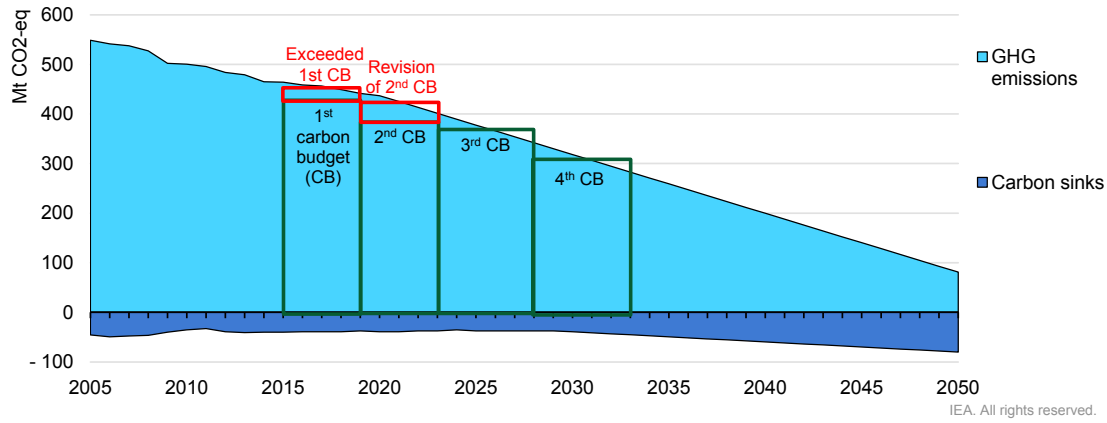
First developed in 2015, the National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone, SNBC), updated in 2018-19 and published in April 2020, describes a net zero roadmap across all sectors – in line with the 85% decrease of emissions by 2050.

The decree of 21 April 2021, adopting the new SNBC, revised upwards the second carbon budget (2019-23), left the third one intact (2024-28) and established a new fourth carbon budget for the period 2029-33.

The SNBC is based on two scenarios – with existing measures and with additional measures, alongside the business-as-usual scenario. The 2020 SNBC pathway requires an average 3% annual reduction of GHG emissions in the period up to 2030 (Figure 3.7). The "with existing measures" scenario reflects policies in place until July 2017; an update is planned for 2021. The "with additional measures" scenario was revised in line with the updated national targets and postpones several policies initially planned up to 2023.

The implementation of the carbon budgets requires sectoral plans and policies. For the energy sector, the two successive five-year energy investment plans (*la programmation pluriannuelle de l'énergie*, PPE) describe the additional policies and measures necessary to meet the SNBC targets.

Figure 3.7 France's path to climate neutrality under the revised National Low-Carbon Strategy, 2005-50



Notes: Mt CO_2-eq = million tonnes of carbon dioxide equivalent. GHG = greenhouse gas. The revised National Low-Carbon Strategy scenario towards climate neutrality requires a faster decarbonisation to decrease emissions from 2015 levels already by 28% in 2030.

Source: MTE (2020), *National Low-Carbon Strategy*, www.ecologie.gouv.fr/sites/default/files/2020-03-25_MTES_SNBC2.pdf.

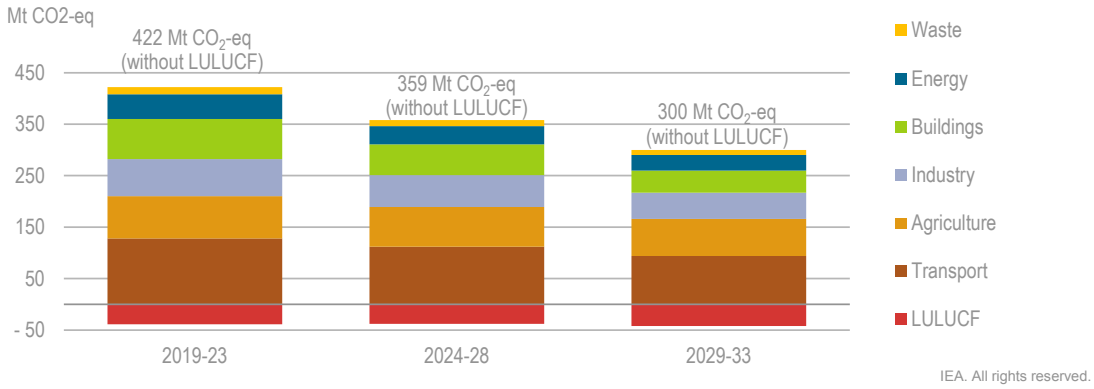
France was not able to meet the targeted reductions of its first 2015-18 carbon budget, with an estimated surplus of 65 Mt CO_2-eq over the whole period, or a mean annual excess of around 16 Mt CO_2-eq. Emissions decreased by only 1% per year on average between 2015 and 2018, because transport sector emissions were on the rise, whereas the SNBC 2015 scenario projected a decrease of 2.2% per year on average. The SNBC of 2020 outlined the discrepancies between the indicative annual budgets and actual emissions. They reflect a widening implementation gap of +3 Mt CO_2-eq for 2015, +14 Mt CO_2-eq for 2016, +28 Mt CO_2-eq for 2017 and +19 Mt CO_2-eq for 2018 (MTE, 2020). Based on the 2021 updated business-as-usual projections, the government expects it will be able to meet the second carbon budget, following the upward revision in April 2020 and taking into account the emissions reduction in 2019 and the effect of the COVID-19 pandemic.[1] In July 2021, the Council of State asked the government to take additional measures by 31 March 2022 to meet its commitments under the Paris Agreement to reduce GHG emissions by 40% by 2030.[2]

By 2050, the SNBC targets the full decarbonisation of energy production (relying more on biomass and low-carbon heat and electricity), more than a 40% reduction of final energy consumption, a strong reduction of non-energy related emissions (-40% agriculture, -50% industry) and an increase in carbon sinks. The SNBC does not consider a major role for carbon capture, utilisation and storage and assumes a rapid phase-out of fossil fuels (see Annex 5 of the SNBC). Carbon capture, utilisation and storage is assumed to support the decarbonisation of industry (non-energy process emissions of around 5 Mt CO_2 in 2050) and the combustion of biomass with negative emissions (10 Mt CO_2 in 2050). Direct air capture has not been taken into account.

[1] https://reportnet.europa.eu/public/country/FR.

[2] Émissions de gaz à effet de serre: le Conseil d'État enjoint au Gouvernement de prendre des mesures supplémentaires avant le 31 mars 2022 (conseil-etat.fr).

Figure 3.8 France's carbon budgets under the National Low-Carbon Strategy



Notes: Mt CO_2-eq = million tonnes of carbon dioxide equivalent. LULUCF = land use, land-use change and forestry.
Source: MTE (2020), *National Low-Carbon Strategy*, www.ecologie.gouv.fr/sites/default/files/2020-03-25_MTES_SNBC2.pdf.

Carbon pricing

For the sectors under the EU Emissions Trading System (ETS), France's emissions are priced under the EU carbon price. The EU ETS price mechanism applies to emissions from electricity production, industry and intra-EU aviation, with a price of above EUR 60/t CO_2 (in September 2021). At the European Union level, France supports the strengthening of the carbon pricing, notably with a carbon price floor in the EU ETS, carbon pricing for the sectors outside the EU ETS, setting a carbon border adjustment mechanism at the borders of the European Union (cross-border adjustment) and a stronger ETS system with a price of EUR 100/t CO_2 in the coming decade. In 2020, France received a total of EUR 728 million in revenues from the EU ETS auctions. The government allocated EUR 420 million to the renovation of buildings for low-income households.

In the sectors outside of the ETS, such as transport, industry and buildings, France has in place a carbon component which was introduced in 2015 as part of its energy taxation in sectors outside the EU ETS. In 2018, the intended automatic increase of the carbon tax rate to EUR 56/t CO_2 on a trajectory to reach EUR 86.2/t CO_2 by 2022 coincided with a period of high oil prices. Due to the social protests in 2018 (gilets jaunes, or yellow vests), the tax was frozen at its 2018 level of EUR 44.6/t CO_2. Although the carbon component was expected to deliver 1 Mt of emissions reductions in transport and 2 Mt of reductions in housing between 2014 and 2017, the tax under-delivered, in part due to a corresponding period of low global oil prices.

Sectoral performance

Responsible for 27% of France's GHG emissions, the transport sector is the top emitter and has become a core focus of policy making in recent years. Transport also accounted for 32% of national energy consumption and a large share of air pollutant emissions, notably nitrogen oxide (NO_x) (56%) and $PM_{2.5}$ (18%) as well as 20% of total non-methane volatile organic compounds.

France's Mobility Strategy and 2019 Mobility Law introduced a wide range of measures to boost the role of alternative fuels – hydrogen, biogas/biomethane – and required all sales of private passenger cars to be low-emission vehicles in 2040, as part of the SNBC. France

is actively working towards a modal shift. The bonus/malus system has been strengthened to shift to electric car sales, alongside a policy focus on reducing their cost and barriers, increasing the number of charging stations, and offering a scrapping premium to accelerate the replacement of old and environmentally low-performing vehicles by newer and cleaner ones. Under the French Recovery Plan, funds are allocated over the period of 2020-22 to clean mobility (rail, biking, low-emission cars and trucks) and hydrogen (EUR 2 billion [bln] as part of the French hydrogen strategy [EUR 7 bln]). These measures will also reduce air pollution, which remains a problem in French cities.

Buildings accounted for 20% of direct GHG emissions in France and 44% of energy consumption and air pollutant emissions (25% of PM_{10}, 40% of $PM_{2.5}$ and 20% of NO_x). In 2021, Environmental Regulation 2020 introduced higher emissions performance standards for buildings, reducing the heating and energy consumption of new buildings.

Governance and compliance

Climate policy governance in France has been strengthened through the creation of the High Council on Climate (HCC), the Ecological Defence Council, the greater role for citizens to promote climate actions and the prime minister's task to co-ordinate climate action across government. Ministries are required to elaborate roadmaps with actions plans in order to implement the SNBC and have to evaluate new laws and policies from the perspective of their impact on GHG one year after their implementation. By October 2021, three roadmaps have been presented (Ministry for the Economy, Finance and the Recovery; Ministry of the Ecological Transition; and Ministry of Agriculture).[3]

Replacing the Expert Committee on Energy Transition (Comité d'experts de la transition énergétique), the HCC provides policy advice, importantly every five years in preparation of the updated SNBC, but does not have a role in the legislative process. It also regularly reviews the country's progress towards meeting its climate goals with an annual report (HCC, 2020). Within six months of the submission of this report, the government has an obligation to formally present to parliament and to the Economic, Social and Environmental Council the measures already implemented and those planned in response to the recommendations and proposals of this report. It shall present an explanation for each of the unmet objectives as well as the means implemented to achieve them. In contrast to the Climate Change Committee in the United Kingdom, an opinion of the HCC does not trigger the revision of the policies.

The Ecological Defence Council is chaired by the president and brings together all ministers concerned with climate and environmental issues. It sets priorities for the ecological transition and ensures their mainstreaming in all state policies. The council monitors the achievement of the SNBC and its carbon budgets. The November 2020 council asked four ministries to elaborate roadmaps with action plans in order to implement

[3] www.ecologie.gouv.fr/ministere-transition-ecologique-publie-plan-daction-climat; www.gouvernement.fr/sites/default/files/contenu/piece-jointe/2021/04/937_-_plan_daction_climat_du_ministere_de_leconomie_des_finances_et_de_la_r._.pdf; https://agriculture.gouv.fr/strategie-nationale-bas-carbone-le-plan-dactions-du-ministere-de-lagriculture-et-de-lalimentation.

the SNBC, to organise an interministerial effort to consolidate the methodology of climate assessment of laws, and to publish the evaluation of the Mobility Guidance Law (Loi d'orientation des mobilités).

The president invited a Citizens' Convention on Climate to define measures to reduce GHG emissions by 40% (compared to 1990 levels) by 2030 in a spirit of a just transition. The Citizens' Convention on Climate presented 149 measures, out of which around 40 were reflected in the Climate and Resilience Law (Loi Climat et Résilience), which was adopted in August 2021. However, the Citizens' Convention on Climate was focused on the implementation of the existing 2030 targets, not on actions needed specifically to achieve climate neutrality by 2050 (MTE, 2021).

Local authorities act alongside the national government in France, and regional alignment of energy and climate goals with national goals remains a challenge. Fuel- and technology-related targets are in place at regional/local levels of government and among ministries there are conflicting policy directions, notably on the question of the future electricity mix and the technology needs.

Territories and regions play a major role in implementing the national goals. Territories and regions are obliged to produce regional plans for spatial planning, sustainable development and equality and territorial climate-air-energy plans (*plans climat-air-énergie territoriaux*, PCAET) (see Chapter 2).

Climate finance

In 2015, France implemented a pioneering regulation related to environmental, social and governance (ESG) risks, which integrates climate change into investment decisions. Article 173-VI of the Energy Transition for Green Growth Act requires institutional investors and trust companies to disclose three elements: 1) ESG criteria used in their policies and strategy; 2) the volume of finance used to contribute to the energy and ecological transition; and 3) related financial – physical and energy transition – risks. These provisions have evolved recently, with the entry into force in May 2021 of the implementing decree related to Article 29 of the 2019 Energy and Climate Law. It takes into consideration recent European legislative developments and is closely linked to the European Sustainable Finance Disclosures Regulation. It includes new requirements related to biodiversity and climate risk management and alignment; more actors and activities included in the scope; provisions for enhanced disclosure requirements on sustainability/ESG risk management; and the adoption of a continuous improvement plan.

The Task Force on Climate-related Financial Disclosures bases its works on the French regulation as well as the EU Sustainable Finance Disclosures Regulation. The first reports are to be published by financial institutions in 2022.

France promotes transparency and environmental commitment of financial products through voluntary labelling, notably the Greenfin label for green investment funds, which aims at channelling investments towards the energy and ecological transition. Currently, 62 funds are labelled, representing a total volume of over EUR 17 bln.

In 2017, France issued its first sovereign green bond. It amounted to EUR 7 bln and has a maturity of 22 years (2039), to leverage a total of EUR 28.9 bln in 2021. The bonds cover climate change mitigation, climate change adaptation, protection of biodiversity and

pollution reduction. In 2021, the French Treasury has issued a second green bond (*obligations assimilables du Trésor*), for another EUR 7 bln, with an initial maturity of 23 years (2044), which has raised an outstanding amount of EUR 9.3 bln to date.

In 2020, the parliament adopted an eco-conditionality mechanism in its third 2020 Amending Finance Law (Article 66). When taking stakes through the Shareholding Agency (APE) in companies that generate a turnover of more than EUR 500 million, the state requires companies to make commitments to reduce GHG emissions. The implementing decree is currently being drawn up by the government.

Climate mitigation and adaptation finance is a priority for France and the government is targeting USD 6 bln per year up to 2025, with one-third, or USD 2 bln, dedicated to adaptation measures, as pledged under the United Nations framework.[4] The French government supports the Global Environmental Facility and the Green Climate Fund.

France plans to end oil export support by 2025 and natural gas support by 2035, as the government supports the alignment of financial flows with climate goals under the Paris Agreement.

France finances environment and climate action under its official development assistance.[5] France's official development assistance has increased in recent years, from EUR 10 bln in 2017 to EUR 12.4 bln in 2020 (0.53% of gross national income), with mainly bilateral support (64% of the total) and mostly grants (72%). Official development assistance is increasingly disbursed, among other financial entities, by the French Development Agency, with grants for projects in priority countries, notably in Africa, thanks to an increase in project assistance under the Solidarity Fund for Innovative Projects and a doubling of funding allocated to civil society organisations between 2017 and 2022.

The French Development Agency has a strong energy transition strategy, with an exclusion of fossil fuel exploration activities. It also excludes coal power plants from its financing and has stringent criteria for gas power plants. A founding member of the Africa Renewable Energy Initiative, France provided EUR 3 bln per year of support to implement the 2030 Roadmap for Renewable Energy Future in Africa during 2016-20. In line with the French Development Agency's climate strategy (2017-22), the agency facilitates the implementation of the Paris Agreement and low-carbon and resilient transitions in developing and emerging countries, with the objective of committing EUR 5 bln of annual climate finance by 2020 in its countries of operation, excluding France's overseas territories, with 50% of commitments dedicated to actions with climate co-benefits. A total of EUR 5.2 bln were committed in 2020 to developing countries, including EUR 2.1 bln for adaptation. Adaptation reached 40% of its climate finance. The French Development Agency is committed to ensure that 30% of its climate finance is nature-positive by 2025, and that annual biodiversity co-benefits reach EUR 1 bln by the same date.

[4] www.un.org/en/climatechange/100bn-finance-goal.
[5] www.diplomatie.gouv.fr/en/french-foreign-policy/development-assistance/french-official-development.

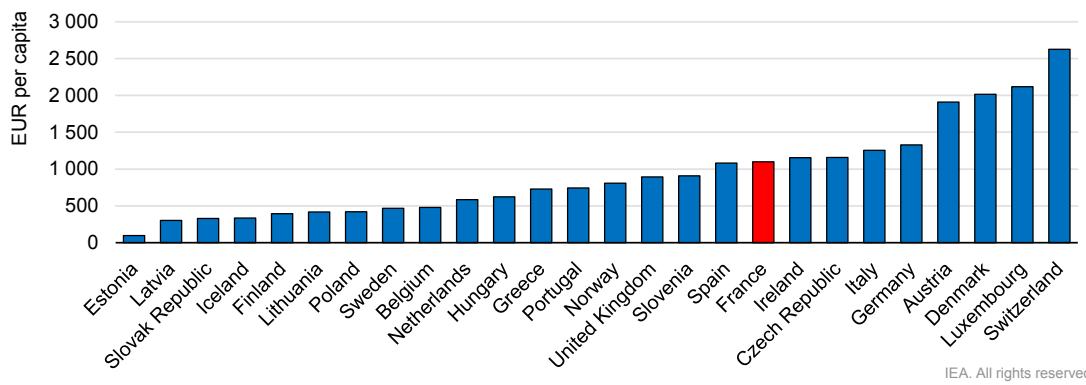
Adaptation and resilience to climate change

The French energy system is increasingly exposed to climate change-related risks, such as periods of droughts, floods and heavy precipitation, which in some cases impact on the water use of nuclear and hydro power plants and the transport of goods on the rivers. France borders four seas: the North Sea, the Channel, the Atlantic Ocean and the Mediterranean. Fourteen out of the 56 nuclear reactors operating in France in 2021 are on the seashore.

Climate impacts are monitored by the National Observatory on the Effects of Climate Change (ONERC), which was created in 2001. France publishes climate data and methods and tools to identify impacts and effects of climate change, for instance through the Drias' *les Futurs du Climat*.[6]

France's mean temperature has increased by 1.7°C since 1900, higher than the average global warming, which impacts energy demand patterns. The year 2019 was the hottest year since temperature recording started. Demand for heating remains high during winter peaks, while the level of electricity demand for cooling during summer has gone up. The average annual precipitation has increased, with some regional disparities. In the northern part of France, average precipitation has increased while the opposite trend can be observed in the southern part. Heavy rainfall events are becoming more intense in the Mediterranean region (IEA, 2021b). Risks of sea level rise and serious storms have not been reported for France. France ranks among the countries which report higher economic losses from extreme weather events as recorded by insurance companies.

Figure 3.9. Losses from extreme weather events in EU countries and the United Kingdom, 1980-2019



Source: EEA (2021a), Economic losses from climate-related extremes in Europe, www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-4/assessment.

Among the historic events, France experienced a range of high impact extreme weather events that can be related to climate change, including, for example, the heatwave of 2003, which caused 14 000 deaths, and the flooding in 2020 of 23 communities in the department of the Gard. For instance, the heatwaves combined with droughts in June-July 2019 forced

[6] www.drias-climat.fr.

Électricité de France (EDF) to curb the output or temporarily shut down 6 of its 19 nuclear power stations to limit the environmental impact of waste heat on rivers.

The National Climate Change Adaptation Plan (PNACC-2) for the period 2018-22 is designed alongside the SNBC. Detailed actions and measures for climate resilience in the energy sector were proposed in the first PNACC, while the second PNACC pays less attention to this topic. The PPE also includes investments in the security of supply, notably in the weatherproofing of energy infrastructure to address climate change impacts and extreme weather events.

In terms of governance, the prime minister is now required to ensure the implementation of the PNACC. A new Adaptation Plan will need to be developed in line with the new stricter climate neutrality goal of the Energy and Climate Law, which refers to "climate urgency".

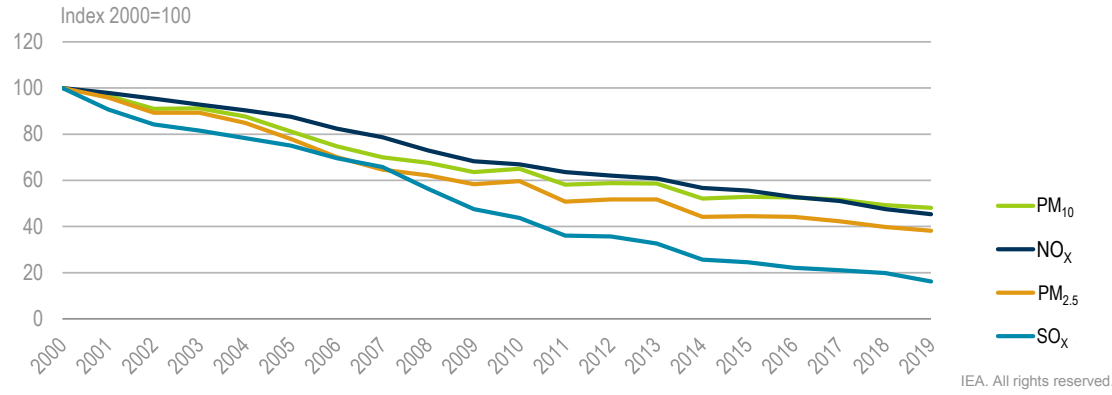
EDF has undertaken a systematic climate change risk assessment for its infrastructure and activities, and developed technology to reduce flood risks following heavy precipitation events, and a plan to deal with increasing temperatures. In 2008, EDF initiated a plan to deal with heatwaves, the so-called "Grands Chauds" plan, which aims to ensure the safety and supply security of EDF's nuclear power plants in the face of increasing temperatures. The "Grands Chauds" plan includes a reassessment of maximum water temperatures expected at each nuclear power plant up to 2030. Revised temperature estimates have informed the revision of engineering guidelines for extreme weather situations and of safety standards taking into account climate change impacts. EDF has also undertaken a systematic climate change risk assessment for its infrastructure and activities, and developed technology to reduce flood risks following heavy precipitation events. This system, called piano key weir, improves flood discharge from hydropower dams during heavy precipitation events.

Air quality

Air pollutant emissions (NO_x and sulphur dioxide emissions [SO_x]) have been declining since 2013 (Figure 3.10). The concentration of particulate matter emissions (PM_{10} and $PM_{2.5}$) has come down, but not as much as NO_x, owing to residential use of biomass for heating, road transport and industrial activities (Figure 3.11).

However, France's air pollution levels remain above the limit values determined by the EU's ambient air quality legislation in Directive 2008/50/EC, notably the daily limit values applicable to PM_{10} particles which have been legally binding since 2005. In October 2018, the European Commission referred France to the European Court of Justice, France's second referral to the court regarding non-compliance with EU air quality standards. In its judgment of 24 October 2019, the court found that France did not comply with the limit values for the concentrations of NO_2 in 12 air quality zones (Commission against France, C-636/18). Local air pollution remains a concern in Paris, which is particularly exposed to air pollution because of the density of the urban area, its geographic location and the structure of its transport system.

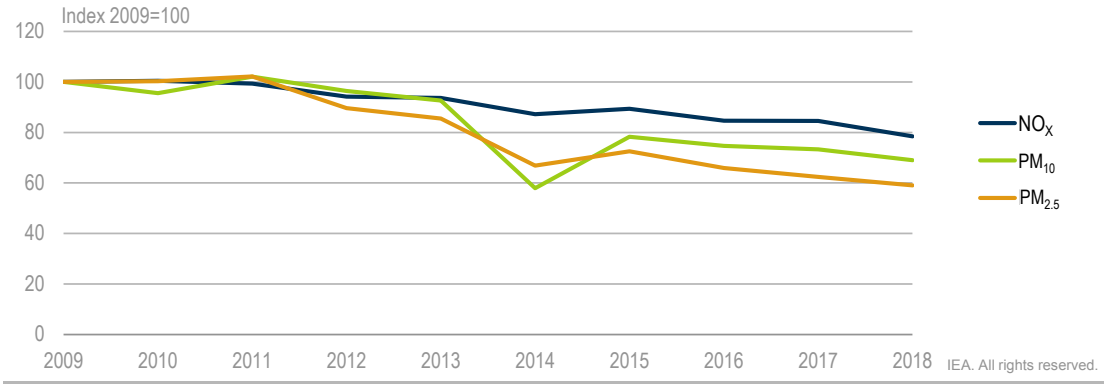
Figure 3.10 Emissions of air pollutants in France, 2000-19



Note: PM = particulate matter. NO_x = nitrogen oxide. So_x = sulphur dioxide.

Source: Citepa (2021), *Inventory of Air Emissions in France*, www.citepa.org/wp-content/uploads/publications/cee-nu/UNECE_France_mars2021_d.pdf.

Figure 3.11 Concentrations of air pollutants in France, 2009-18



Note: PM = particulate matter. NO_x = nitrogen oxide. So_x = sulphur dioxide.

Source: EEA (2021b), France – Air pollution country fact sheet 2020, www.eea.europa.eu/themes/air/country-fact-sheets/2020-country-fact-sheets/france.

France's National Air Pollution Reduction Plan (Plan national de réduction des émissions de polluants atmosphériques, PRÉPA) and air quality rules (Décret No. 2017-949/2017) and its Arrêté/2017 established pollution reduction targets and actions to enhance and implement air quality by 2020 and 2030 (Table 3.1).

Table 3.1 France's targets for reducing emissions of pollutants for 2020 and 2030

Pollutant	By 2020	By 2030
NO_3	-50%	-69%
NMVOC	-43%	-52%
NH_3	-4%	-13%
$PM_{2.5}$	-27%	-57%

Note: NO_3 = nitrate. NMVOC = non-methane volatile organic compound. NH_3 = ammonia. PM = particulate matter.

Responsibility for air quality is shared between the state and local authorities, because air quality policies require actions at different levels of competence (European, national, local)

depending on the action to be taken. Some actions fall within the remit of the state, and local authorities need an authorisation to act on its behalf, including some taxation measures.

City level and territorial actions are being pursued to implement these objectives, notably under the PCAETs. Policy efforts will be set out in the forthcoming PRÉPA and regional climate-air-energy schemes, but also in the PCAET, and local atmosphere protection plans endorsed by the state, in line with Article 23 of EU Air Quality Directive (2008/50/EC).

The government is implementing the 2015 Air Quality Action Plan and its five main measures: 1) introduction of an air quality certificate (*certificat qualité de l'air*, Crit'Air) for less polluting cars; 2) a call for proposals for breathable cities within five years; 3) an anti-pollution framework as part of the Energy Transition for Green Growth Act; 4) financial aid for clean cars (bonus); and 5) implementation of low-emission zones is compulsory where they exceed the limit values, based on the French Mobility Act (2019).

The Crit'Air, which ranks vehicles' environmental performance in terms of air pollutant emissions, was introduced by the Ministry of the Ecological Transition in 2017 as a tool to regulate traffic restrictions during periods of air pollution peaks. To address pollution peaks, for instance, the state allows temporary restrictions to be imposed by local authorities, including urban zonal restrictions, car circulation restrictions and special driving lanes for low-emission cars. This certificate allows local authorities to create low-emission zones.

Real-time air quality levels are monitored at the national and regional levels through regional air quality surveillance by approved associations and the central air quality surveillance laboratory and the Technical Reference Centre for Air Pollution and Climate Change (Citepa). Cities also measure air quality, notably the Observatory of Air Quality in Île-de-France (Airparif).

Assessment

An early global leader on addressing climate change, France has been committed to climate neutrality by 2050 since 2019, with ambitious and legislated targets for its energy transition which rely on the full decarbonisation of energy production and major energy efficiency improvements or sobriety. It is a global leader in setting climate policies and its experience will inform many other countries' low-carbon policy frameworks.

France's National Low-Carbon Strategy and its carbon budgets are operationalised for the energy sector under the PPE, with targets up to 2028. Both were revised in 2020 to take account of a steeper reduction pathway of carbon neutrality, outlined in the 2019 Energy and Climate Law and proposed by the Climate Plan of 2017. However, the 2030 emissions reduction target of -40% by 2030 (from 1990 levels) has not been amended. Instead, the government revised the second carbon budget upwards, with a view to postpone actions to the next carbon budget.

Since 1990, total GHG emissions have decreased by 19%. On a path to net zero, France needs to reduce emissions by 85% by 2050 from 1990 levels, according to the updated SNBC, with some negative emissions. France has not been able to meet its first carbon budget, but is on track towards meeting the second one, in the light of the extraordinary impacts of COVID-19, which lead to a 12% decline in energy-related CO_2 emissions

between 2019 and 2020, notably from transport emissions and the upward revision of the second carbon budged. However, the structural reality has not changed, and it can be assumed that an economic recovery post-pandemic will result in increased emissions.

The SNBC does not outline policy instruments, which is different from the United Kingdom's carbon budgets, where the government presents policy measures for implementation in the Carbon Plan attached to each carbon budget. This was also confirmed by the HCC, as it concluded that the implementation of the SNBC "is hampered by a lack of firm direction and of a cross-cutting vision" as it does not contain the policy instruments necessary in each sector (HCC, 2020).

Climate governance has been strengthened; however, implementation is lagging. All government ministries will have to commit to an implementation roadmap designed to achieve the sectoral targets (carbon budget). At the time of writing, three ministries have presented their roadmaps. Transparency and accountability of climate action is a key requirement for public acceptance and visibility of France's climate goals. The independence of the HCC has been increased to improve the evaluation of climate action, but its role could be much stronger in identifying additional measures, similar to the United Kingdom's Climate Change Committee.

France needs to scale up its climate mitigation policies. Half of the effort has been achieved over the last 30 years; the other half needs to be done in the next 10 (to reduce emissions by 40% by 2030). As emissions in transport are not declining in line with the targeted rates, France is not on track to reach the target.

To achieve net zero and compensate for slower progress under the current SNBC, a full update of the SNBC and stronger medium-term actions are needed to increase the rate of reduction, notably in the transport sector. By 2024, the government plans to present a new SNBC. This would be in line with other EU governments that have recently increased the near-term action to avoid the carbon burden on future generations.

A revision of France's climate strategy is absolutely necessary also in the context of the EU legislated goal of climate neutrality by 2050 and the EU Climate Law's increased emissions reduction target, up to -55% by 2030. This is an opportunity to take stock and align multiple and overlapping targets at all levels of government: national, regional and local. Today, the coherence, readability and transparency of France's climate and energy targets remains a challenge. In addition, time frames differ between EU and national plans. It is critical to align goals across sectors, fuel targets, and regional and EU plans for 2030 and 2050 when preparing the next update of the SNBC and the PPE, which is planned for 2024.

France was the first country in the world to ban the sales of new light vehicles using fossil fuels by 2040. However, today, most countries have more ambitious plans and measures in place, as well as higher EV penetration rates. But France is catching up with EV sales with other countries. The recovery funding and new measures imposed by the government have finally led to a strong increase in sales. The government is confident that it can meet its near-term PPE targets, which are more ambitious with a 1.2 million target for 2023 and a 4.8 million target for 2028. However, the energy efficiency, renewables and GHG reduction targets for 2030 were already legislated in the landmark Energy Transition and Green Growth Act of 2015, but have not been strengthened since. Other countries presented more ambitious plans in 2021, in the context of their net zero plans and the

COP26. The Climate and Resilience Law 2021 includes the ban of the sale of the most polluting vehicles from 2030 onwards.

Given the magnitude of the challenge and potentially slower progress in energy efficiency, the government needs to update the existing measures and evaluate additional ones needed in the forthcoming SNBC update, which may be available in industrial processes; agriculture; and contributions from carbon sinks, forest management, wood products, land use, and carbon capture and storage.

France benefits from its low-carbon electricity footprint. In 2019, emissions from electricity and heat generation were 61 g CO_2/kWh, a 29% decrease compared to 2000, lower than the IEA Europe average at 242 g CO_2/kWh. The contribution of nuclear is incumbent/embedded, and delivers low-cost generation and energy security with low emissions, but no decision on the long-term electricity mix beyond 2035 has been taken, including on the role of nuclear.

Delivery of the net zero climate goals is heavily reliant on effective delivery of targets in particular areas such as the energy efficiency of buildings, decarbonisation of transport, and an increase in renewables for both electricity generation and renewable heat (end-use energy consumption). The trajectory for these transformations is very challenging given the current status and the short time frames, and there is a risk that one, or more, of these will fall short of expected delivery. In this context, it is critical to introduce regular review points for all measures and budgets relating to clean energy technology investments, including energy efficiency targets by sector, and to ensure a level playing field for all energy market participants. While the government has indicators in place to review the SNBC, its capacity of independent progress evaluation and policy guidance is limited, as the SNBC does not contain policy instruments (they are in the PPE). The HCC should strengthen its regular review of the SNBC and do so for the sectoral plans as well, notably the PPE. The government should swiftly respond to the HCC's 2021 report to outline its assessment of delays and new measures to be taken to deepen implementation and strengthen the near-term ambitions.

The coherence and clarity of the available incentives is also critical for all stakeholders. Constantly modifying objectives and support frameworks under the legal framework can have dampening effects on engagement, either by frustrating projects or subsidies. Failing to maintain alignment with rapid developments in new technologies, and an inability to reflect current costs in schemes, could result in the under-utilisation of incentives or cost-inefficiencies in delivery.

Adaptation and climate resilience are not yet at the top of the policy agenda despite the declared climate urgency. Despite the low-carbon intensity of the French economy, the French energy system is nonetheless increasingly exposed to climate change-related risks, such as heatwaves and droughts, storms and floods. The resilience of the country's energy infrastructure requires particular attention; for instance, droughts and floods impact the water use of nuclear and hydro power plants and the transport of goods on rivers. A more regular screening of impacts across government and action by industry to work with government and stakeholders should be encouraged, including through advisory bodies and action groups. The National Observatory on the Effects of Climate Change has been monitoring climate change impacts since 2001 and Météo France is stepping up its efforts to better forecast weather events. The PNACC-2 for the period 2018-22 was designed

alongside the 2020 SNBC and the next PNACC will be an opportunity to review the state of play and set concrete measures, also for the energy sector.

Recommendations

The government of France should:

- Expand the mandate and independence of the High Council on Climate with a view to improve the transparency and accountability of policy decisions on climate action, track progress, and identify additional measures to align with the targets.
- Identify opportunities for action to meet climate neutrality with additional measures and aligned goals across sectors, fuel targets, and regional and EU plans for 2030 and 2050 when preparing the next update of the National Low-Carbon Strategy and the two five-year energy investment plans. Reflect on the opportunities for job creation and adjustment for a just and inclusive transition.
- Review the National Climate Change Adaptation Plan, based on the future National Low-Carbon Strategy and strengthen climate resilience measures with a view to reflect stricter climate neutrality ambitions and "climate urgency".

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4. Energy efficiency

Key data (2019)

Total final consumption (TFC): 150.1 Mtoe (oil 43.9%, electricity 24.7%, natural gas 19.6%, bioenergy and waste 8.2%, heat 2.5%, coal 0.8%, solar 0.1%) -3.9% since 2009

TFC by sector: buildings 39.3%, industry 30.4%, transport 30.3%

TFC per capita: 2.23 toe/capita (IEA average 2.90 toe/capita), -7.8% since 2009

TFC per GDP:* 52 toe/USD million (IEA average: 65 toe/USD million), -16.1% since 2009

France's 2020 targets: primary energy consumption 219.9 Mtoe (2019:** 235.3 Mtoe) and final energy consumption 131.4 Mtoe (2019:** 145.5 Mtoe)

France's 2030 targets: primary energy consumption 202 Mtoe and final energy consumption 120.9 Mtoe

* GDP in USD 2015 prices and PPPs (purchasing power parity).

** Status in 2019 (Source: Eurostat, 2021).

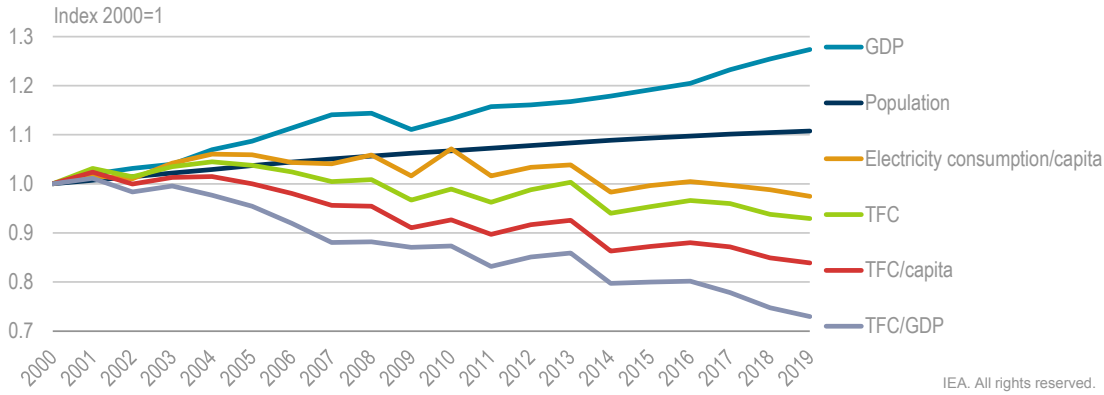
Overview

France's energy transition counts on major energy efficiency improvements to reduce final consumption by 20% in 2030 and 50% in 2050, which were set out in the Energy Transition for Green Growth Act of 2015. The targeted reduction is strongly based on the concept of "sobriety", which has been the spirit of the French energy transition since the oil crisis in the 1970s. It relies on significant behavioural changes rather than productivity increases.

Total final consumption (TFC) in France decreased by around 4% over the decade from 2009 to 2019, thanks to major improvements in the buildings and industry sectors. France has witnessed an overall decoupling between the growth of the country's gross domestic product (GDP) and its final energy consumption (TFC/GDP ratio), despite the population increasing by 4% over the same period (Figure 4.1). GDP increased by 15% between 2009 and 2019. The energy intensity of GDP has declined by 16% since 2009.

Despite the progress made in the past decade, however, France is behind in reaching its targets. In 2019, France's primary energy consumption (PEC) was 235 million tonnes of oil equivalent (Mtoe) and final energy consumption (FEC) was 145.5 Mtoe, much above the targeted PEC of 219.9 Mtoe and FEC of 131.4 Mtoe for 2020 (Eurostat, 2021). At a global scale, the International Energy Agency's (IEA) Net Zero Roadmap for 2050 considers energy efficiency to be the key plank of short- to medium-term mitigation measures (IEA, 2021a). The IEA Roadmap stipulates a 4% annual efficiency improvement for fast emissions reductions. France's energy sobriety will need to develop into real energy efficiency, with a focus on productivity, technology innovation and digitalisation.

Figure 4.1 France's energy demand and key demand drivers, 2000-19



Increasing GDP and population with decreasing energy demand show a decoupling of energy consumption and economic growth.

* *GDP* data are in billion USD 2015 prices and PPPs (purchasing power parities).

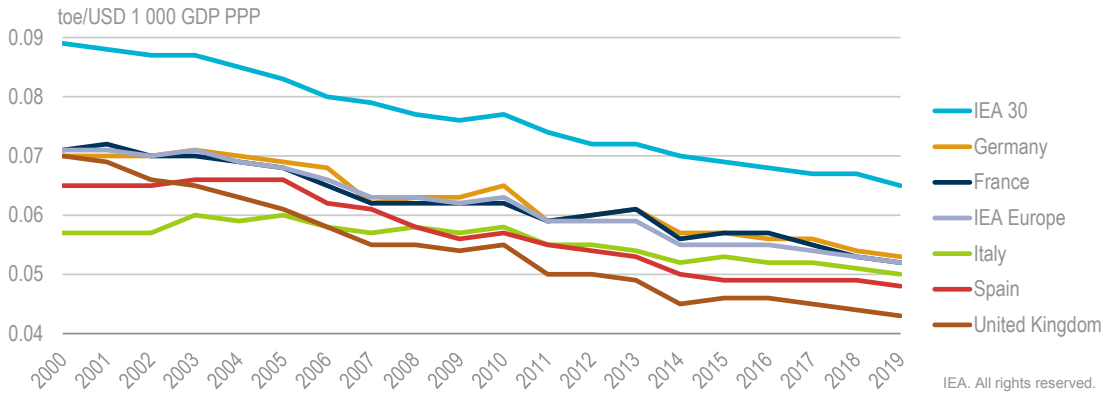
Note: GDP = gross domestic product. TFC = total final consumption.

Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy intensity and energy savings

Energy intensity per GDP decreased in France in the first two decades of this century, following the trend of other European IEA countries (Figure 4.2). France's energy consumption per GDP was about 20% lower than the weighted average of IEA member countries in 2019. France's total final consumption per capita (2.2 Mtoe/capita) was 23% less than the weighted average of IEA member countries, but slightly higher than that of European IEA member countries (Figure 4.3).

Figure 4.2 Energy intensity per GDP in selected IEA countries, 2000-18



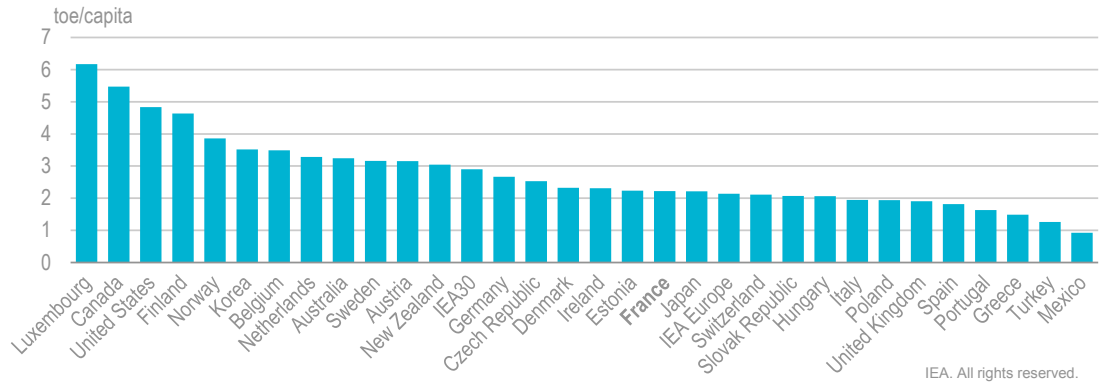
France's energy intensity of the economy decreased in line with the average of European IEA member countries.

**GDP* data are in billion USD 2015 prices and PPPs (purchasing power parities).

Note: toe = tonne of oil equivalent. GDP = gross domestic product.

Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 4.3 Energy intensity per capita in IEA countries, 2019



France has an energy intensity per capita lower than the average of IEA member countries, but slightly higher than the average of European IEA member countries.

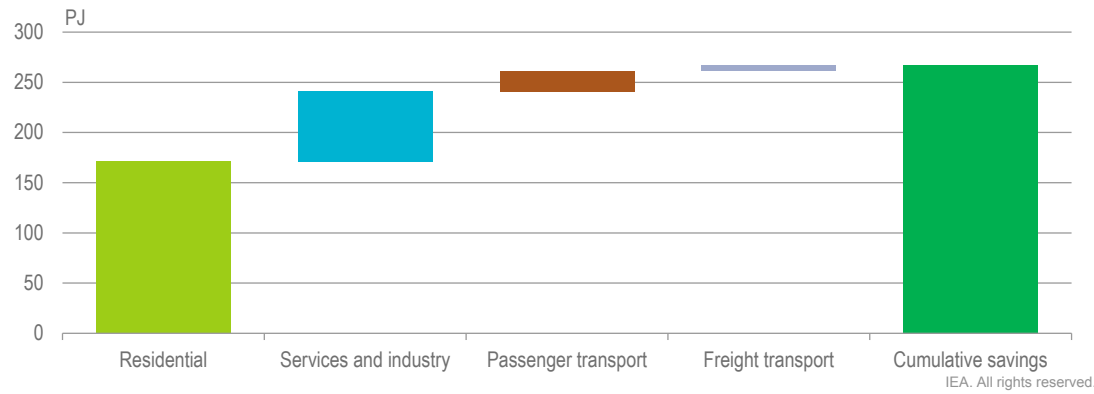
* *GDP* data are in billion USD 2015 prices and PPPs (purchasing power parities).

Note: toe = tonne of oil equivalent.

Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The IEA's decomposition analysis shows that between 2000 and 2018, France achieved energy savings in all sectors, for a total of 267 petajoules (PJ) of cumulative savings, with variable contributions from the different sectors (IEA, 2020) (Figure 4.4). Most of the savings (64%) were achieved in the residential sector, followed by services and industry (26%), passenger transport (8%), and the freight transport sector (2%). Savings in the buildings sector were achieved thanks to increasingly strict performance standards for appliances and buildings envelopes.

Figure 4.4 Energy savings by sector in France, 2000-18



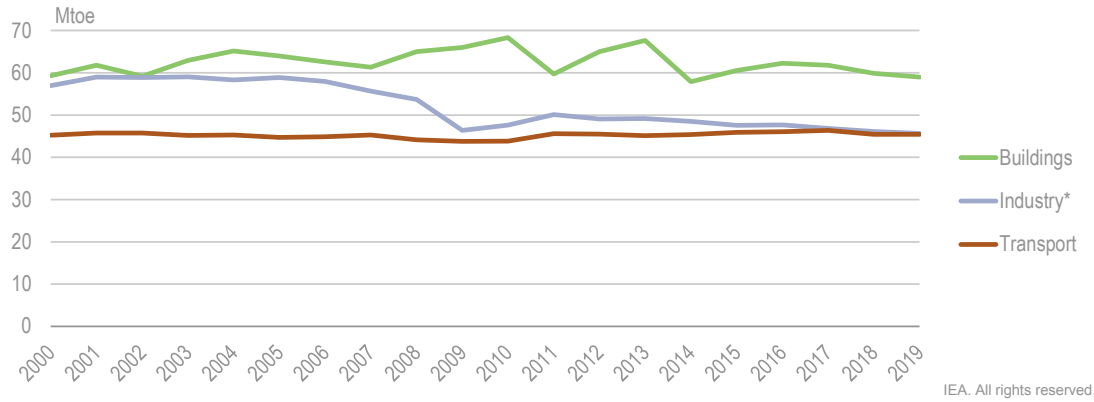
Between 2000 and 2018, France achieved energy savings in all sectors, with a major contribution (64%) from the residential sector.

Note: PJ = petajoule.

Source: IEA (2020), *Energy Efficiency Indicators* (database), www.iea.org/statistics.

IEA data show the consumption trends by sector. France's TFC was 150 Mtoe in 2019. The buildings sector, including residential and service sector buildings, was the most energy-consuming sector in 2019, accounting for 39% (59 Mtoe) of TFC (Figure 4.5), followed by transport and industry, which covered about 30% of TFC (45 Mtoe) each in the same year. Energy consumption in the buildings sector fluctuated around the heating needs during the winter periods. Energy demand in the industry sector dropped following the financial crisis in 2008, to rebound slightly in the following years and decrease again since 2011. The transport sector experienced a slight drop in demand between 2008 and 2010, a rebound in 2011 and has remained constant since.

Figure 4.5 Total final consumption in France by sector, 2000-19



Energy demand from buildings fluctuated around 60 Mtoe, while energy consumption from industry has been decreasing since 2011. Transport demand remained almost constant.

* *Services/other* includes commercial and public services, agriculture, forestry, and fishing.

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy efficiency targets and policies

Progress towards energy efficiency targets

France's National Energy and Climate Plan (NECP) sets out 2020 and 2030 energy efficiency targets for primary and final energy consumption (Figure 4.6). The NECP includes the National Energy Efficiency Plan (MTE, 2020a).

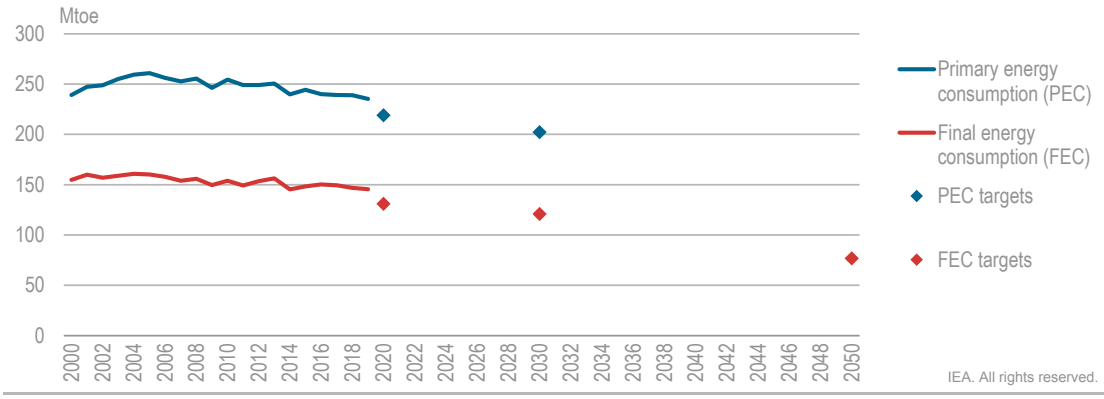
As a contribution to the EU-wide targets for reducing energy consumption (under the Energy Efficiency Directive, EED), France's national target is to achieve a PEC of 219 Mtoe in 2020 and 202 Mtoe in 2030, and a FEC of 131 Mtoe in 2020 and 121 Mtoe in 2030. In 2019, PEC was 235 Mtoe and FEC 146 Mtoe,[1] higher than the 2020 targets, which can be achieved only because of the COVID-19 pandemic. The European Commission considers the level of ambition of the 2030 targets to be "modest" for PEC

[1] 146 Mtoe includes aviation. The FEC target excluding aviation is otherwise 140 Mtoe.

and “sufficient” for FEC (EC, 2020). By 2050, the government is targeting a 50% reduction of the FEC from 2012 levels.

Article 7 of the EED also sets an energy efficiency obligation for France to achieve a total of 365 terawatt hours (TWh) (31.4 Mtoe) of energy savings by 2020 and 758 TWh (65.2 Mtoe) by 2030. As of 2018, France had achieved 322 TWh (27.7 Mtoe) of energy savings, which is in line with the progress established by the EED. The doubling of the energy efficiency obligation for 2030 will require a major scale-up of the energy savings from cross-sector policies.

Figure 4.6 France’s primary and final energy consumption, 2000-18 and targets



Note: Mtoe = million tonnes of oil equivalent.

Sources: Eurostat (2021), *Primary and Final Energy Consumption* (database), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_bal_c.

Cross-sector policies

France’s long-standing energy saving certificates scheme (white certificates) is one of its key policies, alongside minimum performance standards and regulations, to achieve energy savings across sectors. These certificates, so-called *certificats d’économies d’énergie* (CEE), are issued by the Ministry of the Ecological Transition (MTE) to eligible stakeholders that have undertaken energy saving operations. They target energy savings across the residential, tertiary, industry, transport and agriculture sectors, including installations subject to the EU Emissions Trading Scheme (ETS). The CEEs can be traded with a unit expressed in megawatt hours (MWh) cumac, corresponding to the cumulative discounted saving of 1 MWh over the lifetime of a product or investment. The white certificates started in 2006 and are in the fourth period of application, which ends on 31 December 2021. The energy-saving target is 2 133 TWh cumac for the fourth period of 2018-21 (targeting 12 Mtoe of energy savings per year). The government aims to further improve the performance and efficiency of the scheme during the fifth period, which starts on 1 January 2022. The French Court of Auditors, the MTE and the Inspectorate of General Finance review the scheme alongside the French Agency for Ecological Transition (Agence de la transition écologique, ADEME) with a full evaluation every three to four years.

France’s energy efficiency policies are governed by various EU policies, notably the European Performance in Buildings Directive and the Ecodesign Directives and labelling regulations. France supports an ambitious, effective European policy on the ecodesign of energy-related products, and energy labelling of these products. The Ecodesign

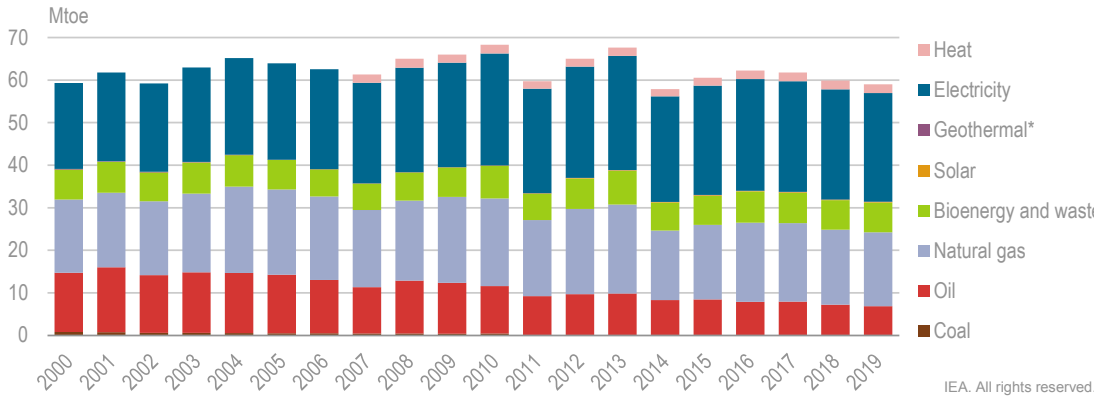
Directive 2009/125/EC and Labelling Regulation (EU) 2017/1369 are implemented through product-specific regulations, directly applicable in France. Ecodesign and energy labelling regulations are complemented by harmonised European standards. These technical specifications require products to comply with the mandatory standards, which are binding for manufacturers. Digitalisation is another important driver of energy efficiency across all sectors. France has been a pioneer in times-of-use pricing and is in the process of completing the roll-out of smart meters, mostly with the Linky Enedis technology. With more than 28 million meters installed since 2015, the country will reach 35 million by 2022, thanks to an overall investment of EUR 6 billion.

Policies and progress by sector

Buildings

Under the National Low-Carbon Strategy (SNBC), the government needs to achieve a 49% reduction in greenhouse gas (GHG) emissions by 2030 compared to 2015 levels in the building sector. Target achievement is expected to accelerate towards later carbon budgets. Within the next ten years, a 22% drop in energy consumption in the building sector is required. By 2040, this decline reaches 29% and by 2050, 41%, compared to 2015 levels.

Figure 4.7 Buildings energy demand in France by source, 2000-19



Energy demand in buildings shows an overall decreasing trend. Electricity provided 43% of energy used in buildings in 2019, with a decreasing share of fossil fuels.

* *Geothermal* increased from 0.014 Mtoe in 2009 to 0.017 Mtoe in 2019.

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

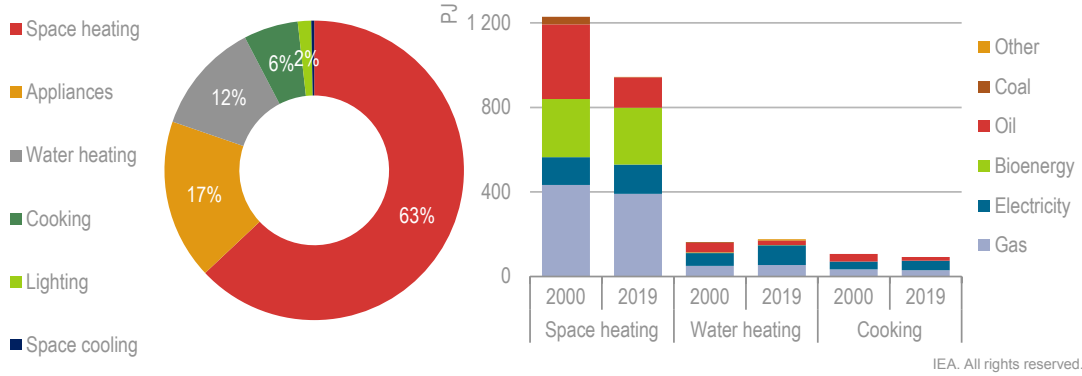
Energy demand from buildings, including the residential and services sector (excluding industry), amounted to 59 Mtoe in 2019, or 39% of TFC. Although consumption from the buildings sector fluctuated between 68 Mtoe in 2010 and 58 Mtoe in 2014, the average energy consumption over the five-year period from 2015 to 2019 was 5% below the previous five-year average (Figure 4.7).

France has a high share of electricity use in the buildings sector, thanks to the historic role of electric heating in the context of the country's nuclear programme. The use of fossil

fuels (coal, oil and natural gas) in the buildings sector decreased by 26% between 2009 and 2019, while electricity demand increased by 4% in the same time frame. In 2019, energy demand was met by electricity (43%), natural gas (29%), bioenergy (12%), oil (12%) and heat (4%).

In 2018, space heating was responsible for more than half (63%) of the energy consumption in the residential sector, followed by residential appliances and water heating (Figure 4.8). Major energy efficiency improvements have been achieved since 2008 in space heating and oil and coal used for heating more than halved in ten years. The consumption of natural gas is still much higher than that of electricity in space heating, despite the rather large share of electric heating in France.

Figure 4.8 Residential energy consumption in France by end-use, 2019, and by source, 2000-19



Space heating accounts for most of energy demand in residential buildings. Energy consumption for space heating has decreased since 2000 thanks to lower use of oil.

Note: PJ = petajoule.

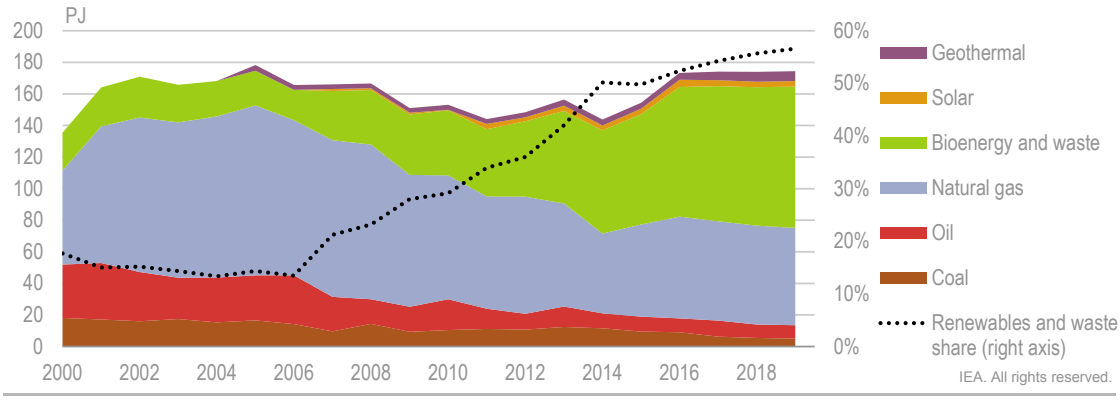
Source: IEA (2020), *Energy Efficiency Indicators* (database), www.iea.org/statistics.

District heating

The amount of district heat supplied in France was stable between 2016 and 2019 at around 175 PJ, but had increased by 16% since 2009. In 2019, 57% of district heating was supplied by renewables and waste – a share that doubled from 2009 as bioenergy is replacing coal, oil and natural gas. The use of geothermal (3.5% of total heat supply in 2019) and solar thermal (2%) heat is also increasing (Figure 4.9).

In 2019, there were 798 district heating networks and 24 cooling networks in France, which supplied 2.4 million household equivalents (two-thirds residential sector and one-third tertiary sector) and around 5% of consumption in heating and domestic hot water in France (ADEME, 2019a).

Figure 4.9 District heat supply in France by source, 2000-19



Note: PJ = petajoule.

Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2020, the government ended its support to co-generation,[2] which uses natural gas and has several support schemes to increase the share of renewables in district heating, notably biogas. ADEME's heat funds have been the core support mechanism over the past decade to drive investment in renewable heat and efficiency of heat networks (see Chapter 5). New regulations (RE2020) support a strong shift to heat pumps in the coming years.

Energy efficiency policies in the buildings sector

New buildings

France has strengthened labelling and building codes for new construction since the adoption of the Thermal Regulation 2012 (RT2012), based on the 2019 Energy and Climate Law and notably with the new Environmental Regulations (RE2020).

France is strengthening the enforceability and definition of its energy performance certificate, the so-called *diagnostic de performance énergétique* (DPE), under Article 179 of the Housing, Planning and Digitalisation Development Act (Loi ELAN) of 23 November 2018. The scale for the DPE (A-G) by its two criteria – primary energy consumption of the building and its greenhouse gas emissions – was upgraded. In 2020, the decrees amending the construction and housing code were undergoing consultations and will enter into force with stricter thermal regulations.

The RE2020 will enter into force in 2022. It aims to reduce the carbon intensity of heating in new buildings with stronger thermal and environmental standards, higher use of decarbonised energy, a reduction of the climate/carbon impact of the construction with new materials, and the adaptation of new buildings to increased summer heat.

The new bioclimate standard (Bbio, *besoin bioclimatique*) requires a 30% improvement in the performance of the building envelope, compared to the RT2012. As an upgrade from the RT2012, the RE2020 focuses on the use of decarbonised energy in new buildings, with a very strong limitation of the carbon impact of energy, starting from 2021 in

[2] Co-generation refers to the combined production of heat and power.

single-family houses (4 kg CO_2-eq/m²/year) and from 2024 onwards in multi-apartment dwellings or so-called collective housing (6.5 kg CO_2-eq/m²/year). Based on these requirements, the RE2020 promotes the systematic use of renewable heat, achieving the phase-out of natural gas (excluding back-up) from 2021 in single-family houses and from 2024 in collective housing as well as oil heating (excluding back-up) from 2021. The RE2020 also encourages a minimum renewable heating rate in new buildings.

Existing buildings

Building on the Energy Renovation Plan for Buildings (2017-22), part of the Climate Plan, the government recently presented its long-term renovation strategy to the European Commission in 2020 with 12 actions along 4 priorities: 1) making building energy renovation a national priority based on accessible data; 2) extending building energy renovation to all citizens, in particular to combat energy poverty; 3) improving energy efficiency in tertiary buildings, particularly public ones; and 4) accelerating the integration of innovative solutions for energy efficiency of buildings (MTE, 2020b).

Poorly insulated housing and fuel poverty remain a concern in France. Out of 29 million primary residence dwellings on 1 January 2018, 1.9 million (6.6% of the total) had low energy consumption (categories A and B of the DPE), while 4.8 million, or 17%, had a very high energy consumption (categories F and G of the DPE, also called energy sieves), according to ADEME data in the national building observatory analysis (MTE, 2020b). There were 7 million poorly insulated buildings in 2019, and half of them belonged to the poorest 30% of the population, who spent more than 8% of their income on their energy bill. Fourteen per cent of households suffered from the cold at home during winter 2019-20 (compared to 15% the two previous winters). Forty per cent of households suffer from poor insulation and 28% from insufficient heating systems (MTE, 2020c).

The government is strengthening building codes and labelling efforts, notably through the reformed DPE and the Low Consumption Building Renovation labelling, which will be promoted through aid for implementing the so-called “global” renovations. In 2019, the government also created a National Observatory of Energy Renovation.

Based on the 2019 Energy and Climate Law, DPE data are now collected by ADEME and provided to local authorities and to the National Housing Agency. Data from the French Family Allowance Fund (Caisse d’allocations familiales) concerning households receiving the housing benefit (Aide personnalisée au logement) are also provided to National Housing Agency to improve the targeted support for renovation. The government is also increasing its efforts in sharing as open data the specifics of governmental buildings, including floor area and type of energy used for heating.

As part of the 2019 Energy and Climate Law, France wants to eradicate the 4.8 million inefficient homes (so-called energy sieves). Starting from 2022, a mandatory energy audit will be required prior to the sale or lease[3] of dwellings, informing the prospective buyer or lessee of future energy costs. A minimum energy performance criterion of 450 kWh/m² year in final energy in the definition of “decent housing” will be required from 1 January 2023. Before 2028, a second phase will be implemented, requiring owners of inefficient

[3] A bill proposes to suppress this mandatory audit for leases, because lessees do not have the power to order energy works in their rentals.

homes to undertake renovations to improve the energy performance of the property. A third phase, planned for 2028, will envisage sanctions for owners of properties that do not comply with the renovation obligations.

Since 1 January 2020, the purchase or repair of heavy fuel oil boilers is prohibited in government buildings. The plan is to end the use of fuel oil in government buildings by 2029.

The long-standing energy transition tax credit (Crédit d'impôt pour la transition énergétique, CITE) had been in place since 2014. This policy instrument provided an income tax credit of 30% for expenditures related to certain building renovation work aimed to improve the energy efficiency of private dwellings or the modernisation of heating installations. On 1 January 2020, CITE was replaced by MaPrimeRénov', which is a grant accessible to all owners and co-owners. A new scale was set in 2020, taking account of the energy efficiency of actions with a fixed-rate, simplifying the process for multi-unit collective renovation projects. The grant rate is increased for low-income households, to combat energy poverty. The National Housing Agency pays the benefits when the renovation work is performed.

The government also expanded and simplified the use of the éco-PTZ, the zero-rate ecological loan for single action projects, using a flat-rate grant. Moreover, all energy renovation works that are eligible for the CITE continue to be granted a discounted value-added tax rate of 5.5%.

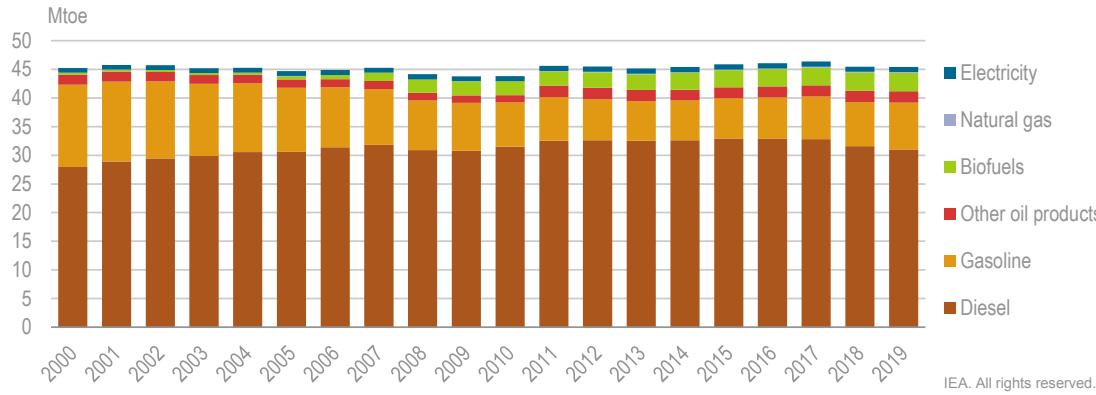
Financial measures to support the renovation of public buildings are planned under the Major Investment Plan (2018-22) and the French COVID-19 Recovery Plan. The Recovery Plan offers subsidised loans of up to EUR 4 billion for local authorities for the energy renovation of public buildings, such as schools, sport facilities, graduate school buildings, hospitals, nursing homes and state buildings, for a total of 15 million m².

The Recovery Plan also offers a tax credit for the energy transition of tertiary buildings of small and medium-sized enterprises (SMEs), available from October 2020 to December 2021. France has an innovative programme for energy efficiency in buildings of SMEs. The government set a target in 2019 to reduce the final consumption of buildings in the tertiary sector, with respect to 2010, by 40% in 2030, 50% in 2040 and 60% in 2060. This target includes all tertiary buildings with a floor area of at least 1 000 m².

Transport

After a drop due to the financial crisis in 2008, energy demand in the transport sector remained constant around 45 Mtoe between 2011 and 2019 (Figure 4.10). In 2019, oil products accounted for 91% of energy demand in the transport sector, with diesel covering the largest share (68%), followed by gasoline (18%). Biofuels (80% biodiesel and 20% biogasoline) accounted for 7% of energy consumption in the transport sector. Electricity still has a low share (2% in 2019) and is used mainly for rail transportation. However, the fleet of electric passenger cars has increased notably since 2020, surpassing 650 000 electric vehicles (EVs) and plug-in hybrids on the road in mid-2021 (AVERE, 2021). At the same time, the number of EV charging points rose significantly, to about 45 700 at the end of 2020 (Figure 4.11). After Norway, Sweden, the Netherlands and Germany, France is now catching up in Europe's electric mobility market, reaching the levels of the United Kingdom for new car registrations (IEA, 2021c).

Figure 4.10 Transport total final consumption in France by fuel, 2000-19

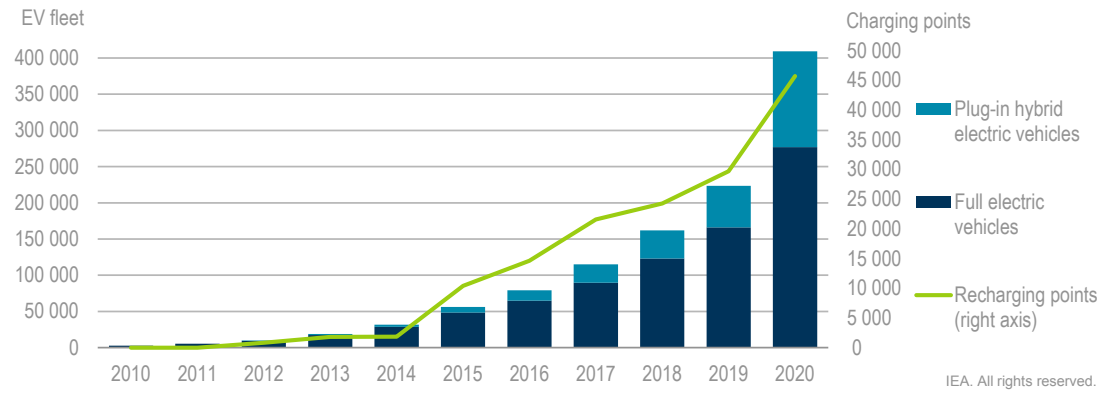


Transport sector consumption has remained flat. Ninety-one per cent of transport demand is covered by oil products, but the share of biofuels is increasing.

Notes: Mtoe = million tonnes of oil equivalent. Transport sector demand excludes international aviation and navigation.

Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 4.11 Total fleet of electric cars and charging points in France, 2010-20



Source: EAFO (2021), France, www.eafo.eu/countries/france/1733/summary.

Road transportation, consisting mostly of passenger cars (58%) and freight road transportation (33%), accounted for 95% of domestic transport demand in 2018, with minor shares of rail and domestic aviation. As of 2008, diesel has replaced motor gasoline as the most used fuel in passenger cars. With an emissions level of newly registered cars of 111 g CO_2/km in 2018, France ranks below the EU average of 122 g CO_2/km (ICCT, 2020), thanks to the bonus/malus scheme.

Transport accounted for 30% of TFC in 2019, or 45 Mtoe, or a 4% increase since 2009. Between 2000 and 2018, the estimated cumulative energy savings in the sector were 26 Mtoe (20 Mtoe from passenger transport and 6 Mtoe from freight transport). In 2018, the transport sector accounted for 30% of total GHG emissions in France, 43% of energy-related CO_2 emissions and 62% of total NO_X emissions.

Energy efficiency policies for the transport sector

Under the SNBC, the transport sector is required to reduce GHG emissions by 31% by 2030 and achieve full decarbonisation by 2050. Emissions from the transport sector have increased by 12% since 1990, and have remained constant since 2000 (similar to the energy consumption trends shown above). The Mobility Guidance Law, enacted on 24 December 2019, sets the framework for achieving emissions reductions actions in the transport sector. The law also sets out the goal of ending the sale of new light-duty vehicles using fossil fuels by 2040. The new Climate and Resilience Law of 2021 bans the sale of the most polluting vehicles from 2030 onwards.

Energy efficiency of the transport system and the vehicles, together with the switch to low-emission fuels (biofuels/biogas, electricity, hydrogen), are the key drivers to leverage emissions reductions, alongside the reduction of transport demand and a modal shift.

The French strategy for improving energy efficiency in the transport sector relies on fiscal measures to encourage the adoption of low-emission (high-efficiency) vehicles; support for EVs and related charging infrastructure; and the promotion of clean mobility with two- and three-wheeled vehicles, carpooling and public transport, and bicycle lanes. The white certificates scheme also applies to the transport sector in France.

The government deploys financial incentives for the purchase of clean vehicles: subsidies (ecological bonus/malus, the scrappage or conversion scheme) and fiscal incentives.

Two subsidies can be used together: the ecological bonus of up to EUR 7 000 for the purchase and replacement of old vehicles with new or used vehicles with emissions lower than 132 g CO_2/km or 137 g CO_2/km (for used vehicles older than 6 months). Under the current policy, the conversion bonus can be as high as EUR 5 000 for passenger cars and EUR 9 000 for commercial vans for low-income households for buying an electric vehicle with emissions less than 50 g CO_2/km. The French government aims to reach 1 million people with this bonus by 2022.

The bonus/malus system is a very effective way to encourage the purchase of less polluting vehicles and support the purchase of EVs. The system is being strengthened with higher penalties (lowering the threshold by 3 g CO_2/km in 2019 and by 5 g CO_2/km in 2020 and 2021) and a new weight penalty of EUR 10/kg for all vehicles over 1 800 kg (except hydrogen or EVs), aiming to counter the trend to larger and heavier sport utility vehicles in France.

There are also substantial subsidies for low-emission vans, trucks and buses, notably used by cities. The government supports investments in clean heavy-goods vehicles, extending the additional depreciation scheme for natural gas vehicles until 2024, reinforcing the scheme for heavy-goods vehicles weighing less than 16 tonnes and establishing technological neutrality to the measure, with the aim to extend it to vehicles fuelled with hydrogen or electricity.

In January 2020, the reduced diesel tax rate for freight transportation by road was increased by EUR 0.02/litre, and since 1 July 2021, the tax advantage for non-road diesel vehicles has been removed. The solidarity tax on airline tickets is planned to be increased to support sustainable transport infrastructure. The Climate and Resilience Law (published on 24 August 2021) prohibits domestic flights for short distances where a train ride offers an alternative with a journey of 2.5 hours or less, offers further subsidies for electric bikes,

and empowers mayors to create low-emission zones in major cities and ban the sale of the most polluting vehicles. The introduction of the government's vehicle air quality certificate (Crit'Air) has allowed cities to regulate and reduce circulation during peak pollution times and ban old diesel vehicles from circulating in the cities. The certificate is mandatory to drive into low-emission zones of cities. By 20 June 2021, around 20 million certificates had been issued in France.

Financial incentives are in place for the roll-out of charging infrastructures with tax credits and subsidies. The national programme ADVENIR develops smart charging infrastructure for EVs in enterprises', public entities' and residents' parking lots, and on roads with fast charging stations. The programme also trains professionals and raises awareness among local actors.

Through the Recovery Plan, the French government is investing EUR 1.6 billion in low-emission vehicles, in addition to other funds for removing barriers to the fast deployment of EVs and related infrastructure. As set out in the PPE, the government aims to increase EV sales in France to 1.2 million by 2023 and 4.8 million by 2028, from about 657 881 in mid-2021 (AVERE, 2021). The charging infrastructure requires special attention if France wants to meet its ambitious EV roll-out targets.

Regulatory measures and incentives are dedicated to the development of urban planning to further encourage the use of sustainable mobility. This includes widening low-emission zones and adding dedicated lanes and parking spaces for two- and three-wheeled clean mobility, including a package up to EUR 400 per user per year to encourage the use of bikes and carpooling for commuters.

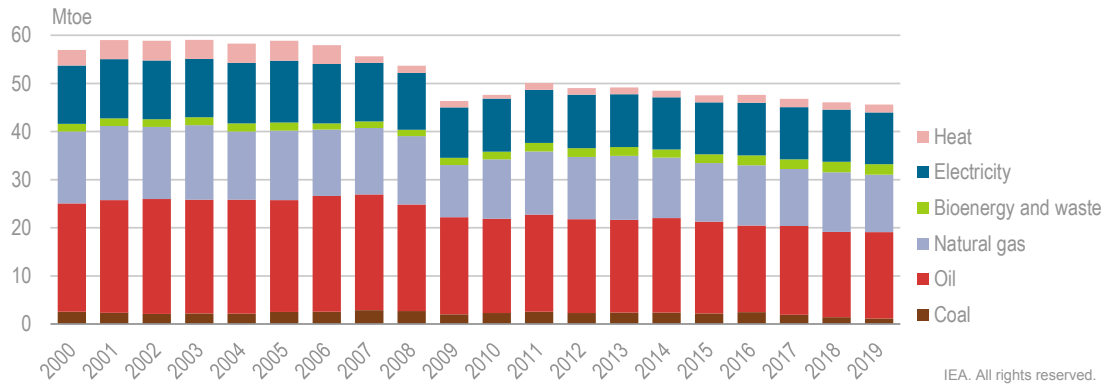
Multimodal mobility has also been promoted by lowering taxes on river navigation. The energy consumption tax has been extended to river navigation and the final electricity consumption tax rate has been reduced for boats and ships using electricity directly when docking. Under the Recovery Plan, rail transport will be upgraded with a view to reduce highway freight transport, in addition to investments in new rail infrastructure (EUR 1 billion by 2024 and 12 billion in 2025-30).

Industry

France's industry sector consumed 46 Mtoe, or 30% of TFC in 2019. In 2009, energy demand in industry dropped to a record low due to the financial crisis, then recovered in 2010-11, but not back to the levels prior to the 2008 financial crisis. Since 2011, energy demand in industry started to decrease again to return to 2009 levels in 2018 and set a new record low in 2019 (Figure 4.12). This is largely the result of relocation and closures.

Oil is the single largest energy source in industry (39% in 2019), followed by natural gas (26%), electricity (24%), bioenergy (5%), heat (4%) and coal (3%). Between 2009 and 2019, the use of fossil fuel decreased: coal by 43%, oil by 11% and natural gas by 10%; while bioenergy increased by 47% and electricity by 2%.

Figure 4.12 Industry total final consumption in France by source, 2000-19

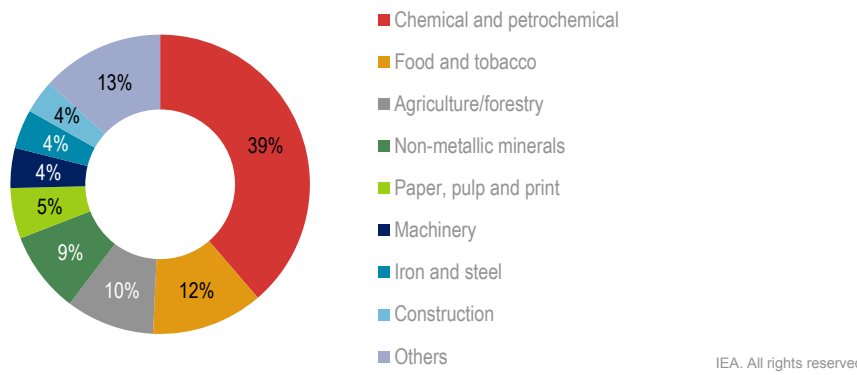


Energy demand in industry has been decreasing, led by a decrease in coal, oil and natural gas. The use of bioenergy increased by 47% between 2009 and 2019.

Notes: Mtoe = million tonnes of oil equivalent. Includes non-energy use in the chemical and petrochemical sector.
Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The largest industry subsector is chemical and petrochemical (39%), including energy use (40%) and of fuels used as raw material in the processes (60%) (Figure 4.13). Other large energy consumers in industry are food and tobacco, agriculture/forestry, non-metallic minerals (9%) and construction subsectors.

Figure 4.13 Industry total final consumption in France by subsector, 2019



The chemical and petrochemical sector was responsible for about 40% of energy consumption in industry in France in 2019.

Source: IEA (2021b), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy efficiency policies for the industry sector

To achieve carbon neutrality in 2050, the SNBC forecasts a significant drop in industry emissions (-35% in 2030 and -81% in 2050 compared to 2015 levels).

Several regulatory obligations apply to the industry sector. Energy audits are mandatory for large companies under the EU EED (Article 8 of Directive 2012/27/EU) and the French

Energy Code. Audits are performed in accordance with EN 16247. Companies which have an ISO 50001 certification are exempt.

The government also requires industry to carry out a cost-benefit analysis with regard to the recovery of residual heat (for facilities above 20 megawatt thermal [MW_{th}]), in line with EU EED requirements (Article 14-5 of Directive 2012/27/EU, as part of the regime for installations classified for environmental protection in the Environment Code).

The white certificates and ADEME's heat funds have also been used in industry. Funding is available through ADEME for biomass use for companies with more than 12 000 MWh/year of consumption); residual heat recovery; the installation of large solar thermal surfaces for collective housing, industry, and the tertiary and agricultural sectors; and for deep geothermal projects.

The 2020-22 Recovery Plan identifies decarbonisation of the industry sector as a priority, allocating EUR 1.2 billion of additional support. This covers three new schemes: 1) investment aid for energy efficiency projects; 2) investment aid for industrial processes (electrification) and support for the production of renewable heat with both investment and operational aid for large-scale projects; and 3) grants for small and medium-sized projects.

Assessment

Energy efficiency is the central pillar of France's National Low-Carbon Strategy, and the government is banking on a very ambitious decrease of final energy consumption by 50% between 2012 and 2050, with a 20% reduction by 2030. In fact, France relies on the concept of sobriety, in line with climate constraints. However, to maintain robust growth of the economy and consume less, productivity needs to increase and behavioural changes to last.

The 2021-30 National Energy and Climate Plan aims to achieve a decline in primary energy consumption of 219 Mtoe in 2020 to 202 Mtoe in 2030, and a decline in final energy consumption of 131 Mtoe in 2020 to 120.9 Mtoe in 2030. In 2019, final energy consumption was 145.5 Mtoe, much above the 2020 target, which could only be achieved because of the COVID-19 pandemic and the temporary dip in energy demand in France.

As of 2018, France achieved 322 TWh (27.7 Mtoe) of energy savings, which is on track with the progress requested by the Energy Efficiency Directive of 365 TWh (31.4 Mtoe) for 2020. However, the targeted doubling of the savings by 2030 (to reach 758 TWh) will require a major scale-up of cross-sector action, notably under the well-established white certificate scheme.

France has made progress in strengthening building codes and labelling and has also enlarged the application of energy audits for enterprises and enhanced measures to improve the efficiency of the mobility system. Cumulative end-use energy efficiency savings between 2000 and 2018 amounted to 260 Mtoe (11.1 PJ) in total. Sixty-four per cent of savings were achieved in the residential sector, 26% in the service and industry sectors, and 10% in the transport sector.

Under the Energy and Climate Law of 2019, the government relies on strong targets for the reduction and phase-out of fossil fuel consumption (coal, gas and oil use) in heating, transport and industry in favour of greater electrification.

While France's efforts are laudable, meeting the energy efficiency targets for 2030 will require continuous progress. To put the country on the trajectory to 2050, pivotal changes in the economic structure and consumer behaviour are required. While electrification is also a driver for energy efficiency, electrification without energy efficiency can result in overinvestment. Efficiency should therefore be tackled with priority across the energy system, including through greater attention to energy system integration.

The energy saving certificates system is the key policy to achieve energy savings across sectors. A fifth period will start in 2022. The government should review the results of the fourth period when designing the fifth one. Since its start in 2006, the obligation has gradually increased (ten times) and energy efficiency services have been developed.

ADEME's independent evaluation of the white certificates in 2019 found that the certificates still created windfall profits (ADEME, 2019b). Among the 16 recommendations, ADEME suggested the creation of an independent commission to periodically evaluate the actual energy savings. Most of the gaps have been filled in recent years through the reinforcement of measurement and verification processes and recalibration of expected savings from the certificate. Progress is visible with energy service company (ESCO) schemes being created in France. In its latest 2019 review, ADEME showed that 59% of CEEs were real energy savings. However, 41% of savings still relate to fraud and an overestimation of energy savings.

In the scheme's upcoming fifth period, the government plans a revaluation of standardised operations lump sums and to increase the fight against fraud. The continued effort to improve the scheme and its performance regarding the effectiveness of renovation, the work of ESCOs and the actual savings performed remains a vital task, in light of the ambition to double energy savings in the next ten years.

Thanks to the big role of electric heating and leadership in times-of-use pricing, France has great potential to increase digitalisation and smart grids to boost both decarbonisation and energy efficiency. The complete roll-out of smart meters in France presents an opportunity to reward flexibility, even at the residential level through the introduction of dynamic prices, offers for smart charging or grid dispatch of EVs, week-end tariffs, and super off-peak hour products.

Buildings

Buildings (including residential and service sector buildings) were the main sector of TFC in France in 2019 (with around 40% of TFC) and were responsible for 25% of national GHG. Between 2000 and 2018, the cumulative estimated energy savings thanks to energy efficiency improvements in residential buildings amounted to 171 Mtoe.

Past performance trends are far from the required climate and energy targets for buildings. Climate neutrality translates into a 49% decrease in GHG emissions by 2030 (compared to 2015 levels), with an envisaged 22% drop in energy consumption in the building sector by 2030, 29% by 2040 and 41% by 2050.

Since the IEA's last review in 2015, France has strengthened buildings regulations for new constructions and the energy performance certificate.

With the entry into force in 2022 of the Environmental Regulation (RE2020), the carbon footprint of the building material and heating systems will have to meet an emissions performance standard of 4 kg CO_2/m²/year for all new single dwellings and progressively

for all multi-apartment buildings (6.5 kg CO_2/m^2/year). France is joining the Netherlands, Sweden and the United Kingdom with these rules. It is expected that woody biomass and heat pumps will gain market shares.

In the renovation of existing buildings, however, overall progress has been limited, notably in historic and old multi-apartment buildings and public buildings, such as hospitals, schools and governments, because of structural barriers, insufficient awareness of the issues associated with reducing energy consumption, but also separate regulatory standards for self-consumption and white certificate schemes. The creation of the National Observatory of the Energy in Building Renovation in 2019 is a welcome development. This will build on the excellent work of ADEME and others and should allow the government to better monitor the process. The High Council on Climate's 2020 report found that only 0.2% of all renovations were providing a real increase in energy efficiency (HCC, 2020). The HCC recommended a one-stop-shop for citizens to get access to all subsidies available for renovation. Such a simplification is indeed a very important tool for making major improvements in the renovation of buildings. A dedicated public investment bank, like the Bpifrance, could be a good tool to channel such funds, notably the éco-PTZ loans with higher amounts and longer loan periods, similar to the experience of the German KfW.

Based on the 2019 Energy and Climate Law, a key focus for government action is the eradication of inefficient homes (so-called energy sieves) with the F or G performance certificate.

France's long-term renovation strategy, which was submitted to the European Commission in 2020, outlines 12 actions along 4 priorities. The Energy Renovation Plan for Buildings (2017-22) is an important driver for public renovation efforts. Its aim is to end the use of fuel oil in government buildings by 2029. The French government is also increasing its effort to open data on the specifics of government buildings, including floor area and type of energy used for heating.

Public funding remains critical for scaling up renovation and the mobilisation of private finance and renovation progress. The Recovery Plan offers subsidised loans of up to EUR 4 billion for state and local authorities for the energy renovation of public buildings such as schools, sport facilities, graduate school buildings, hospitals, nursing homes and state buildings, for a total of 15 million m². School buildings represent 50% of the local authorities' building stock.

The government is making major changes to existing schemes to improve access to subsidies, bring together various public grants and loans to finance the remaining expenses as well as easing access to the support of energy companies via the CEE. For example, France changed its long-standing CITE into a subsidy. MaPrimeRénov' is a grant, which is expected to deliver renovation progress faster than a tax credit (which comes only the year after the expense). MaPrimeRénov' is now available to all owners and rental properties. The government has also facilitated the access and ease of funding for homeowners of multi-apartment buildings. Once implemented, the scheme can be further improved and scaled up in the coming years.

The government set a target for all tertiary buildings with a floor area of at least 1 000 m² in 2019 to reduce final consumption. The Recovery Plan also offers a tax credit for the energy transition of tertiary buildings of SMEs, available from October 2020 to December 2021. France's exceptional scheme can provide lessons to other countries.

Transport

The French strategy for improving energy efficiency in the transport sector includes white certificates, fiscal measures to encourage the adoption of low- and zero-emission (high- efficiency) vehicles (bonus/malus scheme at the registration and scrappage premium), subsidies for the purchase of EVs and charging infrastructure, and the promotion of clean mobility with two- and three-wheeled vehicles and carpooling.

France was one of the first countries to adopt the target of phasing out the sale of new light-duty vehicles that use fossil fuels by 2040, as part of the Mobility Law, but deployment of EVs has been slower than expected. Other countries already have higher targets and more ambitious timelines, including Germany and the United Kingdom. The government should review efforts and emissions reduction ambitions to further accelerate efficiency and the shift to cleaner vehicles. It is a good signal that the new Climate and Resilience Law 2021 includes a ban of the sale of the most polluting vehicles from 2030 onwards.

To meet its target, the government is investing EUR 1.2 billion under the Recovery Plan on clean mobility, removing barriers to the fast deployment of EVs and related infrastructure.

The SNBC projects for 2030 a 35% share of electric cars and 10% for hybrid cars in new vehicles sales, 45% in total, up from 2.8% in 2019 for the two combined. Considering total car sales of 2.2 million in 2019, this would mean about 1 million EVs sold in 2030 and 7 million public/private charging points. The 2020 PPE strengthened this target: the government aims to increase the sales of plug-in hybrid and electric vehicles in France to over 1 million EVs on the road in France by 2023 and 4.8 million by 2028. This would mean an increase from 657 881 in mid-2021 to 1.2 million in two years. However, the government estimates it could meet the EV deployment target in 2023. The bonus/malus system has worked very well in the past, but the recent Finance Law of 2021 has cut back the subsidies of the Recovery Plan.

COVID-19 has led to a massive reduction in transport demand and behavioural changes with a considerable modal shift. However, it remains unlikely that these short-term trends in 2020-21 will be sustained in the medium term as the French economy reopens in 2021-22. Policies should focus on the long-term behavioural changes needed in vehicle use and type and in the transport system as a whole.

Industry

Industry accounted for 30% of TFC in 2019, or 46 Mtoe, a 4% decrease since 2009. France has several large energy-intensive sectors, notably chemical and petrochemical, food and tobacco, agriculture and forestry, and non-metallic minerals.

While energy audits are mandatory in large industries, implementation of the audit results is not. Implementation of measures with a pay-back time of 5 years or less could be made compulsory to enhance the energy efficiency of the sector.

Commendably, the 2020-22 Recovery Plan identifies the decarbonisation of the industry sector as a priority, with an allocation of EUR 1.2 billion of additional support. This includes energy efficiency and the production of renewable heat, supporting both investments and operational costs of large-scale projects, and grants for SMEs. These measures are very helpful to drive industrial transformation and to tap into the large potential for energy efficiency in SMEs.

As a trade-exposed sector, France's manufacturing industry could also benefit from international action. By joining the Super-Efficient Equipment and Appliance Deployment initiative, led by the United Kingdom and co-ordinated by the IEA, France can show leadership on ambitious appliance policy, publish transparent plans for raising ambition between now and 2030 using all available tools, engage with the private sector to enhance trade in highly efficient products and engage with other economies to support their market transformation to highly efficient appliances.

Recommendations

The government of France should:

- Review energy efficiency progress and identify sub-targets by sector and strengthen measures and funding ranked by their cost-effectiveness to implement the 2030 energy efficiency goals.
- Strengthen the white certificates system, improve its effectiveness and enhance synergies with other regulatory frameworks both for private housing and for industry and further simplify administrative procedures.
- Accelerate the renovation of existing buildings in the residential sector and all public buildings and review the outcomes and effectiveness of all support instruments, including the MaPrimeRénov'.
- Boost the policy measures on digitalisation and integrate times-of-use pricing, smart systems/grids and renewable energy opportunities into energy efficiency policies as part of a dedicated sector integration strategy.
- Anticipate possible COVID-19 pandemic rebound effects by supporting policy measures that ensure long-term changes in the mobility behaviours of French citizens, including modal shift, electric mobility, walking and cycling.
- Make mandatory the implementation of energy efficiency audit results in the industry sector and join international efforts with industry and governments to scale up standards.

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5. Renewable energy

Key data (2019)

Renewables in total final energy consumption (TFEC): 19.4 Mtoe/15.8% of TFEC (bioenergy* 12.2 Mtoe, hydro 3.7 Mtoe, wind 2.3 Mtoe, solar 1.0 Mtoe, geothermal 0.2 Mtoe)

Renewables in electricity generation (2020 estimated): 125.7 TWh/23.8%** (hydro 62.2 TWh, wind 40.7 TWh, solar 13.6 TWh, bioenergy* 8.6 TWh, tide/wave 0.5 TWh, geothermal 0.1 TWh)

Renewable shares:* ** gross final consumption 17.2%, electricity 22.4%, heating and cooling 22.5%, transport 9.2%

Renewable 2020 targets: gross final consumption 23%, electricity 27%, heating and cooling 33%, transport 10.5%

Renewable 2030 targets: gross final consumption 33%, electricity 40%, heating and cooling 38%, transport 15%

* *Bioenergy* includes solid primary biofuels, liquid biofuels and biogases, and excludes non-renewable industrial and municipal waste.

** According to the IEA definition: share of renewables in electricity generation.

*** Computed according to Eurostat definitions for consistency with EU targets. Eurostat definitions include normalisation of wind and hydro renewable electricity consumption, and multiplication factors for advanced biofuels and renewable electricity in transport.

Overview

Developing renewable energy sources will be instrumental to reaching net zero targets by 2050 and maintaining France's low-carbon electricity mix, as the share of nuclear energy is expected to decline from 70% in 2019 to 50% by 2035 in line with the 2019 Energy and Climate Law. France has the ambition to boost the share of renewable energy to 33% in total energy consumption and 40% in electricity production by 2030. The government set ambitious near-term targets under the PPE for 2023 and 2028. There is a widening gap between ambition and development on the ground.

In 2021, France is examining a range of scenarios in preparation of a decision on the role of nuclear in the electricity mix beyond 2035. The International Energy Agency (IEA) and RTE (the transmission system operator) jointly analysed the conditions for the technical feasibility of a power system with high shares of renewable energy towards 2050.

Over the past decade, wind and solar photovoltaic (PV) electricity generation have increased, driving the share of renewables in electricity generation from 14% in 2010 up to 24% in 2020. Hydropower represents half of renewable electricity generation.

However, France is not on track to meet its targets. France missed its target for a 23% share of renewables in gross final energy consumption by 2020, but had 17.2% in 2019 and 19.1% in 2020 (provisional) (MTE, 2021). The gap to the 2023 targets under the multiannual plan (PPE) is massive: France needs to add 6 gigawatts (GW) of wind capacity (or 40% of total cumulative capacity to date) and almost double the solar PV capacity in the remaining years up to 2023.

The delivery gap is mainly due to the very long permitting procedures, which entail burdensome administrative authorisations, and lack of land availability, despite a range of reforms under way. The government has engaged in legal changes to reduce administrative barriers (Loi ASAP), address social concerns and opposition, but also increase the say of local communities.

The revision of support mechanisms has been chaotic and their implementation takes too long, like for new solar tariffs. The stop-go policies, notably the retroactive cuts on solar, are undermining investors' confidence and future investment. While services in charge of renewable energy across government are very qualified, they are understaffed. The country needs to make fast progress in the development of renewable energy by increasing the effectiveness of its policies and support schemes.

In 2021, the government has started work to promote a stronger regionalisation of the renewable energy planning, with regional targets under the PPE, as reflected in the 2021 Climate Resilience Law (adopted on 24 August 2021). Close co-ordination and dialogue of national and regional plans and targets is needed to prevent the regional targets from actually hampering wind energy deployment.

Renewables accounted for 22.5% in heating and cooling and 9.2% in transport in 2019. France has had a dedicated support scheme for renewable heating, but progress on the ground remains limited. To shift heating and cooling to renewable energy sources, the consistency of targets and support will be important, notably considering the end of support for co-generation[1] (biomass/natural gas) and reduced support for biogas/biomethane.

Progress towards renewable targets

Under the European Union's (EU) Renewable Energy Directive (RED-I), France had a target to reach 23% renewables in gross final energy consumption by 2020. Starting from a low level, France saw major increases in the share of renewables across heat, transport and electricity. However, France is not on track to meet its overall 2020 target for renewable energy, projected to be 19.1% in 2020 (preliminary data). For the heat sector, France only achieved 40% of the targeted share by 2019 and is also below target for electricity.

[1] Co-generation refers to the combined production of heat and power.

Table 5.1 France's renewable energy targets by sector for 2020 and 2030

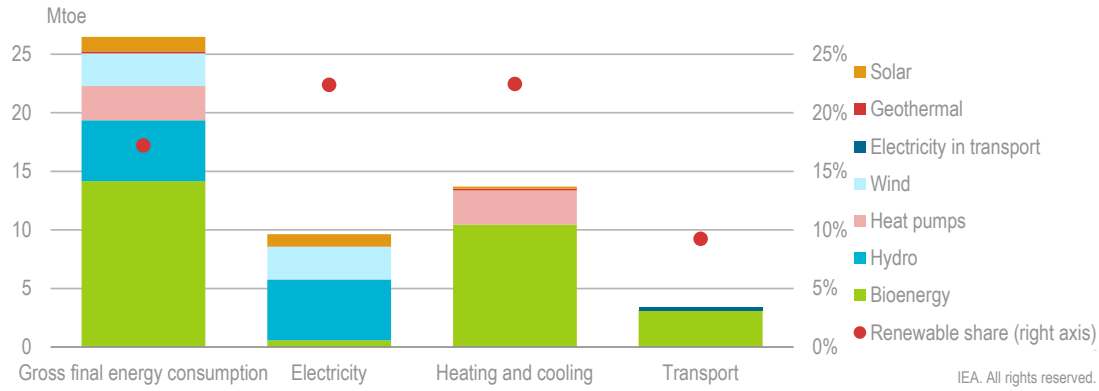
Sector	2019 (share in %)	2020 target	2030 target
Total total final consumption	17.2%	23%	33%
RES-E	22.4%	27%	40%
RES-H/C	22.5%	33%	38%
RES-T (green gases)	9.2% (7% of first-generation biofuels achieved)	10.5%	15% (10%)

Note: RES-E = electricity from renewable energy sources. RES-H/C = renewable energy heating/cooling. RES-T = renewable energy sources in transport.

Sources: EC (European Commission) (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares; MTE (2020a), *National Energy and Climate Plan (NECP)*, https://ec.europa.eu/energy/sites/default/files/documents/fr_final_necp_main_en.pdf.

EU 2019 data show that renewables accounted for 17% of gross final energy consumption in France,[2] 22% each of electricity generation and of heating and cooling demand, and 9% of transport demand (Figure 5.2). The gap to the 2020 target is wide.

Figure 5.1 France's renewable energy by sector, 2019



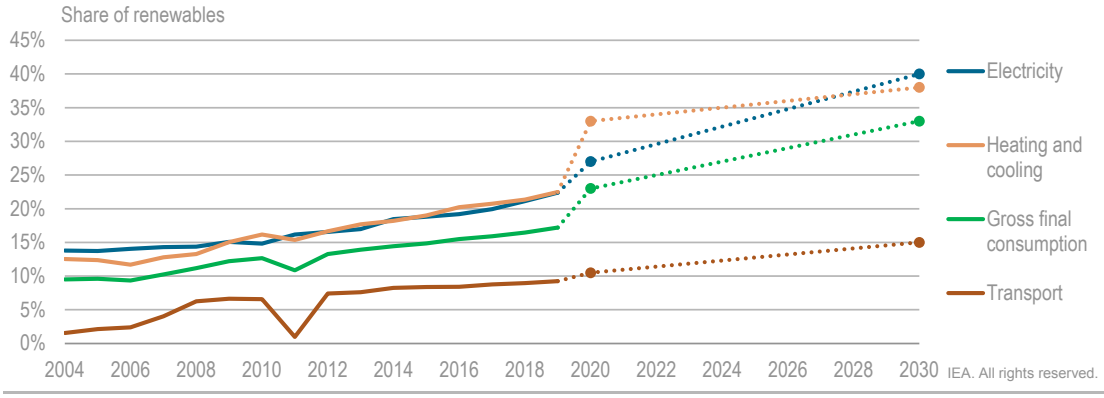
While renewable energy in heating and transport is dominated by bioenergy, renewable electricity is more diversified and comes mainly from hydro and wind.

Notes: Mtoe = million tonnes of oil equivalent. Shares of renewables are computed using the Eurostat definition.

Source: EC (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

[2] Gross final energy consumption, as defined in Directive 2009/28/EC, covers energy commodities delivered for energy purposes to final consumers (industry, transport, households, services, agriculture, forestry and fisheries), including the consumption of electricity and heat by the energy branch for electricity and heat production, and including losses of electricity. Electricity generated by hydropower and wind has to be normalised for annual variations (hydro 15 years and wind 5 years).

Figure 5.2 France's progress towards 2020 and 2030 goals for renewable energy deployment



Source: EC (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

For 2030, France has set targets in its National Energy and Climate Plan for the contribution of renewables in gross final consumption (33%), electricity (40% of renewables power production in total power generation), heating and cooling (38% by 2030), and transport (15%).

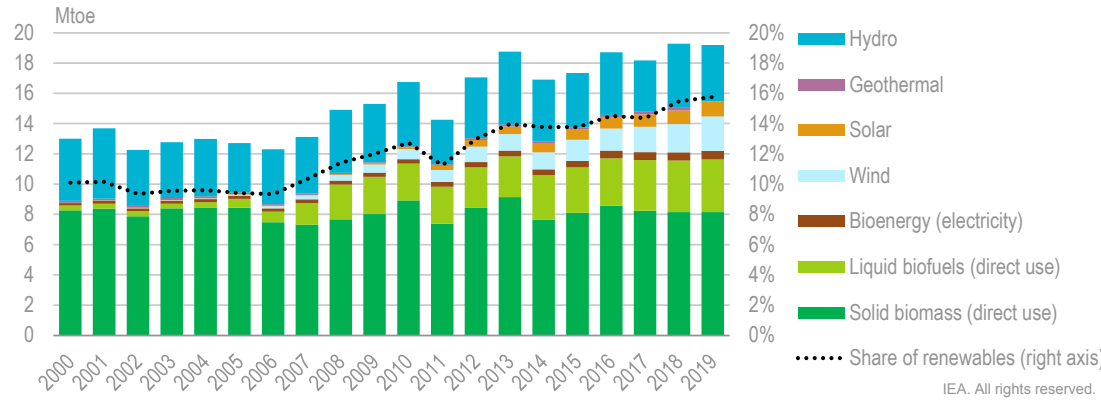
Trends in renewable energy by sector

IEA data show a positive trend: the share of renewables in France's total final energy consumption (TFEC)[3] was 15.8% in 2019, a 31% increase since 2009 (Figure 5.3). Renewables energy consumption in France consisted mainly of bioenergy (63%), followed by hydro (19%) and wind (12%). Energy consumption from solar power is increasing fast, but still only accounted for 5% of renewable TFEC in 2019. Geothermal contributes to renewable electricity and heat.

The highest penetration of renewables is in the industry sector, where renewable sources meet 24% of the total sector's energy consumption (excluding non-energy use, such as feed stocks in chemical and petrochemical), followed by buildings, where they cover 20% of energy consumption. In both cases, renewables consist mainly of solid biomass and renewable electricity (Figure 5.4).

[3] TFEC excludes non-energy use, which is counted in total final consumption (TFC). TFEC provides a more accurate assessment of the share of energy demand covered by renewable energy and is better aligned with the EU's gross final energy consumption metric, which is used to set EU member states' renewable energy targets. However, feedstocks included in non-energy use may end up as energy use and contribute to CO_2 emissions.

Figure 5.3 Historic trend of renewable energy in total final energy consumption in France, 2000-19



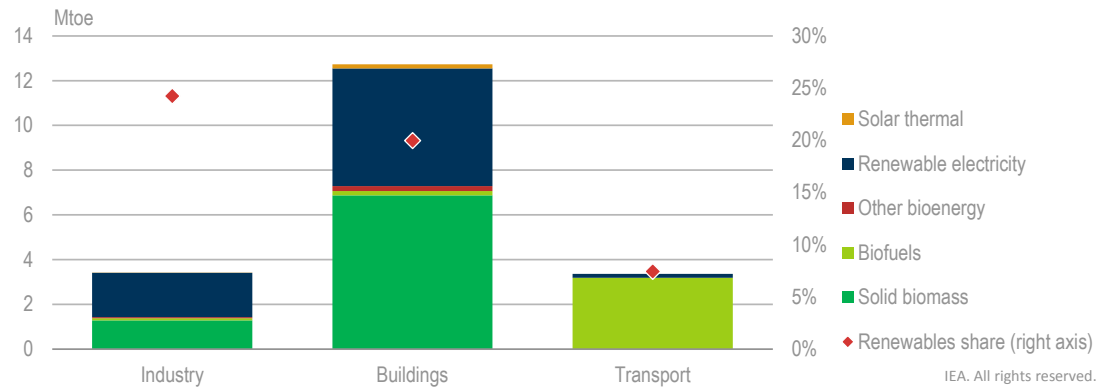
While renewables in total final energy consumption are still dominated by bioenergy, growth in recent years has been driven by solar and wind.

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Renewable heating and cooling are mainly provided by bioenergy (and heat pumps), with small contributions from solar and geothermal. Biofuels cover most of the renewable energy used in the transport sector. Renewables provide 7% of the energy needs in transport (without considering the EU's multiplication factors for advanced biofuels and renewable electricity in transport).

Figure 5.4 Renewable energy consumption by sector in France, 2019



Renewables cover 12% of buildings energy demand, 7% of transport and 5% of industry.

Notes: Mtoe = million tonnes of oil equivalent. Ambient heat harnessed by heat pumps is not represented here due to limited data availability, but represents an increasing share of renewable heat supply in buildings and industry.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Policies and measures

In April 2020, the government presented an updated National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone, SNBC) to align with France's pledge for climate neutrality by 2050. The SNBC includes targets by fuel, in line with the 2019 Energy and Climate Law. For renewable energy, the government translated the SNBC's goals into concrete targets for two five-year periods up to 2028 under the updated multiannual energy plan (PPE) of 2020.

The PPE sets out the calendar of renewable energy tenders until 2028 and progress is reviewed every five years. The government adopted sector (non-binding) targets for electricity, heating/cooling and transport under the National Renewable Action Plan, which are now integrated into the National Energy and Climate Plan. France did not yet set the targets for the sources of electricity beyond 2035. To assess scenarios of higher shares of renewable electricity, the IEA and RTE presented a joint study in 2021 (see Box 5.1).

Table 5.2 France's targets by fuel for the electricity mix up to 2035

	2023	2028	2030	2035
Renewables	27%	33-36%	40%	45%
Nuclear	67%	59-61%	-	50%
Fossil fuels	6%	5%	5%	5%

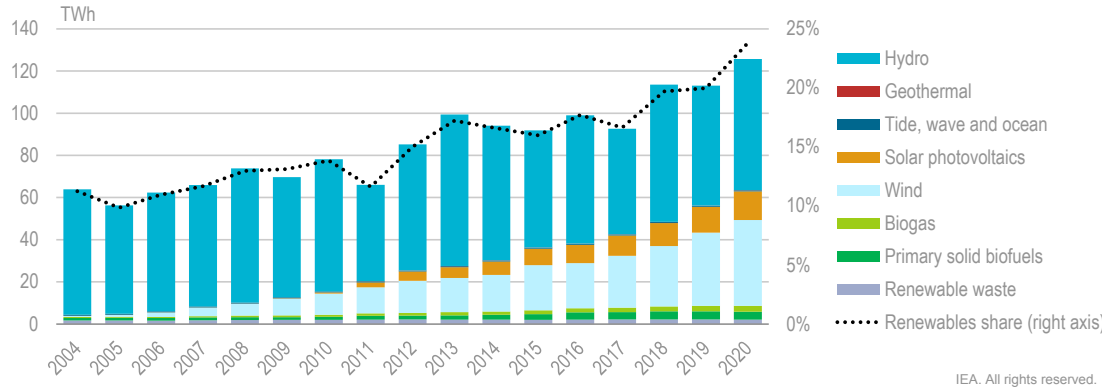
Note: 2035 targets are only indicative as opposed to the binding 2020 and 2030 targets.

Sources: MTE (2020b), *National Low-Carbon Strategy*, www.ecologie.gouv.fr/sites/default/files/2020-03-25_MTES_SNBC2.pdf; MTE (2020c), PPE (with a range outlining the two scenarios), www.ecologie.gouv.fr/sites/default/files/20200422 Programmation pluriannuelle de l%27énergie.pdf

Renewables in electricity

According to IEA data, between 2010 and 2020, renewable electricity production in France increased from 14% to 24% of total power generation, thanks to growing generation from solar, wind and bioenergy (Figure 5.5). Generation from hydro formed a strong basis, providing almost half of renewable electricity generation in 2020, with fluctuations between 45 terawatt hours (TWh) (2011) and 72 TWh (2013), depending on water availability. In 2020, 126 TWh of electricity was generated using renewable energy sources: 57 TWh from hydro, 35 TWh from wind, 13 TWh from solar and 9 TWh from bioenergy.

Figure 5.5 Renewable electricity generation in France, 2004-20



Wind and solar photovoltaic electricity generation increased significantly between 2010 and 2020, driving the share of renewable electricity generation up to 24% in 2020.

Note: TWh = terawatt hour.

Sources: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The PPE sets two five-year plans for each technology and envisages a five- to sixfold increase in solar PV capacity and a 2.5-fold increase in wind capacity by 2028, from 2017 levels. As shown in Table 5.3, the gap is widening; progress to the 2020 target is low, but the distance to the 2023 target even greater. Between 2020 and 2023, solar PV capacity needs to almost double, and wind would need to add 6.4 GW (i.e. 40% of total cumulative capacity to date) in three years. The first offshore wind farm in France will be commissioned in 2022. Only one floating prototype of 2 megawatts (MW) (Floatgen) is in operation. Construction works have started for the wind parks in Saint-Nazaire and St Brieuc.

Table 5.3 Targeted promotion of renewable electricity capacity (GW)

Source	2021	2023	2028
Hydro	25.6	25.7	26.4-26.7
Onshore wind	17.7	24.1	33.2-34.7
Offshore wind	0	2.4	5.2-6.2
Solar photovoltaic	11.9	20.1	35.1-44.0
Biomass	0.67	0.8	0.8
Biogas/biomethane	0.5	0.27	0.34-0.41
Geothermal	0.014 (2019)	0.024	0.024
Total		**73.5**	**101-113**

Sources: MTE (Ministry of the Ecological Transition) (2021a), Renewable energies in France in 2020 – Monitoring of Directive 2009/28/EC relating to the promotion of the use of renewable energies, www.statistiques.developpement-durable.gouv.fr/les-energies-renouvelables-en-france-en-2020-suivi-de-la-directive-200928ce-relative-la-promotion. MTE (2020c), PPE (with a range outlining the two scenarios), www.ecologie.gouv.fr/sites/default/files/20200422 Programmation pluriannuelle de l%27énergie.pdf

Box 5.1 Technical conditions for a power system with a high share of renewables in France towards 2050

The Ministry of the Ecological Transition commissioned a framework report jointly from the IEA and RTE, France's transmission system operator, to identify the conditions and requirements to assess the technical feasibility of a power system based on very high shares of renewables. The report was published on 27 January 2021 and outlines four groups of strict conditions that need to be met to integrate very high shares of renewables in a technically secure way in a large and meshed power system such as that of France.

Power system strength: Even if they still need to be proven at large scale, there is general scientific consensus that technological solutions to maintain system strength – and therefore stability – without conventional generation exist in several cases. Specific difficulties are expected in the case of a system with a significant share of distributed solar photovoltaics (PV). Further assessment of the impacts of distributed PV on the power distribution network and their implications for electricity security is needed.

System adequacy: This is the ability of a power system to cope with a given load at all times. It can be ensured even in a system mainly based on variable renewables, as long as substantial sources of flexibility are available, including demand response, large-scale storage, peak generation units, and well-developed transmission networks and interconnections. The maturity, availability and cost of different flexibility mixes need to be further evaluated.

Operational reserves: The sizing of these reserves and the regulatory framework for balancing responsibilities and procurement would need to be substantially revised in a large power system such as France's. Moreover, forecasting methods for variable renewables would need to be continually improved.

Grid development: Substantial efforts would be necessary beyond 2030 at both transmission and distribution levels. This requires strong proactive steps and public engagement in long-term planning to assess costs and work with citizens on social acceptance of new infrastructure. These efforts can nonetheless be partially integrated into the renewal of ageing network assets.

Assessing the costs of these conditions is outside the scope of the joint study. However, the report underlines that costs may be substantial and that these conditions have deeper technical and social implications.

On 27 January 2021, RTE opened a public consultation assessing this framework and assumptions of these future scenarios, and further studies – building on the conclusions of the framework report – are necessary to assess the different options to reach carbon neutrality by 2050 in France.

In October 2021, RTE published its full assessment of different electricity scenarios towards carbon neutrality (RTE, 2021).

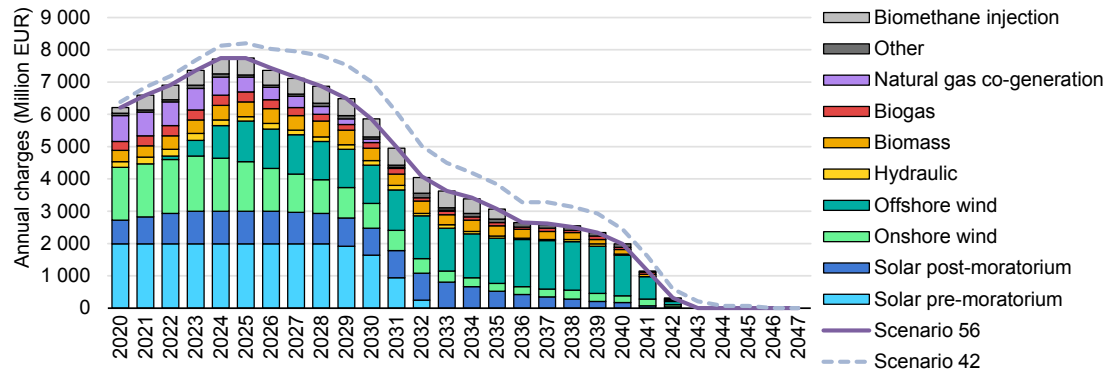
Source: IEA (2021c), Conditions and Requirements for the Technical Feasibility of a Power System with a High Share of Renewables in France Towards 2050, https://www.iea.org/reports/conditions-and-requirements-for-the-technical-feasibility-of-a-power-system-with-a-high-share-of-renewables-in-france-towards-2050.

Renewable electricity support schemes

France promotes renewable electricity through feed-in tariffs[4] for small-scale renewable plants and feed-in premiums issued in tenders for large-scale facilities. Large-scale tenders have been organised for offshore wind, onshore wind, solar rooftop and biomass co-generation projects. The new call for a tender[5] for 2021/26 was approved on 27 July 2021 by the European Commission (onshore renewables with a budgetary commitment up to EUR 31 billion [bln] over 20 years). The Commission also approved a EUR 5.7 bln aid scheme to support renewable electricity production from small solar installations located on buildings in August 2021. Support to biomass and natural gas-fired co-generation ended.

Over the past decade, there have been significant changes in financing for renewable energy support. Until 2016, renewable energy support was financed by the consumer through public service charges on electricity. In 2010, the government declared a four-month moratorium on new solar PV projects to change to a new feed-in tariff framework (Figure 5.6). Later, the support was financed mainly through the internal tax on final consumption of electricity (EUR 22.5/MWh) and tax revenues from excise duties and from 2017 onwards, only through the domestic consumption tax on polluting energy products (oil and coal).

Figure 5.6 France's renewable electricity budgetary commitments (20 years)



Note: Scenario 42 and Scenario 56 are part of the PPE reference scenarios for the share of renewable energy in the energy mix. Co-generation refers to the combined production of heat and power.

Source: MTE (2020).

As of January 2021, the support is charged to the state budget, in line with the 2020 Finance Law. In 2021, the budget support for renewable energies accounted for more than EUR 6 bln, including EUR 5.7 bln for electricity and EUR 544 million for biomethane injection (Figure 5.6). The total cost of renewable energy support committed over the period 2000-19 amounts to EUR 140-154 bln (MTE, 2019). Only EUR 38 bln has been paid so far, while the lion's share of EUR 102-116 bln remains to be paid in the coming decades.

[4] France uses feed-in tariffs for small projects (PV < 100 kW, onshore wind).

[5] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3922.

Large-scale tenders have seen long procedures. The time until the bidding results are announced and the tender awarded is very long, much longer than in other European countries, which accumulates delays in the PPE calendar of tenders.

Grid connection

Connection to the grid has not been a major issue in France. France developed a special legal framework for the development and connection of renewable energy sources, the so-called Regional Connection Schemes to Renewable Energy Networks (S3RenR scheme) to share the costs at the regional level among the renewable project operators and for a small part by the transmission and distribution system operators. The transmission system operator RTE elaborates and implements the schemes. This planning exercise intends to give visibility to the producers and to share equitably the costs among them. Previously, costs were supported only by few producers because of thresholds inside the connection procedures. A state representative in each region formally approves the cost per megawatt. Conversely, for the development of offshore wind, RTE ensures and invests in the necessary grid connections.

Wind power

In 2021, France had 17.7 GW of onshore wind energy connected to the grid and 3.6 GW of offshore wind projects awarded through tenders and calls for projects (no project is online yet).

French authorisation procedures for onshore wind are very restrictive compared to other countries, classifying wind turbines as a potential threat to heritage, landscaping and the environment as a whole (*installation classée pour la protection de l'environnement*). Moreover, spatial constraints, including for defence and civil aviation purposes, such as radars perimeters, remain high and require greater co-ordination across government with a clear prioritisation of renewable energy deployment. The required radar distance of 30 km was extended to 70 km in 2021, which has a negative impact on deployment.

The PPE sets out the calendar of tenders and ensures visibility; however, tenders are delayed for several reasons, from public acceptance issues to lengthy permitting procedures and litigation. Special wind zones were abolished in 2013. Today, tenders are based on price and the zones with the lowest levelised cost of electricity benefit from renewable deployment. Current progress is slower than the tender schedule in the PPE, but there is no consistent tracking of permits or the delays encountered. The latest evaluation of the tenders awarded by the government versus the targets under the PPE dates back to 2016.

France has passed legislative reforms on environmental authority, administrative simplification and litigation treatment, which all allowed the legal framework to be simplified and secured, including the limitation to first and last instance rulings of the administrative appeal courts, a simplified environmental permitting, and the removal of construction permits. The Loi ASAP (Law No. 2020-1525 of 7 December 2020) has been a major step forward. The implementation of these reforms is ongoing in 2021.

There is a lack of planning co-ordination of the different national government entities that work on urban planning, biodiversity guidelines and even the regional plans for spatial planning, sustainable development and equality (*schémas régional d'aménagement, de développement durable et d'égalité des territoires,* SRADDET) approved by the state and the regional climate-air-energy plans (*plans climat-air-énergie territoriaux*, PCAET).

In May 2021, the Ministry of the Ecological Transition announced a national Onshore Wind Charter for 2022, to be prepared together with the industry and regions. This would involve the preparation of guidelines for best practices shared across France on permitting and public engagement. In this context, the Minister of the Ecological Transition requested the prefects of the regions to carry out a mapping exercise of the favourable onshore wind zones for fall 2022, in consultation with the regional directorates for the environment, planning and housing and the local municipalities. Each year by 1 June, an annual summary of the state of play in ongoing authorisations should be prepared by the departments of each region to better track the onshore wind deployment. The government is discussing how to best support local engagement by creating a regional split of the PPE for renewables, for instance in the form of renewable energy zones or regional targets, in close co-operation with the local authorities and others. The 2021 Climate and Resilience Law has provisions that allow mayors to get advanced information about onshore wind projects, but does not provide them with a veto right.

Offshore wind

France has seen important delays in offshore wind. The first investment decisions were only taken in 2019. The first six commercial projects have had to discover and deal with several barriers, notably court proceedings, and lengthy planning procedures, led by the industry consortia.

Offshore wind deployment is low by European comparison, considering the competitiveness of the technology and economies of scale in Europe. With 11 million km² of territorial waters under French jurisdiction and 20 000 km of coastline, France has both an extensive and wind-abundant seafront. France is, however, aiming to catch up with Germany, the Netherlands and the United Kingdom, which is reflected in the increasing targets in the PPE: France plans to award close to 3.5 GW (including 3 floating wind farms of 250 MW each) by 2023 and at least 1 GW/year starting in 2024.

The results of the Dunkirk project were announced in April 2021. For the Dunkirk offshore wind farm (600 MW), Eoliennes en mer de Dunkerque (EMD), a consortium of EDF Renouvelables, innogy and Enbridge, was selected at a strike price of EUR 44/MWh. The Normandy (bottom fixed offshore wind) and Brittany (floating offshore wind) tenders are still under discussion.

Under the PPE, three calls for tenders are planned for bottom fixed wind farms of 2.75 GW and three tenders for floating wind farms totalling 0.75 GW in the first period of the PPE (2019-23), and 1 GW per year (bottom fixed or floating) from 2024 onwards. For bottom fixed wind turbines, a request for tenders for a capacity of 1 GW MW is planned to be launched in 2021-22 in the south Atlantic. For floating wind power, the first 250 MW tender is planned to be launched in south Brittany in 2021, followed by two tenders in the Mediterranean in 2022. The target prices for floating wind represent almost twice the target price of bottom fixed wind power (EUR 120/MWh, EUR 110/MWh).

France used to have a semi-centralised model for offshore wind planning. Developers and consortia had to take all the necessary steps for siting, permitting and financing. Project developers needed to consult with the local authorities and civil society through a public debate. Due to the important delays, the financial terms of the project changed since their first conception and renegotiations of contracts were necessary. These renegotiations were achieved in 2018. Along with the development of the first offshore wind farms in

France, manufacturing plants (most notably, GE, LM Wind, Siemens Gamesa and Chantiers de l'Atlantique plants) were developed and will provide significant local content to these projects.

Building on the lessons on these first farms, France has passed legislative reforms to simplify the legal framework and accelerate processes. The Façade Strategic Documents define the objectives for integrated sea and coastal management, providing for a map with a zoning system identifying zones for the development of wind farms. RTE is now in charge of providing the connection and has adapted its standard grid connection to offshore wind. Thanks to the ESSOC Law (Law No. 2018-727 of 10 August 2018), the government is now in charge of technical and environmental studies for the derisking of the projects as well as consultation with civil society through a public debate aiming to discuss the properties of the farm, especially its location. A simplified environmental permitting (the "*permis envelope*") scheme has also been created. In October 2020, the French parliament adopted the Loi ASAP ("acceleration and simplification of public action"). Article 55 authorises the launch of tender procedures prior to the completion of the public consultation, when the choice of the site is not yet official, and supports faster litigation procedures with the important role of the Council of State as first and last instance. It also limits the duration of the public debate to four months and enables the organisation of public debates at the façade level to decide on the location of several offshore wind farms. This is a major step forward.

In Europe, Denmark and the Netherlands are going one step further and have centralised one-stop shop models for offshore wind development. These governments take the lead in the identification of suitable offshore wind zones, the selection of the sites, the organisation of the permits as well as the award of the financial envelope through tenders. Permitting procedures and tenders are awarded independently of litigation procedures. Tenders can be rolled out at scale and are industrialised.

Solar power

France has ambitious solar PV targets under the PPE, which will require doubling installed capacity in three years up to the end of 2023. However, lack of land eligibility, grid access and lack of administrative resources, regulatory barriers and stop-go support policies are currently preventing France from achieving the targeted 23 GW by end 2023, up from 11.5 GW in March 2021.

France offers feed-in tariffs for small-scale solar PV (up to 100 kilowatt peak [kWp] on rooftops), which can use the scheme for individual and collective self-consumption.[6] Under this scheme, net metering is not allowed and the French regulatory authority CRE regulates a specific grid tariff for self-consumption, notably for collective users. Small self-consumers (< 3kW) can be exempted from balancing responsibility for the surplus fed into the grid. The distribution system operator (DSO) must ensure the transparent and non-discriminatory conditions for the implementation of self-consumption projects and must deploy separate smart meters and a contract between the DSO and the legal entity for collective users. Self-consumption is exempt from the domestic tax on the final consumption of electricity (TICFE) for every project under 1 MW which has improved the

[6] The self-consumption framework is based on an ordinance (ratified by parliament in February 2017) and a decree (No. 2017-676), which became effective in 2018.

business case for solar PV installations in private homes, business and industrial sites in France. Support for large-scale projects (rooftops of 100 kWp – 8 megawatt peak [MWp] and ground solar PV from 500 kWp) is tendered.

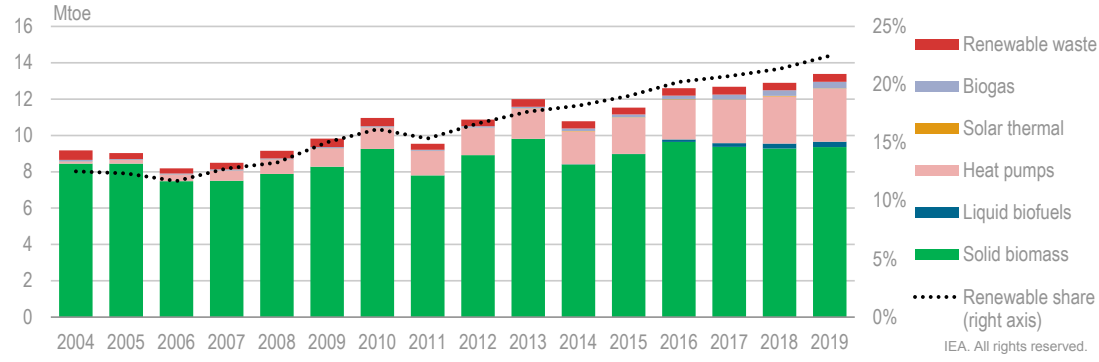
In 2020, the Ministry of the Ecological Transition proposed to revise downwards the solar PV subsidies (feed-in tariff level) for a small number of ongoing projects in their remaining years of contracts until 2030. The law has been adopted but is under review by the Council of State, as it has created controversy among project developers and investors. This unilateral contract modification by the government affects ongoing projects and reduces the generous solar PV tariffs allocated between 2006 and 2010 (reaching EUR 600/MWh for building integrated PV in 2009) with power more than 250 kWp. The French Recovery Plan does not have any additional incentives for the solar sector.

Building regulations, notably the Climate and Resilience Law, mandate solar PV rooftop installations on certain large buildings. They are based on the French Energy Transition Act (2015), which mandated all new buildings built in commercial zones to either be partially covered with vegetation or solar PV. Despite these important upcoming legal provisions, there are many administrative barriers relating to the building code, urban planning and net metering. Municipalities should be supported in the mapping of the solar potential and project development, in particular on commercial buildings, including parking lots. By implementing those measures, France could make fast progress towards its target of 40 GW for 2028.

Renewables in heating and cooling

In France, heat production accounts for half of energy consumption and is still largely based on fossil fuels.

Figure 5.7 Renewable energy in heating and cooling in France, 2004-19



Renewable energy in heating and cooling has been growing, thanks to stable contributions from biomass and the growth of heat pumps in recent years.

Notes: Mtoe = million tonnes of oil equivalent. Shares of renewables are computed using the Eurostat definition for consistency with EU and national targets. This does not include direct use of electricity for heating.

Sources: EC (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

Heat supply in France has already started the transition away from fossil fuels. The use of oil, natural gas and coal has decreased, while the share of bioenergy has increased.

In 2019, 22% of heating and cooling in France was provided by renewable sources. Among those, bioenergy plays the largest role, followed by heat pumps, and small shares of geothermal and solar thermal (Figure 5.7). However, by IEA comparison, France ranks 12th when it comes to the share of renewable heat in total heat generation.

The PPE aims to increase the production of renewable heat by 60% compared to 2017 levels (ranging from 219 TWh to 247 TWh in 2028, or 34-38% of the total consumption of heat) (see Table 5.3). To date, only half of the 2020 heat target has been achieved (Table 5.4).

The amount of renewable heat and cold recovery delivered by district networks is targeted to double compared to 2016 (ranging between 32.4 TWh and 38.7 TWh in 2028).

Table 5.4 France's targets for renewable heat under the PPE 2020 (TWh)

Heat by source	2017	2023	2028 (low)	2028 (high)
Biomass	120	145	157	169
Aerothermal heat pumps	23.5	35	39	45
Geothermal heat pumps	3.14	4.6	5	7
Deep geothermal energy	2	3	4	5.2
Thermal solar	1.18	1.75	1.85	2.5
Biogas (including injected biogas)	4	7	12	18
Total	**154**	**196**	**219**	**247**

Source: MTE (2020c), PPE, www.ecologie.gouv.fr/sites/default/files/20200422%20Programmation%20pluriannuelle%20de%20l%27e%CC%81nergie.pdf

Policies and support schemes

The main support tools for RES-heat are the Fonds chaleur administered by the French Agency for Ecological Transition (Agence de la transition écologique, ADEME) (EUR 350 million per year) and the white certificate scheme (*certificats d'économie d'énergie*), complemented by funding from the Recovery Plan for the heat applications for the decarbonisation of industry (EUR 1.2 billion over the period 2020-22). Support levels are much lower than the funding provided for renewable electricity.

Between 2009 and 2018, ADEME committed EUR 2.16 bln to support local authorities and businesses across all sectors and leveraged EUR 6.7 bln of investments. In addition, the French Recovery Plan provides for investment and operating aid of EUR 1.2 bln over two years (2020-22) for the decarbonisation of industry, with a focus on energy efficiency and low-carbon heat projects.

The government ended support for co-generation based on natural gas or solid biomass. It prioritises the support for heat (over electricity) and has reduced support for biogas co-generation to prioritise gas injection.

Renewable heat has also been incentivised through the CEE, with bonuses to help save energy for industry materials, equipment for individuals, zero-interest loans (éco-PTZ) and the energy transition tax credit (CITE) (which has been converted into the broader MaPrimeRénov') as well as through the revised energy performance diagnostic (DPE), which now introduces a greenhouse gas-based criteria that can favour on-buildings RES

installation. The support schemes have been broadened and simplified over time and are more and more dedicated to heating/cooling (heat pumps, very efficient gas boilers), even though these programmes are not explicitly geared to investment in renewable energy.

Biomethane/biogas support

In less than ten years, biomethane injection capacity has reached 3.9 TWh (214 sites injecting into the gas grid at the end of 2020), equal to the consumption of 900 000 households and more than 15 000 BioCNG and is growing by 60% per year (MTE, 2021b). During the period 2021-23, another 150 sites, or 3 TWh, per year will be added.

Since the 2015 Energy Transition for Green Growth Act, France has had the ambition of reaching a share of 10% of biogas in total gas consumption in 2030. The PPE has set a biogas target of 7% of gas consumption in 2030 and up to 10%, depending on the decline in costs.

Third-party access to the gas network applied to biogas producers prior to 2018. Since then, gas network adaptation costs are no longer solely borne by biogas producers, but have been shared between all gas network users. In 2018, the Agriculture and Food Law (EGAlim Act) established a support scheme for adapting the infrastructure necessary for more biomethane injection.

In 2020 and 2021, France implemented the EU RED II Directive and the government lowered the support tariff for biomethane. The revision of the support schemes was rather chaotic. The new support scheme gives priority to the injection of biogas into the natural gas grids (biomethane) over power generation. Funded by the state budget, the biomethane feed-in tariff provides for a 15-year contract with a purchase guarantee at an average tariff of EUR 103.3/MWh, compared to the price of natural gas of EUR 13/MWh.

There is a more restricted support for electricity generation from biogas. Biogas plants with a power capacity of 300 MW or more located in an area served by a natural gas network are requested to inject their biogas production into the natural gas network.

In 2021, France will launch a new tender scheme for medium and large biomethane plants with two calls for tender each year for an annual production objective of 350 gigawatt hours (GWh) per year each. The calls for tender will be built on a purchase price trajectory baseline, with the aim of achieving an average of EUR 75/MWh for the injected biomethane projects selected in 2023 and EUR 60/MWh in 2028.

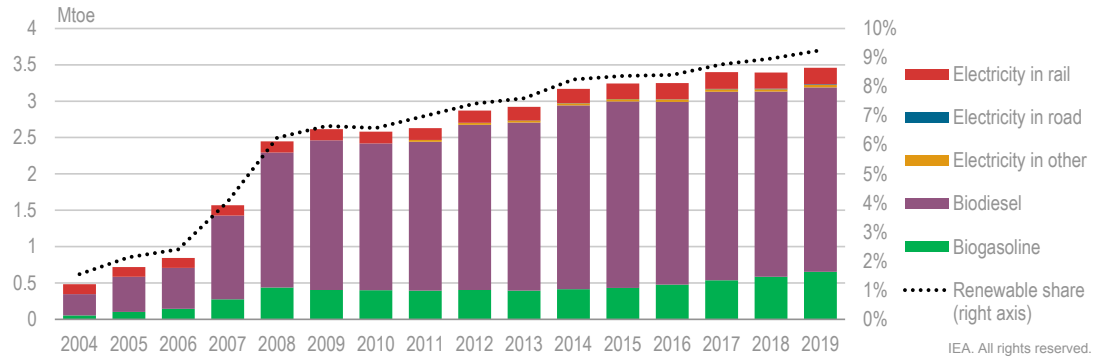
Small-scale biomethane plants can receive new feed-in tariffs. They can be adjusted downwards if the contracted biogas production capacity is higher than the annual target of 800 GWh per year. A new support scheme (feed-in premium) for biomethane not injected in the gas networks will be implemented for biomethane used directly for bio natural gas vehicles.

Renewables in transport

In 2019, renewables accounted for 7.4% of France's transport demand. Based on the Eurostat definition, which uses multiplication factors for advanced biofuels and renewable

electricity,[7] the share of renewables in transport reached 9.2% in 2019. Renewables in transport consisted mainly of biofuels, and has increased in recent years, with a growing contribution from bioethanol (Figure 5.8).

Figure 5.8 Renewable energy in transport in France, 2004-19



Renewable energy in transport is provided mainly by biodiesel, with an increasing contribution of biogasoline in recent years

Notes: Mtoe = million tonnes of oil equivalent. Shares of renewables are computed using the Eurostat definition for consistency with EU and national targets.

Sources: EC (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

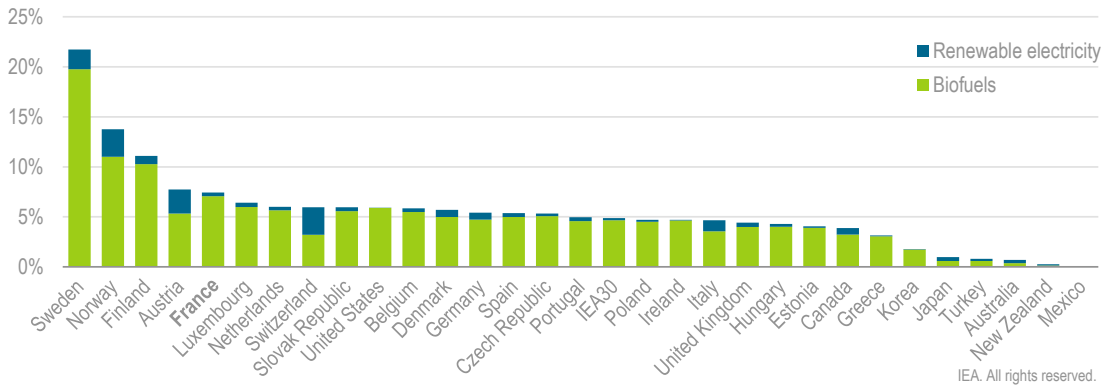
Support schemes and policies

In transport, France aims to achieve a share of 10% renewables by 2020 and 15% by 2030, in line with and above EU targets. The blending of diesel/petrol with biofuels is encouraged through the exemption or reduction of the incentive tax on the incorporation of biofuels (TIRIB). The TIRIB acts as a penalty for non-blending and is proportional to the quantity of biofuels incorporated. The tax exemption has recently been adjusted to exclude high ILUC (indirect land-use change) feedstock (palm oil and soy). France met its 2020 target for first-generation biofuels, but biofuels from second-generation sources are still at a very low level of market penetration. The government is encouraging second-generation blending targets for advanced biofuels in gasoline and diesel/kerosene of 3.8% and 2.8% in 2028, respectively.

By international comparison, France ranks fifth among IEA countries for the share of renewables in the transport sector consumption, after Sweden, Norway, Finland and Austria (Figure 5.9).

[7] RED II uses a multiplier of four for renewable electricity, directly used in electric vehicles, which is a reflection of the higher efficiency of electric vehicles over internal combustion engines and aids their contribution in meeting the renewable transport targets. Multipliers apply to other renewables such as waste-based biofuels, like used cooking oil (which is double-counted).

Figure 5.9 Renewable energy in transport in IEA countries, 2019



Among IEA countries, France has the fifth highest share of biofuels in transport.

Sources: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In January 2020, the Ministry of the Ecological Transition launched a roadmap for the development of sustainable aviation fuels in the French air transport sector. The roadmap builds on the "Green Growth Engagement" initiative launched in 2017 by the government alongside Air France, Airbus, Safran, Total and Suez Environnement, and is linked to the recovery funding provided to the airline industry. The roadmap is based on the substitution of fossil fuels by sustainable aviation fuels of 2% by 2025, 5% by 2030 and a massive target of 50% by 2050.

Impact of COVID-19 on renewables

Electricity production from renewable energy sources maintained high shares during lockdown measures during the COVID-19 pandemic. However, the COVID-19 pandemic and related measures exposed projects under development because of delays on worksites, limitations of the supply of components, especially when coming from outside the EU, and increases in the cost of financing.

To tackle these issues, the French government extended the validity of administrative authorisations and staggered the schedule of tenders. Additional time was granted for the commissioning of renewable projects for which the completion was initially due after 12 March 2020, a support scheme granted through a complete application for a feed-in tariff or by winning a tender process before or during the period between 12 March 2020 and 23 June 2020. Only projects with nominal power less than 200 MW were considered for this extension, due to the importance for security of supply of bigger projects. The COVID-19 crisis has hit the biofuel industry, as the halt in transport activity led to a fall in diesel and petrol consumption. The government has not explicitly included renewable energy in its Recovery Plan and is not providing an additional budget to make up for delays or speed up deployment.

Critical minerals in France

Like in other countries, France's ambitious energy transition plans will result in a strong increase in the demand for critical minerals. Over the next decade, the number of electric cars in France is expected to increase almost twenty-fold, solar energy installations up to fivefold and wind capacity will see an almost threefold increase. France is a producer of 5

out of 30 minerals deemed by the European Union as critical[8] (bauxite, hafnium, indium, silicon metal and tantalum)[9] and also has a nickel and cobalt refining plant, and a platinoid production from recycling. France is one of the four countries outside of the People's Republic of China that have rare earth elements processing capacity.

According to the 2019 Annual Report of the French Geological Survey,[10] France has significant resources of critical minerals such as tungsten, antimony, gold, lead, zinc, germanium, copper, lithium and molybdenum, but none of them are mined at substantial scale yet. Were these resources developed, France could become self-sufficient for lithium, with a potential production of more than 200 000 tonnes in total. However, the construction of new mines in France would require an overhaul of the Code for Mines, which is included in the Climate Resilience Law of 2021.

The car manufacturing industry will likely remain the largest consumer of critical minerals in France, with an envisaged annual production of more than one million electric vehicles as of 2024. France has the potential to become a substantial producer of crystalline silicon solar panels, using its considerable silicon production capacity. Over the next few years, domestic demand for solar panels will rise to 25 000 panels per day, which could partly be produced in France. To put this into context: the planned expansion of solar PV with 20 GW of capacity will require up to 4 000 tonnes of neodymium and over 500 tonnes of rare dysprosium in addition to tens of thousands of tonnes of copper and aluminium, which France is well placed to produce given its largely decarbonised electricity.

France started assessing its needs and potential for critical minerals already in 2015 with the Energy Transition for Green Growth Act. The act called for detailed planning of the needs for natural resources and for decoupling GDP growth from the consumption of these. This was reinforced later that year in the Resources Plan for France,[11] which called specifically to "improve knowledge of metal flows and their evolution in relation to future energy technologies, in order to identify critical metals and enable French companies to anticipate future tensions on their supplies". The Roadmap for the Circular Economy in France, adopted in April 2018,[12] obliged the MTE to deliver detailed plans for critical minerals based on the plans of the Committee of Strategic Metals, focused on stable supply and advanced recycling. Based on the Energy Transition for Green Growth Act and this roadmap, in 2019, the MTE initiated a three-year project to produce detailed reports in each of four technology areas of greatest energy interest for France: 1) PV panels; 2) electricity grids and stationary storage; 3) low-carbon mobility; and 4) wind power. For each of these four technologies, the reports aim to provide policy makers with knowledge on technology choices and to identify actions and levers needed to advance French potential and reduce the risk of mineral supplies for the clean energy transition. All four

[8] https://ec.europa.eu/docsroom/documents/42882.
[9] In the case of hafnium, France is the biggest global producer, with 49% of world supply (84% of the EU demand). For indium, France supplies 4% of global needs (28% of demand in the EU).
[10] www.brgm.fr/en/news/annual-report/brgm-2019-annual-report-constant-capacity-adaptation.
[11] www.ecologie.gouv.fr/sites/default/files/FREC%20-%20Plan%20Ressources%20pour%20la%20France%202018.pdf.
[12] www.ecologie.gouv.fr/sites/default/files/Feuille-de-route-Economie-circulaire-50-mesures-pour-economie-100-circulaire.pdf.

reports are supposed to be finalised by the end of 2021, and will then constitute the basis for developing a comprehensive national programming plan for critical minerals.

Two of the announced reports are already completed – on PV panels and on electricity grids and storage.[13] The report on PV acknowledges that production of panels in France is facing challenges due to strong competition from China. The report calls for strengthening the verification of sustainability criteria of the critical minerals used in PV technologies globally, and proposes to accept only materials and products manufactured with the highest environmental, social and governance standards on the French and European markets.

The report on electricity grids and storage notes that France is not only dependent on critical minerals to build and maintain its electricity networks, but Asian suppliers are also to a large extent responsible for providing the equipment increasingly needed to build and manage smart grids. After 2030, France will need additional technological solutions for grid management to accommodate a large share of variable renewables and energy storage systems – where there is limited domestic industry presence too. The report proposes that the French electro-digital sector find new opportunities through imposed ecodesign standards, echoing the recommendations of the PV report.

The report on grids and storage also puts a strong emphasis on the recycling industry, especially of used batteries, relevant for the increasing number of electric cars expected in France in the coming years. In this context, SNAM, the largest French recycling company, with financial support from ADEME, launched the Phoenix project for the recycling and reuse of minerals, with an 80% minerals reuse/recycling ratio.

The French government should assess the opportunities and prospects for both the supply and demand of critical minerals. Clear signals to industry, with appropriate financial and regulatory support, will be key to building the country's capabilities and determining its role in the global critical minerals market. Swift action and co-operation with other European countries will be crucial. As was underlined in a recent IEA report on *The Role of Critical Minerals in Clean Energy Transitions* (IEA, 2021c), there is a variety of roles governments should assume to support strengthening adequacy of supply of critical minerals and their use for energy transformations, notably by creating conducive conditions for investments in critical minerals supply chains. France's ambitions to lead on clean energy transformations hinge on the availability of critical minerals; a lack of proper policies may undermine achieving those ambitions.

Assessment

France has ambitious and legally binding renewable energy targets for 2030, as stepping stones towards climate neutrality by 2050 under the SNBC pathway. The share of renewable energy in gross final consumption in France was 17.2% in 2019 and 19.1% in 2020, still lower than its mandatory target of 23% for 2020 under the EU Renewable Energy Directive. In 2020, France was the EU country the furthest from reaching its target

[13] www.mineralinfo.fr/actualites/plan-programmation-ressources-minerales-transition-bas-carbone-parution-deux-premiers.

for 2020 (OECD, 2021). The government has set ambitious targets, already for 2023 and 2028 under the PPE. France is well behind its neighbours when it comes to renewable targets and development. However, France can catch up in the coming decade, thanks to on reforms under way and further efforts to be made, as set out in the recommendations of this report.

Distance to the 2030 target has been increasing. Under the 2019 Energy and Climate Act, France has set a target of 33% of renewables for 2030 (in consumption). The gap to the 2020 target and the distance to the 2030 target (6 and 15.8 percentage points, respectively) calls for a significantly stronger focus on implementation to accelerate the pace of renewables deployment over the next decade. France did not manage to achieve the necessary doubling of the historic growth rates over the past decade. Renewable electricity accounted in 2019 for 22% of total electricity, with a major contribution by hydropower. Wind and solar have increased since 2011, but at a slower pace than planned and than developed in neighbouring countries.

This slow pace is due to a combination of administratively complex and overlapping support schemes; lengthy permitting procedures; a lack of public acceptance for onshore wind; and stop-go policy for support schemes, notably solar PV and biogas. Authorisations are a prerequisite for tenders. Tenders are awarded within a few months and projects must be in place within 18-36 months depending on the technology. Delays can be longer in case of litigation. The government should consistently track tender progress against PPE targets and make all efforts to facilitate renewable deployment. The government may also consider reversing the order and deem every tender approved unless there are complaints raised within a certain short time frame.

The government must ensure a greater achievement focus in delivering results in line with its ambitious targets and increase the effectiveness of its renewable policies and the adequacy of financial and human resources dedicated to the sector.

France has ambitious solar PV targets under the PPE. As seen in other countries, stop-and-go policies are harmful for the development of the sector. There was significant undersubscription in rooftop PV auctions in 2018-20, for good part due to uncertainty on future policy support. In 2021, France plans to enact unilateral decisions to cut solar PV subsidies for ongoing projects. Such a *de facto* retroactive and unilateral policy increases investment risks in France. While the objective of keeping the cost of the energy transition at the lowest for taxpayers and electricity consumers is understandable, any retroactive decisions can discourage investment across the entire sector by increasing the feeling of uncertainty and negatively affecting the cost of financing, with the risk of making any new investment in renewables more expensive.

Moreover, the shift from electricity tariff-based renewable support schemes to the financing of renewables under the state budget may increase the policy risk even more. It will be important that the state ensures the necessary financial support, in line with the important step change needed to meet targets. Creating more certainty for investors needs to be prioritised.

For each renewable sector, a number of important facilitating actions can be outlined.

Wind power

The government has carried out important work to support renewable electricity deployment, with a clear calendar for tenders, enshrined in the trajectories defined in the PPE up to 2028 and has simplified administrative procedures introduced in 2020 for onshore wind under the Loi ASAP. The proposed Onshore Wind Charter would be an excellent way to improve the regional co-ordination of targets and consultations as well as enable the sharing of best practices in permitting and public consultation. The tracking of permits by the regions, which is proposed under the charter, is an important milestone. The government should itself track tenders and PPE targets more consistently, based on the return from the regions.

Offshore wind would benefit from a more co-ordinated and coherent approach to permitting and siting, which could be done as one-stop shop authorisations and consultations, using existing maritime spatial planning tools (i.e. with all the sea users, non-governmental organisations, etc.). This scheme would facilitate the tender processes and ensure better visibility for RTE and investors in the future.

Solar PV

The distributed solar PV sector is struggling, which could create negative spillover effects on small and medium-sized enterprises active in the sector. The self-consumption scheme entails a fairly high administrative burden. Recently, the government clarified that self-consumption projects are exempt from the electricity tax, which is a welcome development. France could consider fast-tracking grid connections for small solar PV projects, like what Portugal did in April 2020. Incentives for distributed PV on buildings are the most cost-effective when combined with building renovations and investments in energy efficiency and other distributed energy resources, such as heat pumps, solar thermal and electric vehicle charging infrastructure. The Recovery Plan includes an additional EUR 6 bln for renovation with the MaPrimeRénov' scheme and funding for local authorities. However, there is no additional funding provided for renewable energy. Combining incentives for renewables and energy efficiency in the built environment is a very important way to achieve the most efficient and resilient solutions while creating local employment and fast economic recovery in the labour-intensive construction sector, which is a driver for the entire economy.

The Energy Transition for Green Growth Act (2015) mandated all new buildings in commercial zones to be partially covered either by solar PV panels or vegetation on the roof. Municipalities should be supported in mapping the solar potential and project development, in particular on commercial buildings, including parking lots. The Recovery Plan does not provide for additional funding nor new policies, as projects are funded under existing schemes. Without incentives and a radical simplification of the administrative burden for siting and connections, planned and future investments in PV installations may remain below targeted levels for a long time.

France is still facing large structural barriers in relation to permitting, due to a combination of a lack of human resources to handle requests, uneven application of permitting rules across regions and public acceptance issues translating into long judicial procedures. Project promoters also report difficulties in identifying suitable new sites for project development due to a mix of regulatory limitations to land availability (military radars for wind, agricultural land for ground-mounted PV) and public acceptance issues.

France is not yet facing significant system integration issues thanks to its strong grid capacity and the still low share of variable renewables. But integration issues may appear in the coming decade, as total renewable energy capacity exceeds 50 GW and will necessitate significant grid investments. These grid investments need to be designed now so that they can be launched by 2025. The exact investment needs will, however, also depend on the timetable and geographical localisation of nuclear closures.

RTE has recently published its reference Ten-Year Network Development Plan up to 2035, in line with ENTSO-Es European development plan. The plan envisages not only grid adaptations, but also a push in grid optimisation through the generalisation of real-time use of flexibility from renewables (mainly wind farms). In this decade, these changes are considered to be enough to keep the need for new grids in France lower than, for example, Germany today or France in the 1980s, while still attaining ambitious targets for renewables. Beyond 2030, however, grid expansion, reinforcement and restructuring would be needed to increase the share of renewables in the power mix. In addition to grid investments, system integration will require that time-of-use tariffs, smart charging, and batteries and demand-side response are activated to their full potential.

Heating and cooling

Renewable heat reached 22% of total heat consumed in France in 2019, of which solid biomass represented by far the largest share, followed by ambient heat and small additions of solar thermal and geothermal. Renewable heat developed at a lower pace than planned (the objective for 2020 was 33%). Reasons are numerous and include: lack of information, low internalisation of the carbon price in competing fossil fuels, necessity to invest in energy efficiency/building envelope, split incentives and high upfront costs.

The target for renewable heat in 2030 set in the PPE implies a growth rate that is 50% faster than today, to be delivered mainly through biomass and heat pumps, and to a lesser extent by deep geothermal and solar thermal. Overall, renewable heat should increase by 40-60% by 2028 (compared to 2016), and renewable heat and cold and recovery heat by 50-100%. Renewable heat benefited from support schemes (ADEME heat funds) and from funding from the Recovery Plan.

However, there is ample scope for making progress in geothermal and solar thermal heat development. Geothermal targets under the PPE remain below their potential in France, which could be significant if the state supported the mapping and derisking of the cost of exploration. The government should also review the situation of renewable heat use in co-generation, which is efficient and useful for multi-apartment buildings to assess the impact of the end of the support scheme in 2020.

Transport

According to IEA data, renewables in transport accounted for 7% of France's transport demand in 2019 (including double counting of electric vehicles and advanced biofuels); 95% of the demand was accounted for by biofuels blended with road transportation fuels and 5% by renewable electricity. As described in Chapters 3 and 4, the Law on Mobility is being implemented with a strong focus on mobility, behaviour change, active mobility and modal shift. Biofuels are only a small component of the French clean mobility strategy.

France is a leading biofuels market and has a large biodiesel and bioethanol industry (9 000 jobs in the bioethanol industry alone). However, the contribution of first-generation

biofuels (food and feed crop-based biofuels) to the renewable objectives will be capped at 7% of final consumption of energy in road and rail. The development of second-generation biofuels has not yet started at scale. The SNBC foresees that the bulk of scarce bioenergy resources should be consumed in those transport sectors where electrification will be difficult, in particular aviation, maritime and some heavy-duty transport. France should thus progressively channel (advanced) biofuels towards these sectors.

Sustainable aviation fuel has a role to play in the decarbonisation of air travel, and meeting the aviation industry's own long-term goal of reducing CO_2 emissions by 50% (versus 2005 levels) by 2050. France has made use of the recovery from the COVID-19 crisis and opened the door to a scale-up of aviation biofuels demand through widespread inclusion of sustainable aviation fuel provisions in bail-out packages. Support for sustainable aviation fuel helps France in the delivery of its roadmap to develop a national sustainable aviation fuel industry. Advanced technologies for reuse, substitution and recycling of critical minerals could also be supported by the French government, especially given already existing significant industry and scientific potential in that regard.

The following policy frameworks could be considered: financial derisking measures for refinery project investments (e.g. grants, loan guarantees); measures to provide guaranteed sustainable aviation fuel offtake (e.g. mandates, targets and public procurement); and other mechanisms that close the cost gap between sustainable aviation fuels and fossil jet fuel (e.g. carbon pricing).

Measures to accelerate the availability of E85 ethanol blends would also serve to lower CO_2 emissions from transport while supporting French industry. Support could come in the form of programmes to extend the supply of the blend, which today is only available in one-fifth of service stations, or fostering the adoption of conversion kits to facilitate petrol vehicles to use E85. Polices to boost the market prospects for ED95 (95% ethanol) fuel for heavy-duty road fright, buses and coaches could also be assessed.

Renewable gas

As regards renewable gas, the use of biogas for electricity generation has steadily increased over the past years. Since 2016, biogas is also increasingly upgraded into biomethane and injected into the gas network. France already has a support framework for biomethane production and injection into gas network infrastructure. This can be built upon to meet, and potentially surpass, the target for 10% renewable gas consumption in 2030.

There is a strong need for policies to ensure industry growth, given the significantly higher costs than for natural gas. These could take the form of measures to extend the duration of the existing feed-in tariff mechanism, enhanced support frameworks for gas network injection or measures to stimulate consumption (e.g. in heavy-duty vehicles or captive fleets). Alongside investment in renewable hydrogen, biomethane support also helps to ensure a future role for existing natural gas infrastructure in a low-carbon energy transition.

Regional and national targets

In the past years, regional and local authorities have been required to develop integrated energy plans covering, *inter alia*, renewable energy deployment: the SRADDET, introduced by the NOTRe Law in 2016, and the PCAET, as part of the 2015 Energy Transition for Green Growth Act. The prefect defines the capacity for the planning of the transmission and distribution system operators of regional renewable energy network

connection plans (S3RenRs). Despite these regional competences, the national SNBC and the PPE do not include a concerted territorial component. While both planning levels should inform each other, there is no mechanism to reconcile inconsistencies between national and regional targets and plans.

The 2021 Climate Resilience Law will promote the regionalisation of the next PPE in 2024. While this can be useful for the co-ordination of national and regional efforts, it may create barriers and delays to renewable deployment, in regions that are opposing renewables. Regions insist that they have a better view of their renewable energy potential and should rather inform national planning bottom-up – which may go in the direction of higher ambition. For instance, the objectives for marine renewables under the PPE 2018 were revised upwards, thanks to a common approach reached with regions when defining goals, based on the state competence for maritime planning. Better dialogue and co-ordination are critical. A reconciliation mechanism could ensure that the national ambitions are underpinned by commensurate ambition and ownership at regional/local levels, closer to the citizens and the realities of territories. Coherence is also important.

Recommendations

The government of France should:

- Increase its implementation focus and policy certainty to ensure investor confidence and accelerate affordable private investment at the pace necessary to meet the 2020 and 2030 target for renewables and sectorial as well as interim sub-targets under the two five-year energy investment plans. Support the tracking of tender results against targets and increase financial and human resources commensurate to the distance to the target.
- Increase land access and site eligibility for wind and solar electricity by removing regulatory barriers, where possible. Further strengthen the spatial (maritime) planning exercise aiming to identify suitable sites for offshore wind projects in a long-term perspective (2050 horizon) and consider greater one-stop shop procedures.
- Ensure that national level trajectories for renewables (PPE) translate into consistent regional targets (regional plans for spatial planning, sustainable development and equality) based on closer co-ordination and dialogue with regions, as provided for in the Climate and Resilience Law.
- Introduce minimum requirements for on-building renewables as part of new buildings and deep renovations policies to accelerate the deployment of decentralised renewables.
- Ensure a swifter and more harmonised application of permitting rules for renewable electricity projects across decentralised state administrative services, underpinned by increased human resources, strong monitoring and an accountability framework against regional targets.
- Seize the opportunity of economic recovery from the COVID-19 pandemic by directing funding to support various renewables, notably renewable heat, distributed photovoltaics (i.e. under renovation) and advanced biofuels, such as sustainable aviation fuels and maritime low-carbon fuels.

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6. Energy research, development and innovation

Key data (2019)

Total public RD&D expenditure: EUR 1 264 million

Share of GDP: 0.051% of GDP (IEA average: 0.035%)*

Share of energy in total RD&D: 9.2% (IEA average: 4.9%)

* Average of 25 IEA countries as data for Greece, Italy, Luxembourg, Mexico and Turkey are not available for 2019.

Overview

France has a dynamic energy-related research, development and demonstration (RD&D) landscape, which is supported by active collaboration, strong integration and stable funding.

France's National Strategy for Energy Research (Stratégie nationale de recherche énergétique, SNRE) is based on the Energy Transition Law of 2015. It has been the main reference for stakeholders in research and innovation since its adoption in 2016. With the ambitious targets set forth in the 2020 National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone, SNBC) and the multiannual energy plan (*la programmation pluriannuelle de l'énergie*, PPE), the 2016 SNRE needs to be updated. This is an opportunity to get a broad societal vision on France's energy future and set the direction for France's energy RD&D in the coming years. Such a refreshed strategy can cater for critical technology needs in support of France's climate neutrality, such as hydrogen, small modular reactors or low-carbon fuels. Today, the SNBC does not rely on technology pathways.

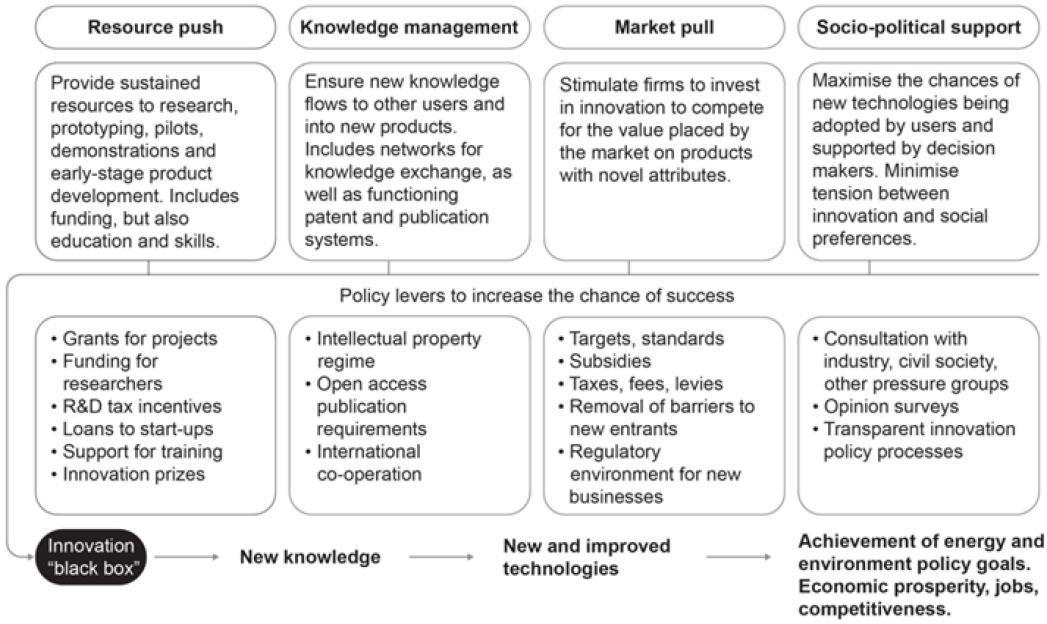
Over the past decade, public RD&D funding has remained relatively flat, around EUR 1.2 billion (bln) in public funding for energy RD&D, corresponding to roughly 9% of French public spending for research and development (R&D) and 0.05% of national gross domestic product (GDP). Energy R&D spending is, to a large extent, dedicated to nuclear energy (mainly fission), energy efficiency and cross-cutting research areas. On an energy RD&D budget per GDP comparison, France ranks sixth after Norway, Finland, Japan, Switzerland and the Czech Republic. The flat funding levels also mean that France was not able to deliver on its Mission Innovation pledge, which required doubling the clean energy innovation spending by 2020 compared to 2015.

The IEA sees several key opportunities for France to focus on clean energy innovation in the context of the preparation of the SNBC for 2024 and setting future funding programmes, in light of the sustainable recovery of the French economy following the COVID-19 pandemic and future investment under the Investment 2030 Plan.

IEA framework for energy innovation policy

Technology innovation processes are complex and decision makers must pay attention to a variety of elements that characterise successful energy innovation systems (IEA, 2020). The IEA groups these elements into four core functions: A) resource push; B) knowledge management; C) market pull; and D) socio-political support (Figure 6.1).

Figure 6.1 The IEA's four functions of a successful innovation ecosystem for energy



Successful innovation systems involve a wide range of actors and a wide variety of functions, each of which can be enhanced by public policy. Such a system will need to have action under each of these four headings to successfully translate research into technological change. A sustained flow of R&D funding, a skilled workforce (e.g. researchers and engineers) and research infrastructure (laboratories, research institutes and universities) are required: these resources can come from private, public or even charitable sources, and can be directed to specific problems or basic research (resource push). Knowledge should be exchanged easily between researchers, academia, companies, policy makers and international partners (knowledge management). The expected market value of the new product or service must be high enough to make the R&D risks worthwhile, and this is often a function of market rules and incentives established by legislation. If the market incentives are high, then much of the risk of developing a new idea can be borne by the private sector (market pull). And there needs to be broad socio-political support for the new product or service, despite potential opposition from those whose interests might be threatened (socio-political support).

This chapter applies the IEA innovation framework to the French case to assess the current state of play and derive concrete recommendations to enhance clean energy innovation. It includes: A) recent trends in funding for energy R&D by public and private actors; B) an overview of key knowledge institutions and management; C) illustrations of

public support for business innovation and market creation; and D) references to monitoring frameworks to track progress of innovation.

Key energy innovation priorities

Based on the 2015 Energy Transition for Green Growth Act, France presented its SNRE in December 2016, which is the main reference for stakeholders in research and innovation. In the preparation of the SNRE, the government consulted across ministries and received opinions from the Association of Regions of France, the National Energy Transition Council and the Higher Energy Council.

Specifically, the SNRE sets four main objectives to shape the future of France's R&D:

1. **Focus on the transition of the energy system** by stimulating multidisciplinary R&D, involving environmental science, digitalisation, and economic and social science, consumer involvement and decentralisation, as well as the analysis of several options of flexibility of energy supply and demand management.
2. **Develop R&D in tandem with regions and industry, in particular small and medium-sized enterprises (SMEs),** to promptly transfer technologies from R&D laboratories to the market.
3. **Develop the necessary skills and knowledge** by strengthening international collaboration, the creation of global networks of researchers, expansion of modelling and forecasting capacities, the deployment of training courses for jobs associated with the energy transition, and the involvement of civil society.
4. **Create a high-performing governance** through the monitoring committee, which is convened every year to review the SNRE with ministries responsible for research, innovation and energy; the National Research Agency; the Agency for Ecological Transition (ADEME); and the National Alliance for the Coordination of Energy Research.

By design, the SNRE aspires to cover all four core pillars of successful innovation systems. The strategy aims to provide resources to innovation actors, help them develop new knowledge and bring new products from lab to market, and foster socio-political support by promoting transparent governance and collaborative projects.

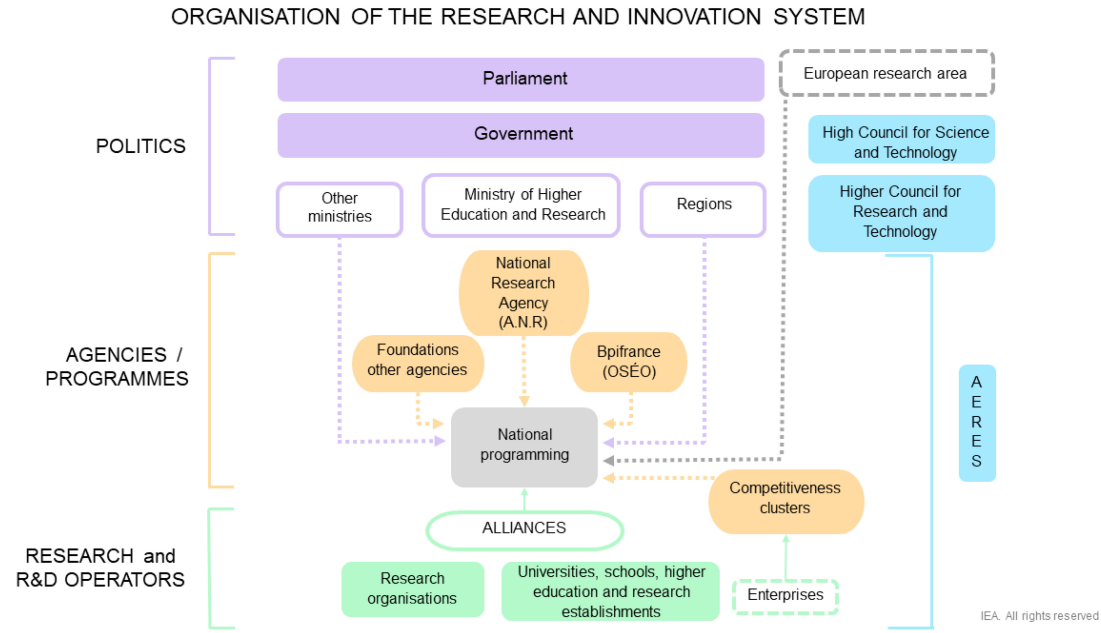
Main actors shaping France's energy innovation

Energy RD&D is a joint effort of the Ministry of the Ecological Transition and the Ministry of Higher Education, Research and Innovation. The SNRE is the fruit of their strong collaboration. To support the co-ordination and implementation of the SNRE across the government, a permanent secretariat and a monitoring committee are in place. The National Alliance for the Coordination of Energy Research and ADEME participate in the work of the committees, but industry and academia do not directly.

A diverse set of entities are involved in France's energy research and innovation ecosystem (Figure 6.2). With the right co-ordination mechanisms in place, this allows for comprehensive coverage of the whole energy spectrum and strategic allocation of resources across sectors (e.g. power, transport, industry and buildings) and stages of technology development (e.g. basic and applied research, demonstration, market uptake). For the most part, decision making for innovation priorities is centrally led by the

government, with a consultative role and some responsibilities in implementation for regions and local authorities, such as to set up technology innovation clusters.

Figure 6.2 Energy innovation ecosystem in France



The political, general objectives and the budget for research are defined by the ministries and the Strategic Research Council under the prime minister. Thematic priorities and budget allocation are programmed by the ministries (Departments for Research, Energy and Economy) and the funding agencies. These include mainly the National Research Agency under the lead of the Ministry of Higher Education, Research and Innovation and ADEME under the Ministry of the Ecological Transition, as well as Bpifrance, France's public investment bank.[1]

ADEME is active in the implementation of public policy and provides expertise and advisory services to businesses, local authorities and communities, government bodies, and the public at large. As part of this work, the agency helps finance projects, from research to implementation, in its areas of action, such as the Investments for the Future Programmes (PIA).

The funding agencies work with several alliances and research organisations. For the energy sector, the National Alliance for the Coordination of Energy Research is the key alliance of research organisations and participates in the implementation of the national strategy and is active in the European Energy Research Alliance.

[1] Bpifrance is a joint venture of two public entities: the Caisse des Dépôts et consignations and EPIC BPI-Groupe, formerly EPIC OSEO.

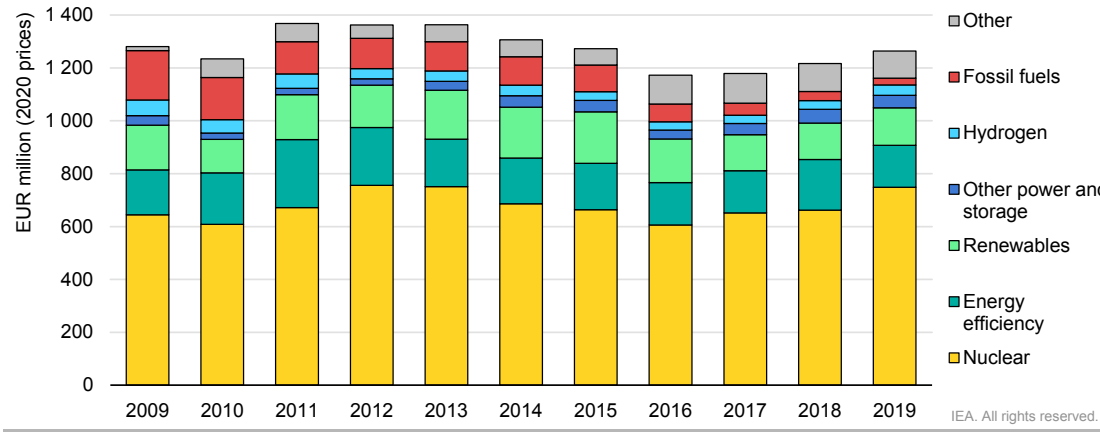
A. Funding for energy R&D and innovation

The research programming bill was initiated in early 2019 by the President of the Republic and the Prime Minister and supported by the Minister of Higher Education, Research and Innovation. The law plans for EUR 25 bln in additional investments to be injected for research between 2021 and 2030, which will increase the current annual budget from EUR 15 bln to EUR 20 bln per year in 2030.

Out of this total, the energy sector has a funding stream of around 9%. In 2019, France allocated EUR 1.2 bln to energy-related RD&D (Figure 6.3). Energy RD&D funding peaked in 2011 at EUR 1.36 bln, decreased thereafter and rebounded in 2019 to EUR 1.26 bln.

Nuclear consistently made up half of the total energy RD&D funding and its share has increased in recent years, reaching 59% in 2019 (EUR 748 million). Three-quarters of the nuclear budget was allocated to nuclear fission technology and one-quarter (EUR 181 million) to research of nuclear fusion (ITER project). The second-highest budget allocation is energy efficiency (13% of energy-related RD&D in 2019), of which 70% went to road vehicles, with a significant share for electric vehicles (EVs), batteries and infrastructure, followed by buildings (10%) and industry (9%). RD&D in renewables accounted for 13% of the total energy RD&D budget in 2019, followed by other cross-cutting technologies (8%), other power and storage technologies (4%), hydrogen and fuel cells (3%), as well as a very small share in fossil fuels (2%).

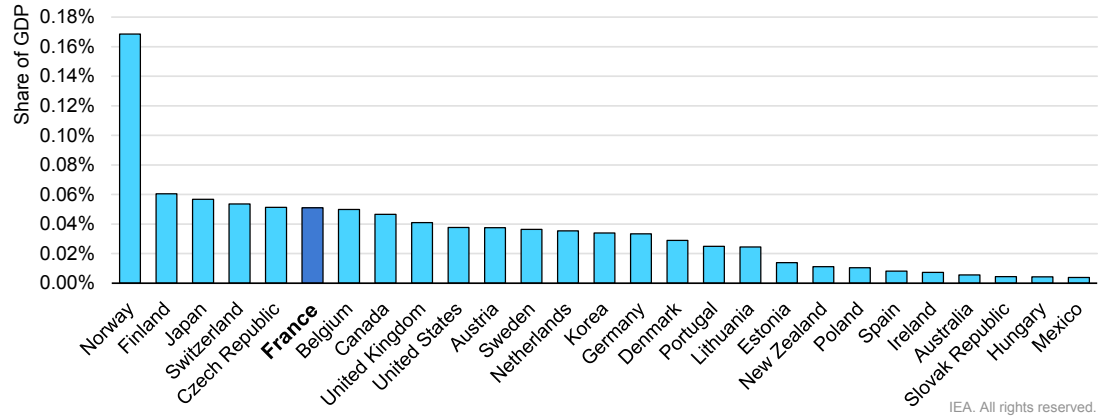
Figure 6.3 Energy-related public RD&D budget by sector in France, 2009-19



Source: IEA (2021a), *Energy Technology RD&D Budgets 2020*: *Overview*, www.iea.org/statistics.

With an energy-related RD&D budget per GDP of 0.05%, France ranks sixth by IEA comparison, after Norway, Finland, Japan, Switzerland and the Czech Republic (Figure 6.4).

Figure 6.4 Energy-related public RD&D spending per GDP in IEA countries, 2019*



* 2019 data are not available for Greece, Italy, Luxembourg, Mexico or Turkey.

IEA (2021a), *Energy Technology RD&D Budgets 2020*: *Overview*, www.iea.org/statistics.

Under Mission Innovation, France pledged to double its public funding for clean energy innovation by 2020 from its baseline in 2015. Clean energy includes energy efficiency; carbon capture, utilisation and storage; renewable energy sources; hydrogen and fuel cells; power and storage technologies; and cross-cutting technologies, excluding nuclear. Funding remained stable. In 2019, France spent around EUR 497 million, less than the baseline.

Table 6.1 Mission Innovation – Spending overview

Funding (EUR million)	Baseline	First-year RD&D spending	Second-year RD&D spending	Third-year RD&D spending	Fourth-year RD&D spending
Year	2015	2016	2017	2018	2019
Total RD&D spending	502	488	471	516	497

Source: Mission Innovation (2021), France, http://mission-innovation.net/our-members/france/

The private sector also plays an important role in financing energy R&D activities in France (Figure 6.5). A small number of large multinationals – including in the utilities and power sector, automotive, and oil and gas companies – account for the bulk of the country's corporate energy R&D spending, which was estimated at about EUR 4.5 bln in 2020 based on the annual reports of globally listed firms headquartered in France and additional sources focusing on France's nuclear industry.

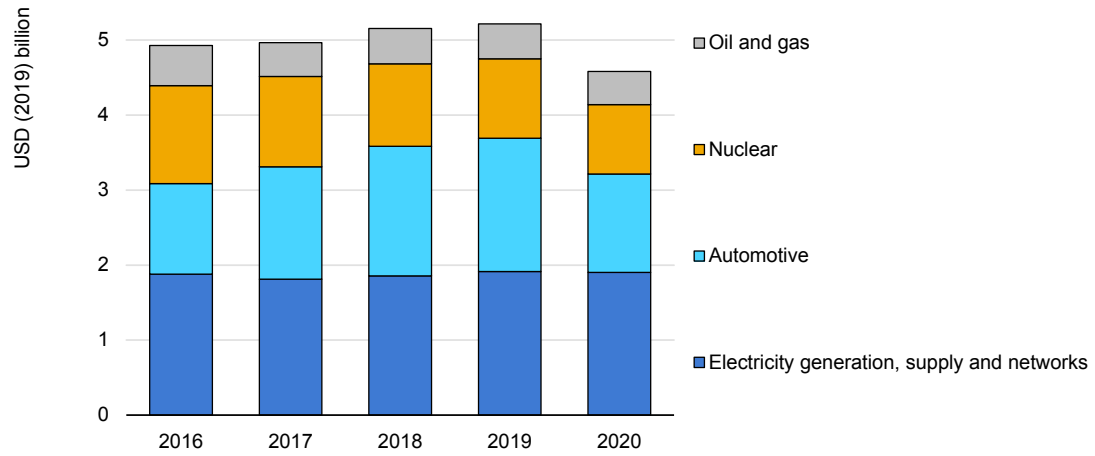
In 2020, car manufacturers reported lower spending on R&D, wiping out years of strong growth, potentially due to lower revenues generated during the COVID-19 pandemic. This drop, however, warrants further analysis in 2021 and beyond as French companies accelerate innovation in EVs and associated technologies. R&D spending by oil and gas companies has been steadily decreasing in the last five years, and remained stable in the power sector. As a result of a decreasing number of nuclear programmes, R&D spending levels in this area remained lower in 2020 than in 2015.

Created in 2019 by the French government, the Next40 label helps support and promote 40 young start-ups in France to become technology leaders and receive international recognition.

France has temporary exemption arrangements for innovative start-ups and new businesses. The main tool to support corporate R&D spending is through a research tax credit (CIR). The CIR provides for a tax credit for 30% of eligible R&D expenditure (up to EUR 100 million per year) and 20% of eligible cost for innovation expenditure (up to EUR 400 000 per year). In 2017, 26 100 companies declared EUR 24.1 bln total expenditure on R&D, with an eligible tax credit of EUR 6.6 bln.

The Court of Audit evaluated the results of the tax credit and found that if fiscal incentives (e.g. tax relief or direct cash injections) for R&D are maintained, stricter monitoring (spending, impact) is needed (Court of Audit, 2013).

Figure 6.5 Energy-related R&D spending by globally listed companies headquartered in France, by sector, 2015-20



Notes: In the case of nuclear, small and medium-sized enterprises are also included alongside globally listed companies based on additional sectoral sources. Given the difficulty to separate R&D spending specific to nuclear technologies from general power generation and the lack of granularity in R&D budgets reporting, there may be partial overlap between the "nuclear" and "electricity generation, supply and networks" categories.

Sources: Estimates based on data extracted from Bloomberg for globally listed companies. Also see IEA (2021b), *World Energy Investment*, www.iea.org/reports/world-energy-investment-2021. For nuclear, other estimates are drawn from the *Cartographie de la filière nucléaire française* published in 2016 and 2020 by the Strategic Committee for the Nuclear Sector.

B. Knowledge management

France's energy innovation landscape relies on more than 200 higher education institutions, including 67 universities, 6 public research institutions and 12 government-funded research organisations. These institutions carry out much of France's publicly led R&D programmes and are overseen by central agencies mandated by the government to implement high-level energy innovation priorities.

Although this goes beyond the scope of energy, there are about 110 000 active public sector researchers in France, aggregating to about 40% of the country's total pool of researchers. The remainder are in business enterprises (OECD, 2021a)[2].

France's energy research community is present across the entire R&D value chain, and public sector actors are typically involved at least to some extent in all steps of technology development, from basic and applied research to demonstration.

- Fundamental research is primarily performed by public laboratories under the National Centre for Scientific Research (CNRS), including in research facilities located in institutions of higher education such as universities, scientific and engineering schools, and "*grandes écoles"*, France's elite academic institutions.
- Applied research and demonstration are carried out by public bodies, including the Alternative Energies and Atomic Energy Commission (CEA), the French Geological Survey and IFP Énergies Nouvelles (IFPEN) and by the industry.
- Pre-commercial experimentation, product development and demonstration in some instances are conducted by industrial companies, in partnership with public laboratories and public industrial and commercial establishments.

Although this goes beyond the scope of energy, French public R&D spending is distributed as follows: about 25% for basic research, 40% for applied research and 35% for experimental development (OECD, 2021b). As a share of total domestic R&D spending, France typically spends more on basic research than other innovating countries, including Japan, Korea, Norway, the United Kingdom and the United States, but less on technology development stages that are closer to market.

During its long history of developing new low-carbon energy technologies, France has shifted focus over the decades. Until the 1990s, much of energy patenting by inventors residing in France was in nuclear power technologies, reflecting the country's national priorities in this area. Targeted and sustained government support through publicly led R&D programmes enabled building a first-class nuclear innovation system. As French nuclear technologies, which largely focused on large-scale reactors and infrastructure, gained in maturity and found markets for domestic deployment and exports such as in the People's Republic of China, and as new priorities and opportunities arose for technology development, inventors progressively shifted towards non-nuclear technologies as well. Since the 2000s, nuclear accounts for only a fraction of all French low-carbon energy patenting. However, this may somewhat change looking forward if appetite for advanced nuclear technologies such as small modular reactors increases in the country and ranks among innovation priorities.

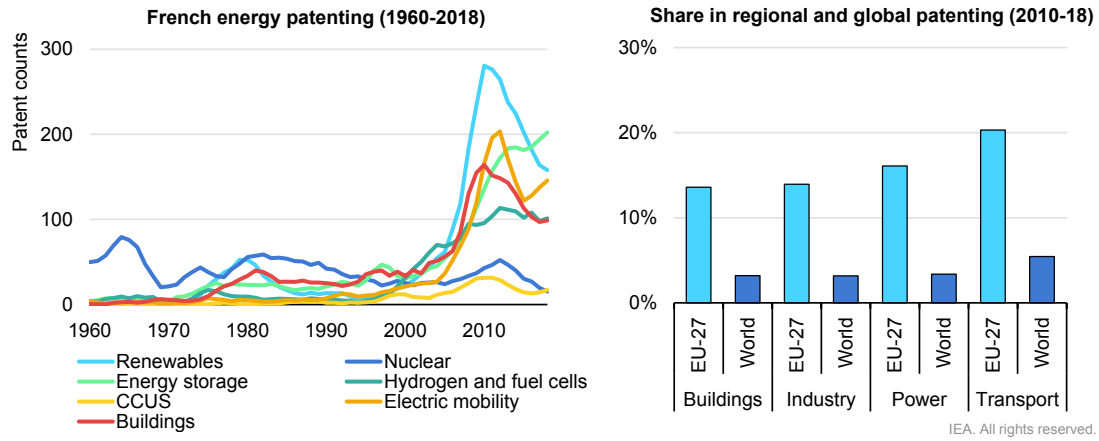
In 2018, energy storage, renewables, electric mobility, and hydrogen and fuel cells accounted for most of French low-carbon energy patenting. Patents in renewables, for example, outnumbered those in nuclear tenfold. As in most regions, France saw a dip in overall patenting in the 2010s[3] (Cárdenas Rodríguez, Hascic and Johnstone, 2019), but it is notable that patenting in energy storage and hydrogen technologies – which are key

[2] OECD data (2015) say 277 631 total researchers, of which 28 445 are in government and 79 622 in higher education institutes, which combined equal 108 067. The bulk of the remainder is in business enterprise.

[3] www.iea.org/commentaries/global-patent-applications-for-climate-change-mitigation-technologies-a-key-measure-of-innovation-are-trending-down.

technology areas for global decarbonisation – continued to steadily increase over the period. Recent trends suggest France accounts for about 15% of European Union patenting for climate change mitigation technologies in the power sector and about 20% in transportation – about 5% of the world's total.

Figure 6.6 Energy patenting trends in France (left) and contributions to global patenting (right)



Notes: CCUS = carbon capture, utilisation and storage. Patents for climate change mitigation technologies relevant to the energy sector. Patents filed in at least two geographical areas (family 2) by inventors residing in France.

Source: IEA analysis based on OECD (2021c), Climate change mitigation, *Patents – Technology Development* (database), https://stats.oecd.org/Index.aspx?DataSetCode=PAT_DEV (accessed on 8 July 2021).

To strengthen the links and foster collaboration between public research institutes, academia and industry actors, France has promoted the creation of regional high-tech and innovation clusters. One such example is Saclay Plateau in the Île-de-France region, which hosts the CNRS and the Alternative Energies and Atomic Energy Commission, many leading scientific and engineering schools, a network of research labs (e.g. the Île-de-France PV Institute set up in 2016), corporate R&D centres, and state-backed incubators and accelerators for start-ups. Overall, the Saclay Plateau gathers over 10 000 researchers and 50 000 students, providing a large pool of skilled workforce and talented graduates available for innovation activities.

Regional clusters can serve as innovation platforms for collaborative projects between academia, public and private actors, including start-ups. With the right incentives to collaborate, they can help bridge the gap between labs and markets thanks to the proximity between basic and applied research activities and product development in companies. They also attract financial actors such as venture capital investors looking to fund start-up projects burgeoning after graduate programmes or PhDs. Collaborative projects are generally able to mobilise greater resources and contribute more effectively to global innovation efforts. Overall, scientific and innovation clusters can play an important role in boosting France's technology innovation for the energy transition, such as to develop new concepts and technologies in areas including EVs; hydrogen; and carbon capture, utilisation and storage.

At the international level, France is active in CERT, 22 IEA technology collaboration programmes, Mission Innovation (MI), and EU Energy Technology Initiatives (batteries, nuclear safety). France has actively participated in all the actions of the EU Strategic Energy Technology Plan.

During the first phase of MI, France was a member of the MI steering committee and the Business and Investor Engagement Sub-Group and co-led with India the challenge "innovation in off-grid electricity access from renewables". Since their inception, France supported the innovation challenges on carbon capture, utilisation and storage and hydrogen. France supported the launch of the second phase of MI and has declared its interest to contribute to the missions most relevant to French priorities for the energy transition. France supports the Zero-Emissions Shipping Mission and participates in the Hydrogen Initiative. France actively participates in two main initiatives of the Clean Energy Ministerial – ISGAN (smart grids) and ZEV (zero emissions vehicles) – and recently joined the NICE Future (Nuclear Innovation for Clean Energy Future) Initiative. France has co-led a campaign on near-zero emissions buildings under the Global Alliance for Buildings and is a member of the Energy Efficiency Hub.

France supports the international exposure of its public research organisations; access to an international network of specialists; the possibility for researchers to collaborate, exchange and benchmark their work, stimulate the creation of new projects outside of technical collaboration programmes and access economic, technical and political information at the international level.

C. Support for innovation and market creation in strategic technology areas

While public institutions carry out much of France's R&D activities in the early stages of technology development, companies typically allocate the bulk of innovation budgets on demonstrating new concepts and developing new and improving existing products. To complement investments in traditional RD&D, France mobilises funding to support business innovation and foster the creation of markets for emerging energy products and services. This can help bridge possible gaps between innovators and consumers and trigger feedback loops and learning from markets to the lab.

The French government has taken the lead in using public funding for pulling market creation, notably by setting targets and providing funding. Measures have been focused on public procurement of new or emerging energy technologies, notably EVs and hydrogen applications; promoting performance or technology standards within the EU minimum levels; and deployment targets or quotas for emerging technologies, notably in renewable energy. Such instruments help create markets for new technologies, which provides incentives for innovators to innovate and trigger feedback loops from consumers to innovators.

In 2010, the government launched the PIA implemented by ADEME, Bpifrance and the Caisse des Dépôts. The programme includes equity investments, calls for demonstration funding, SME interventions and collaborative industrial projects. It seeks to support public and private actors – from idea to markets along the entire innovation value chain – to develop new concepts and technologies in strategic areas that can contribute to medium-

term structural economic growth and job creation in France. Four PIA tranches of funding and support mechanisms were set up successively in 2010, 2014, 2017 and 2020.

From 2010 to 2017, ADEME operated several programmes under the economy-wide PIA to fund innovations for the energy transition and environmental protection. Over the period, the PIA focused on technology areas including renewables, storage, smart electricity networks, energy efficiency in buildings, industry and agriculture, bio-based chemistry, circular economy and waste, as well as transport and mobility. This activity was comprised of 745 projects for a total grant amount of EUR 2.5 million on total project budgets aggregating to EUR 7.2 bln. Since 2018, ADEME has implemented several actions of the PIA-3 related to the ecological and energy transition for a total amount of EUR 1 bln: EUR 400 million in equity, EUR 300 million in state aid for demonstration projects, EUR 150 million in calls for participation for SMEs and EUR 150 million for sustainable mobility.

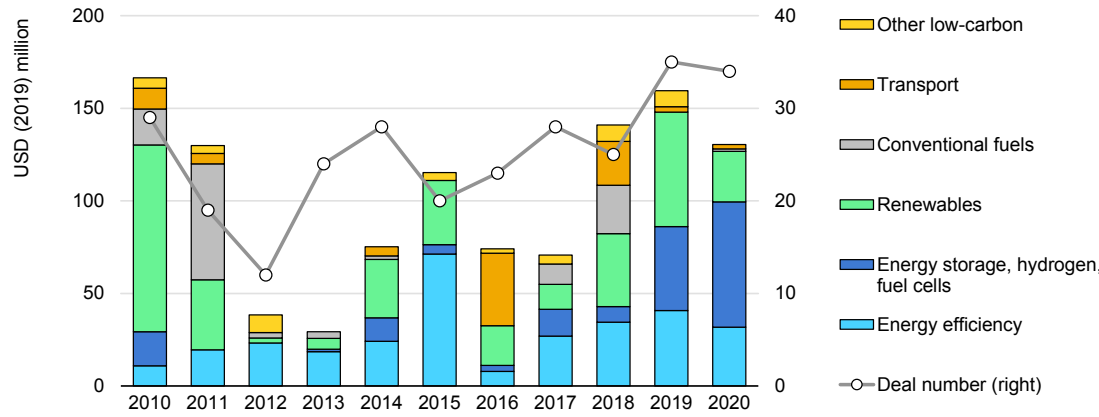
Supported by the French Recovery Plan, the PIA-4 (2021-25) will mobilise an additional EUR 11 bln for innovation, bringing total PIA-4 budgets to EUR 20 bln. Those investments will be allocated to the development of innovative and green technologies (EUR 3.4 bln); economic resilience and sovereignty (EUR 2.6 bln); support to higher education, research and innovation ecosystems (EUR 2.55 bln); and support for innovative companies, including SMEs and start-ups (EUR 1.95 bln).

As part of PIA-4, France plans to accelerate strategies for additional areas in need of innovation, such as technologies to support industry decarbonisation, bio-sourced products and biofuels, the circular economy, and energy systems. The first strategy is for low-carbon hydrogen, with a budget of EUR 7 bln, including EUR 2 bln in 2021-22 focused on electrolysis, hydrogen heavy vehicles and research in systems integration. Given the step change in funding, the government will need to ensure that regulatory frameworks and project pipelines are in place to leverage private funding (see Box 6.1).

The PIA funding also allows Bpifrance to finance companies in the field of sustainable development and the energy transition, regardless of their size, from start-ups to SMEs or mid-caps, with financial solutions both during the feasibility study stage of innovation projects and during their implementation and launch in France or abroad. The public bank also invests in companies' equity with high growth potential via innovation capital or seed capital, with the aim to create a ripple effect with regards to private funding.

Venture capital investments in French early-stage start-ups recovered well after the economic crisis. In 2019, venture capital deals aggregated to about USD 160 million, which were similar to levels in 2010 (Figure 6.7). As a result of the COVID-19 pandemic, lower investments were recorded in 2020. Strong growth in energy storage, hydrogen and fuel cells and relatively stable investments in energy efficiency partly compensated for considerable drops in renewables. Estimates for 2021 suggest that France's start-up ecosystem might be recovering. Hype's successful raising of EUR 80 million in January 2021 to develop hydrogen refuelling infrastructure and fuel cell-powered taxi fleets in Paris is a positive sign, but a few years may be needed to catch up with pre-COVID expectations.

Figure 6.7 Early-stage venture capital investments in clean energy start-ups in France, by sector, 2010-20



Note: Early-stage investments include seed, series A and B financing rounds.

Source: IEA analysis based on Cleantech Group i3 database. See also IEA (2021b), *World Energy Investment*, www.iea.org/reports/world-energy-investment-2021.

Box 6.1 France's national hydrogen strategy

For France, hydrogen represents a strategic opportunity to make a successful transition to a "zero-carbon" economy, particularly in the industrial and heavy mobility sector. In September 2020, the government launched the national hydrogen strategy, with a view to decarbonise hard-to-abate sectors, create a domestic hydrogen value chain and jobs, and lower the country's import dependence.

As the main technology for the development of renewable and low-carbon hydrogen, the government places a strong focus on electrolysis. This implies giving priority to the direct use of hydrogen over its transformation into a synthetic gas that can be injected into a natural gas network.

The government made a financial commitment to accelerate the deployment of hydrogen production and use by electrolysis with EUR 7 billion of public support until 2030. The acceleration strategy is based on the development of the production value chain to produce 6.5 gigawatts of decarbonised hydrogen by 2030. This commitment includes funding of EUR 2 billion under the French Recovery Plan.

With this financial support, the government aims to kick-start investment through support schemes to the large-scale demonstration and deployment of electrolysers in industry. The funding also supports the demonstration of shared hydrogen refuelling infrastructure (local hydrogen hubs) and of heavy-duty transport hydrogen applications in the transport sector as well as innovation and research and development (R&D), large-scale demonstrators and development of key components for hydrogen usages. To implement the ambitious hydrogen strategy, an action plan towards 2023 is in place.

R&D and innovation actions are financed under the pluriannual research programme. Demonstration is supported under the Investment for the Future programme with a key role

for the Agency for Ecological Transition (ADEME) to develop several hydrogen demonstration sites, including under the EU Important Projects of Common European Interest. With regard to deployment, ADEME is organising calls for the local hydrogen hubs, the Energy Regulatory Commission is supporting non-interconnected areas and the government offers support mechanisms for clean hydrogen projects, including an exemption from the biofuels tax.

The Ministry of the Ecological Transition set up a dedicated working group together with representatives of French industry to prepare and discuss the regulatory framework for hydrogen.

In terms of international collaboration, the government is involved in the Clean Energy Ministerial Hydrogen Initiative (H2I). French ports are joining EU and global initiatives to share good practices for scaling up clean hydrogen production and demand in ports and coastal industrial clusters, notably under the Global Ports Hydrogen Coalition and the European Hydrogen Ports Network initiative.

D. Tracking progress of energy innovation

Research results are evaluated and supervised by the High Council for the Evaluation of Research and Education (Hcéres). As an independent administrative authority, Hcéres is responsible for evaluating all higher education and research structures and for validating the procedures for evaluations conducted by other bodies. Hcéres provides recommendations and accompanies, advises and supports the process of improving the quality of higher education and research in France.

Specific processes are put in place for every funding programme to assess and monitor the effectiveness of the relevant expenditures, in particular for the PIA, for which both *ex ante* and *ex post* evaluations are performed, including of their compliance with the international and EU regulations in terms of state aid. There is no separate funding review by the Ministry of the Ecological Transition or the funding agencies. As part of the PIA, the National Research Agency monitors the research progress and structures and awards labels.

The national research strategy is evaluated every two years by the Parliamentary Office for Evaluation of Scientific and Technological Options. It also evaluated the SNRE in 2017. Out of the 15 recommendations, the office highlighted the need for the government to evaluate the SNRE, to communicate a clear vision for the French energy system, to define national research priorities that boost international competitiveness, to increase international collaboration on hydrogen to respect its financial commitments under MI (OPECST, 2017).

Assessment

France's National Energy Research Strategy, published in December 2016, covers well the core components of successful energy innovation systems, from providing resources for innovation to supporting new knowledge and market creation. Based on the Energy

Transition Law of 2015, the SNRE is the main reference for stakeholders in research and innovation in their efforts to support the transformation of the energy system.

The SNRE takes an energy system perspective and does not identify technology priorities. It aims at creating linkages across research priorities; it does not set out a common vision for France's future energy system. The SNRE dates back to 2016 prior to the update of the National Low-Carbon Strategy and the multiannual plan in 2020.

In the context of France's pledge to climate neutrality by 2050, the IEA sees several key opportunities for France to boost clean energy innovation in the context of the preparation of the next SNBC for 2024 and future funding programmes, and in the light of the sustainable recovery of the French economy following the COVID-19 pandemic.

First, with ambitious targets in the SNBC and PPE for climate neutrality by 2050, the SNRE needs to be updated. The next SNRE should be based on an evaluation of the current SNRE and France's technology pathways, create a common vision for the future energy system, set clear technology and innovation priorities and the direction for France's energy RD&D in the coming years. To design the next SNRE, the government should not only consult widely across government and key stakeholders, but also directly involve the private sector, civil society and academia. Having citizens participate in the work on the future SNRE and the definition of national investment strategies could be envisaged, building on the "Citizens' Convention on Climate".

Second, the IEA considers that in 2050, almost 50% of the global carbon emissions reductions required for carbon neutrality will come from technologies that are currently at the demonstration or prototype phase. Investment in RD&D and innovation remains critical.

Over the past decade, public energy RD&D funding has remained relatively flat, at around EUR 1.2 billion, corresponding to roughly 9% of French public spending for R&D and 0.05% of national GDP. Energy R&D spending is, to a large extent, dedicated to nuclear energy (mainly fission), energy efficiency and cross-cutting research areas. On an energy RD&D budget per GDP comparison, France ranks sixth after Norway, Finland, Japan, Switzerland and the Czech Republic. As a founding member of Mission Innovation, France pledged to double its clean energy R&D funding (excluding nuclear) from the 2015 baseline by 2020, but it did not succeed in doing so. This is a cause for concern and re-evaluation, given France's ambitious plans for emissions reductions in hard-to-decarbonise sectors that require more innovation quickly, like heavy industry and heavy and long-distance transportation.

The economic downturn following the COVID-19 crisis may have a negative impact on clean energy innovation, notably due to a short-term decrease in public and private budgets allocated to energy RD&D. Slower innovation today could have negative impacts in the medium to long term on the economy (jobs, competitiveness) and the clean energy transition more generally. The stability of RD&D support is critical, and funding even needs to expand quickly and significantly on the way to net zero. Investing in innovation opens significant opportunities for French companies and innovators to capture a share of growing clean energy technology supply chains. For example, Air Liquide in hydrogen; Renault in EVs in China; and Total in renewables or carbon capture, utilisation and storage are leading players in innovative technology segments.

The government should secure current clean energy innovation funding (e.g. PIA, core CNRS) and commit to raising it in sectors where more innovation is needed to achieve

goals in clean energy transitions (e.g. road transport, aviation biofuels, buildings, heavy industry). It is a welcome development that the government has adopted acceleration strategies for boosting technology innovation in four areas: 1) decarbonisation of industry; 2) bio-sourced products and biofuels; 3) circular economy; and 4) energy systems technologies. The first validated strategy in the energy field is "zero-carbon hydrogen", with a EUR 7 billion investment, including EUR 2 billion in 2022-23, focused on the investment in electrolysis, hydrogen powered heavy vehicles, and support to analysis and research of system integration.

The French Recovery Plan offers support to investment in RD&D and higher education infrastructures and fiscal incentives (e.g. reimbursement of debt of research tax credits) or loans (e.g. loans for innovation support, subsidised loans for innovation) for corporates to carry out innovation activities. While some of these mechanisms were tailored to clean energy transition objectives (e.g. subsidised loans for innovation for car makers aimed at low-carbon RD&D), funding could have been more tailored to the clean-tech sector.

To avoid disruptions of innovative start-ups, SMEs and demonstration projects in the clean energy space, the government should ensure the continuity of support schemes and focus on smaller scale, less complex, "shovel-ready" projects that also benefit SMEs (e.g. hydrogen electrolyser installations building on the Hydrogen Deployment Plan for the Energy Transition). These are more likely to have high stimulus effects than large-scale, novel projects. To provide alternative financing for start-ups and SMEs, the government should prefer "matching funds" schemes with private sector actors instead of fully public grants, to ensure technologies under development are more likely to be market viable (e.g. planned equity in start-ups through Bpifrance).

Third, mechanisms for market pull could be improved. Beyond a large portfolio of public procurement, regulatory rules and targets, France offers and promotes corporate and private investment support for energy demonstration and innovation through the research tax credit. While this policy support to spur RD&D seems effective, French RD&D entities noted that industry and market pull factors remained stagnant. Learning from tax credits in other countries, such as the United States, France should evaluate its incentive mechanisms, including the research tax credit. Recovery funding could be focused on retaining talent in SMEs to avoid discontinuing innovation capacities in the short term. The bar for clean-tech start-ups in the French Tech Next40 index could be lowered.

For instance, in the United States, RD&D efforts are often supported by tax credits authorised by Congress. The US government offers tax credits and other tax incentives to certain energy sectors to incentivise the development or consumption of alternative technologies. Consumers can claim tax credits for buying alternative energy vehicles or installing energy-saving equipment in their households. Congress has granted the renewables sector support with tax credits in the form of production tax credits and investment tax credits for solar, wind energy and advanced nuclear technologies. As part of the Bipartisan Budget Act passed in February 2018, Congress extended and significantly increased tax credits for CO_2 use and storage under Section 45Q of the Internal Revenue Code. Specifically, the changes raised the amount of tax credits that carbon capture for enhanced oil recovery receives from USD 10 per tonne to USD 35 from 2026, while lifting the credit for carbon capture in geological storage sites from USD 20 per tonne to USD 50 per tonne. The legislation also did away with a previous annual cap on the tax credits of 75 million tonnes of carbon dioxide. To support the nuclear new build

energy projects, the US administration also provided loan guarantees as well as production tax credits like those granted to renewable generation projects (IEA, 2019).

Embedding energy innovation potential in infrastructure spending is an opportunity that should not be missed as part of the implementation of the recovery funding. This can be part of several areas: clean energy infrastructure investment by local authorities (e.g. EV charging, hydrogen networks, buildings retrofit, district heating and cooling), sectoral industry bail-out plans (e.g. performance standards, deployment targets in aviation or heavy industry to "pull" medium-term clean energy innovation) or public procurement (e.g. targeting clean energy technologies that are close to market and can be scaled up quickly, such as batteries, fuel cells, smart energy efficiency).

Patent data suggest that French public research institutes are strong on applied R&D for new inventions, often in partnership with the large French companies. But French corporations are not as strong in patenting compared to other countries and French start-ups are not yet very present in venture capital markets.

Despite being a stated objective of the SNRE, engagement with industry and technology leaders remains low within the SNRE's governance and funding initiatives. The government needs to maintain support to corporate RD&D in low-carbon energy areas and associated human capital. This support, notably from the recovery funding, may be conditional upon publicly defined low-carbon innovation missions, such as the aforementioned acceleration strategies to ensure that R&D activities benefit society at large. Conditionality can also include job guarantees, the fair distribution of financial returns, if any, with public research institutions involved in public-private collaborative projects.

The SNRE is supported by oversight and governance through its monitoring committee, which is convened every year to review the SNRE progress. This committee does not include industry or civil society stakeholders in the evaluation and monitoring. And it is unclear how the overarching tracking of results by the higher councils are co-ordinated with the SNRE evaluations or how that process feeds into the formulation of future energy innovation priorities.

The government has put in place monitoring tools, including the PIA reporting and impact reviews. The major sources of funding such as PIA, with a large coverage and structured governance, allow monitoring the launched actions in a co-ordinated way. It remains less evident to track results for the clean energy technology progress towards the national strategy and investment objectives.

The Ministry for the Ecological Transition could accelerate delivery by consistently tracking the energy- and climate-specific programmes and actions and their contributions towards net zero objectives under the SNBC. Better tracking will help reassess priorities over time and reallocate budgets accordingly, identify good practice approaches in certain R&D programmes that might be applicable to other projects, focus on domestic strengths and weaknesses with the view to focus on comparative advantages, and capture global clean energy technology supply chains.

With regard to international research and innovation collaboration, France is an active partner of IEA-CERT, IEA technology collaboration programmes, Mission Innovation, the EU Strategic Energy Technology Plan, and the EU's European Technology and Innovation Platforms. International collaboration is critical for areas where France can show its technology leadership globally and learn from other leaders. The government should work

closely with global partners to exchange experiences and knowledge, notably in Mission Innovation 2.0 (second phase) for boosting transition technologies in support of investment acceleration strategies, such as hydrogen and bioenergy. Recently, France also joined the Clean Energy Ministerial Hydrogen Initiative.

Recommendations

The government of France should:

- Create a common vision on the future technology and innovation priorities of France's energy transition by evaluating and updating the National Energy Research Strategy, in close collaboration with civil society and industry, to support the work on technology pathways of the next National Low-Carbon Strategy and the two five-year energy investment plans.
- Strengthen the delivery of the energy and climate component of large-scale funding programmes by tracking results to ensure appropriate co-ordination of priorities and funding. Require public funding recipients (projects, individuals and companies) to report project and technology status or status changes after the expiration of research funding.
- Leverage opportunities for technology offtake and supply chains by further augmenting RD&D funds and market incentives for the uptake of research-derived technologies through instruments such as enhanced tax credits, follow-on funding, cost-sharing and other government scale-up support mechanisms.
- Activate and expand international collaboration efforts in clean energy RD&D sectors, specifically with regard to the EU's joint research centres and Mission Innovation 2.0 initiatives, building on France's investment strategies for clean energy technology deployment, such as hydrogen and bioenergy.

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OPECST (Parliamentary Office for Evaluation of Scientific and Technological Options) (2017), *Assessment of the National Energy Research Strategy*, *Summary of the Report Produced*, on behalf of the OPECST, by Anne-Yvonne Le Dain, MP, www.senat.fr/fileadmin/Fichiers/Images/opecst/quatre_pages_anglais/OPECST_2018_0004_synthese_SNRE_anglais.pdf.

7. Electricity

Key data (2020 estimated)

Electricity generation: 528 TWh (nuclear 67%, hydro 12%, wind 8%, solar 3%, biofuels 2%, coal 1%) -6% since 2009

Electricity net exports (2019): 57.7 TWh (imports 15.6 TWh, exports 73.3 TWh)

Electricity consumption (2019): 441 TWh (services/other 33%, industry 26%, residential 36%, energy sector 2%, transport 2%) -1.5% since 2009

Overview

Low-carbon, secure and affordable electricity will be required to achieve net zero emissions across the entire economy in the coming decades. In 2019, the role of electricity in France's total final energy consumption stood at 25%, above the IEA average of 23%. Electricity demand is expected to substantially grow with the stronger electrification of the buildings (with the installation of heat pumps) and transport sectors, as confirmed by RTE's decarbonisation scenarios presented in 2021 (RTE, 2021a, 2021b).

Globally, France has the highest share of nuclear in its power generation (67% in 2020), which has allowed the country to benefit from a low-carbon electricity mix for decades. However, France's power sector is going to face major transformations in the context of the legislated target of decreasing the share of nuclear in electricity production from 70% (pre- COVID-19) to 50% and the ambition of boosting the share of renewables to 45% by 2035, alongside the phase-out of the remaining four coal-fired power plants by 2022.

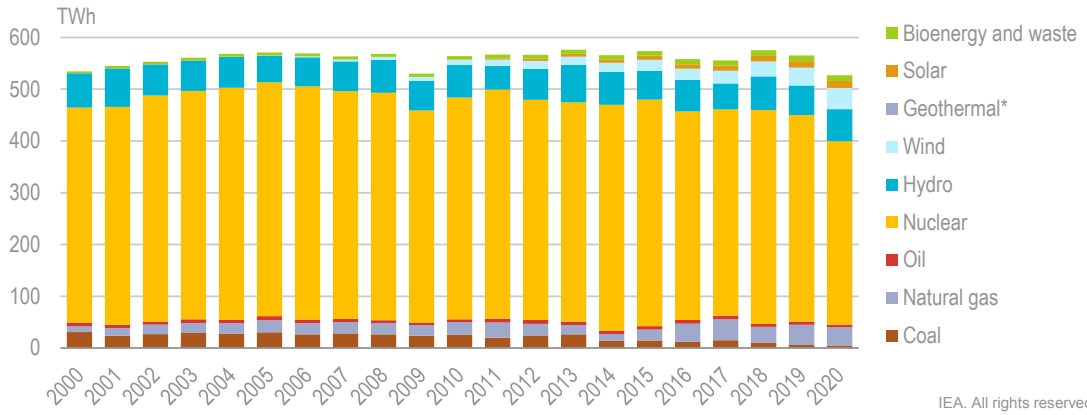
This will also entail major reforms in the French electricity market. The government needs to decide on the power market design for this future, including through EU level engagement, which relate to the organisation of the market, the role of the largest supplier, the incumbent Électricité de France (EDF), the regulation of hydropower and nuclear, and the future of the regulated tariffs. Key elements of the future market design are the availability and regulation of dispatchable capacity and the remuneration of a generation fleet that is driven by fixed rather than variable costs. Second, the government needs to prepare the decision on the role of nuclear in the electricity mix beyond 2035. Third, as the nuclear generation fleet ages and the share of variable renewables grows, France needs to ensure electricity security during its transition. A review of the capacity market mechanism and demand-response management can be useful. Fourth, as the share of variable renewables is rising, the government is looking to expand the flexibility of the power system by using demand response, grids/interconnections and hydrogen.

Electricity supply and demand

Electricity generation

France's electricity generation decreased by 7% between 2019 and 2020 to reach 528 terawatt hours (TWh) (Figure 7.1). In 2020, nuclear remained the main source of electricity, but at lower than usual levels (67%), following the closure of two reactors and lockdowns during the COVID-19 pandemic. The third source of electricity generation is hydro (12%), followed by natural gas (7%) and coal (1%). Coal decreased from 5% in 2010, while renewables (including hydro) increased their role in electricity generation, up from 80.4 TWh in 2010 to 116 TWh in 2020. Wind and bioenergy led this growth. Bioenergy almost doubled (up from 6 TWh in 2010 to 11 TWh in 2020). Wind power saw the highest growth (from 10 TWh in 2010 to 41 TWh in 2020). In 2020, solar and wind made up 11% of France's electricity mix.

Figure 7.1 France's electricity generation by source, 2000-20



France's electricity supply comes mainly from nuclear, with a growing share of renewables.

Notes: TWh = terawatt hour. *Bioenergy and waste* includes non-renewable waste. Considering the marginal difference between waste from renewables and waste including non-renewable sources, the present review incorporated non-renewable waste.

* *Geothermal* is not visible at this scale and increased from 0.0 TWh in 2010 to 0.13 TWh in 2020.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

France's installed generating capacity amounted to 135 gigawatts (GW) in 2019, up by 13% since 2009 (Table 7.1). Nuclear power accounted for 63.2 GW in 2019,[1] while the second-highest capacity source was hydro, with 26 GW. Installed solar and wind capacity experienced noticeable increases between 2009 and 2019, with solar photovoltaic up from just 0.3 GW in 2009 to 9.4 GW in 2019 and wind from 4.6 GW to 16.5 GW over the decade. Gas-fired power plant capacity doubled over the same decade, to reach 12.2 GW in 2019.

[1] Nuclear capacity stood at 61.3 GW at the end of 2020 after the shutdown of the two reactors at Fessenheim.

Coal power generation capacity has declined and in 2019 France had four remaining coal-fired power plants, with a total capacity of 3 GW. The closure plan is confirmed for Le Havre (April 2021) and must be determined by 2022 for the others (St. Avold, Cordemais[2] and Garanne). Coal-fired power plants account for one-third of the CO_2 emissions of the entire French power generation fleet, although they only contribute 1% to the country's electricity production. In 2019, coal represented less than 1% of domestic energy production, 3% of total energy supply, 1% of electricity generation and less than 1% of total final energy consumption (TFC). The main sectors using coal are industry (56%, cast iron), electricity and heat production (25%), and manufacturing (14%).

Table 7.1 Structure and evolution of electricity generating capacity in France

Fuel type	Installed capacity (2019) (GW)	Capacity share in 2019 (%)
Nuclear	**63.2**	**46.6%**
Thermal power plants	**18.6**	**13.7%**
- coal	*3.0*	*2.2%*
- heavy fuel	*3.4*	*2.5%*
- gas	*12.2*	*9.0%*
Hydro	**25.6**	**18.9%**
Wind	**16.5**	**12.2%**
Solar	**9.4**	**7%**
Bioenergy	**2.1**	**1.6%**
- biogas	*0.5*	*0.4%*
- biomass	*0.6*	*0.5%*
- waste	*0.05*	*0.04%*
Total	**135.3**	**100%**

Note: GW = gigawatt.

Source: RTE (2021c), Electricity Review 2020, https://assets.rte-france.com/prod/public/2021-03/Bilan electrique 2020_0.pdf

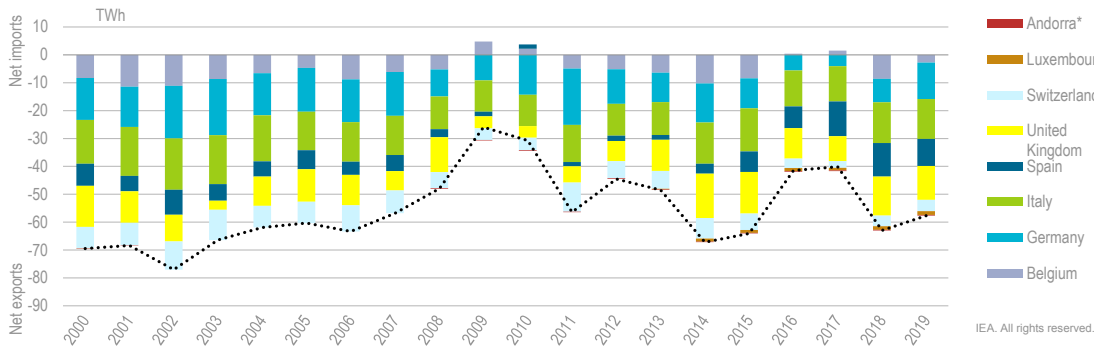
Electricity trade

France has been a net exporter of electricity for decades and is Europe's largest electricity exporter. Net exports decreased during 2009 and 2010 and 2016 and 2017 (Figure 7.2). In 2019, France recorded net exports of 57.7 TWh, with only a marginal amount of total imports (15.6 TWh in 2019), as illustrated in Figure 7.2. Net exports from France went mainly to Italy (14.3 TWh), Germany (13.1 TWh), the United Kingdom (12.1 TWh), Spain (9.7 TWh) and Switzerland (4.1 TWh) with some exports to Belgium (2.8 TWh).

France's transmission system operator (TSO) RTE operates a very large network of 106 000 km of power lines (at medium- to high-voltage levels above 63 kilovolts [kV], while most European TSOs only own/operate above 220 kV). Since 2017, 50.1% of the shares of RTE are held by EDF, 29.9% by the Caisse des Dépôts and 20% by CNP Insurance.

[2] The Cordemais coal-fired power plant will be kept for residual operation of a few hours a year up to 2024, if necessary, until the Flamanville 3 nuclear power plant and St Nazaire offshore wind farm are in full operation. Plans by EDF to convert the Cordemais plant to biomass have not been confirmed.

Figure 7.2 France's electricity net trade (imports/exports), 2000-19



France has consistently exported electricity to its neighbouring countries, notably to Italy, Germany and the United Kingdom, and increasingly to Spain and Belgium.

* Andorra: electricity trade to Andorra is not visible at this scale, accounting for less than 0.26 TWh in 2019.

Note: TWH = terawatt hour.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

France is well interconnected, with 17.4 GW of export and 12.5 GW of import capacity, or an interconnection rate of 11.4%. This is above the European interconnection target of 10% by 2020 (measured as electricity import capacity over installed generation capacity).

France has improved its interconnection capacity with the United Kingdom thanks to the commissioning of the Interconnection France-Angleterre 2 in January 2021. Plans are in progress on the Celtic Interconnection linking France and Ireland (planned by RTE and EirGrid) and works are under way for the Eleclink to the United Kingdom (through the Channel Tunnel) to be commissioned in 2022.

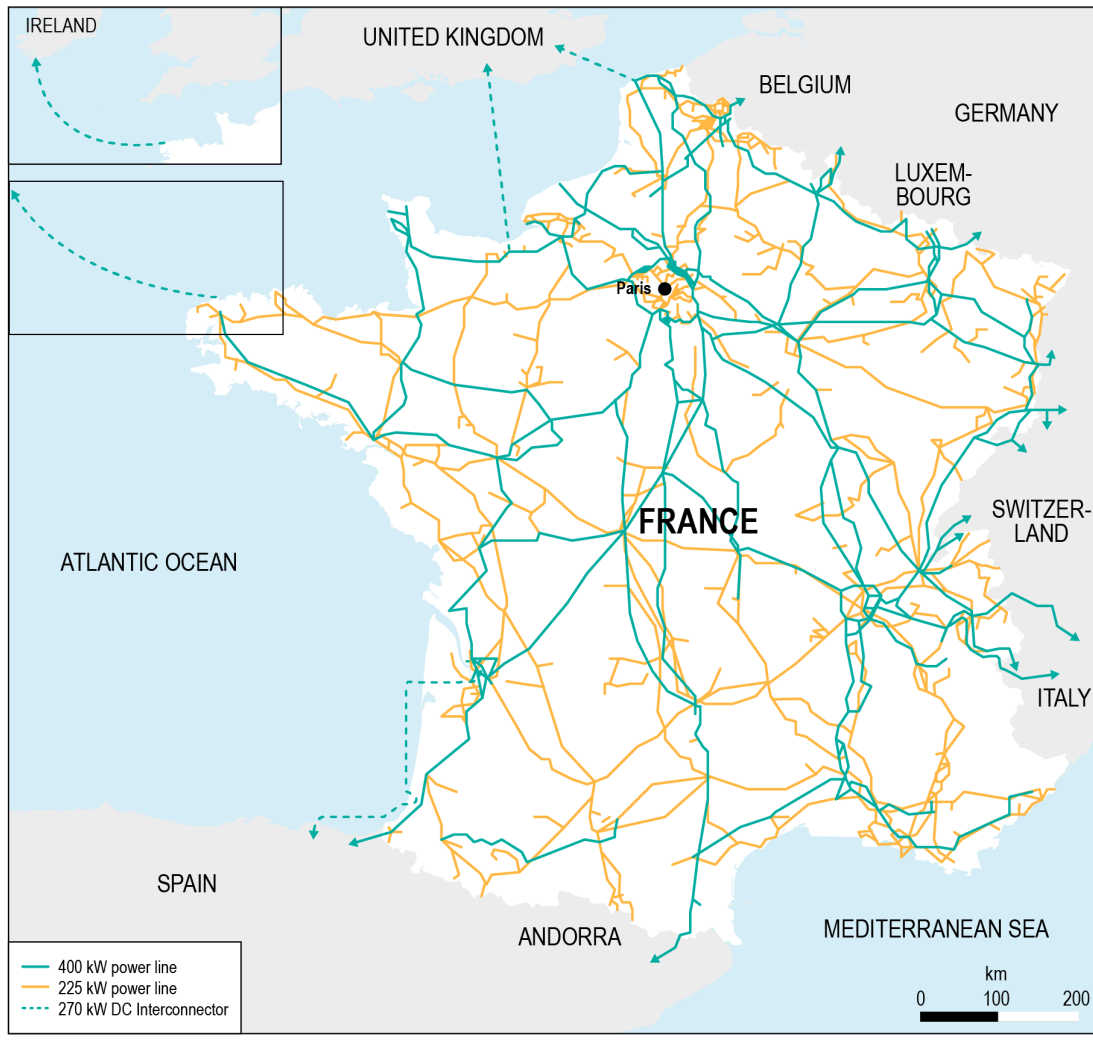
A new interconnection to Italy (Savoie-Piemont) is expected to start by the end of 2021. The integration with the Iberian Peninsula was strengthened with the commercial opening of a new interconnection in 2015, which will further increase with the planned high-voltage direct current cable France-Spain (Gulf of Biscay), which however will only come online by 2027. France remains the main bridge for Spain and Portugal to access the European electricity market and progress is expected under the Lisbon Declaration of Spain, Portugal and France (Figure 7.3).

Electricity distribution and supply

In France, public local authorities[3] are the conceding authorities for electricity (and gas) distribution in a specific framework created after 1946. The National Federation of Granting Authorities and Regies, which was created in 1934, brings together around 500 authorities, in addition to the large cities and urban communities.

[3] In application of the French energy code, local communities are "local authorities or groups of local authorities" (*des collectivités territoriales ou des groupements de collectivités territoriales*).

Figure 7.3 Electricity infrastructure of France



In application of the French Energy Code, local authorities can concede the electricity distribution network operation to:

- in mainland France: Enedis or a local distribution company, one of the so-called *entreprises locales de distribution* (ELDs)
- in the areas which are not connected to mainland France (except for Mayotte and Wallis and Futana): EDF SEI
- in Mayotte: “Électricité de Mayotte”
- in Wallis and Futuna: “Électricité de Wallis et Futuna”.

In mainland France, more than 80% of the concession contracts are being renewed during 2018 and 2023. Most of the renewal has already taken place. The law does not allow customers to choose a DSO other than the historical one, except under limited conditions. Enedis holds about 95% of the distribution concessions in terms of customers served (serving 35 million customers, including those in the large cities like Paris, Marseille and Bordeaux). The other 5% of concessions are held by 116 local electricity (and gas) distribution companies (ELDs), serving 1.8 million clients.

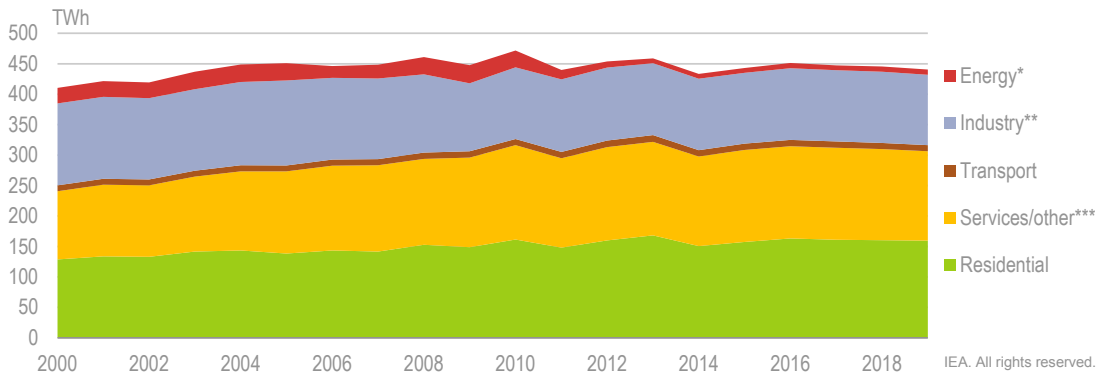
In France, 95% of these distribution companies serve networks with less than 100 000 clients. Only five ELDs (around Strasbourg, around Metz, around Grenoble, in the Vienne department and in the Deux-Sevres department) serve more than 100 000 customers and adopted functional and legal separation between distribution and supply activities.

Investments in (transmission and) distribution networks are financed by the tariff for the use of public power grids (tarif d'utilisation des réseaux publics d'électricité, TURPE), which is regulated by the Energy Regulatory Commission (CRE) in four-year periods. France equalises or cross-subsidises the distribution grid tariffs across its territory (urban areas subsidise rural ones). Investment decisions, however, vary from one DSO to another, and are subject to discussion with the local communities.

Electricity demand

Shares of electricity consumption by sector have remained relatively stable (Figure 7.4). Total electricity consumption reached 441 TWh in 2019, with residential consumption at 160 TWh (36%), followed by services at 147 TWh (33%), industry at 116 TWh (26%) and energy transformation at 9 TWh (2%).

Figure 7.4 Electricity demand in France by sector, 2000-19



Residential, services and industry are the main electricity consuming sectors in France.

* *Energy* includes oil and gas extraction, coke ovens, gas works, petroleum refineries, and nuclear industry.

** *Industry* includes non-energy use.

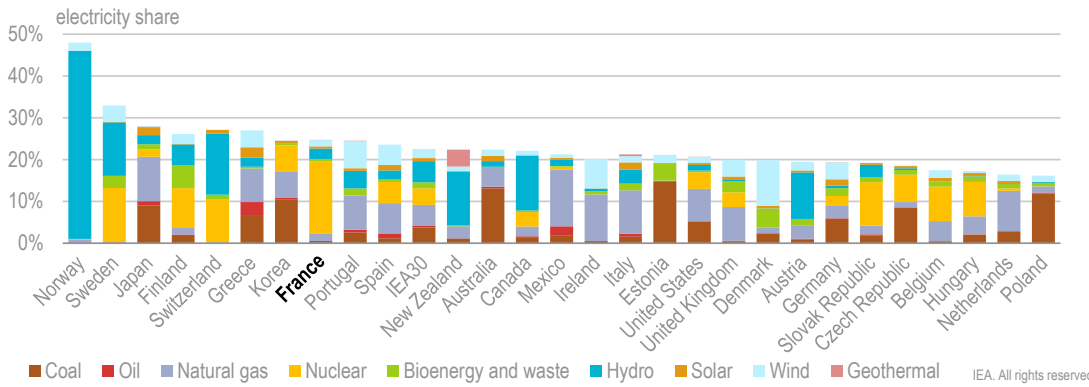
*** *Services/other* includes commercial and public services, agriculture, forestry, and fishing.

Note: TWh = terawatt hour.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2019, France's share of electricity in TFC stood at 25%, which was the eighth-highest among IEA countries (Figure 7.5), above the IEA average of 23%. By international comparison, in 2020, France had the highest share of nuclear, one of the lowest shares of wind and solar, and the fourth-lowest share of fossil fuels in the electricity mix (Figure 7.6).

Figure 7.5 Share of electricity in total final consumption in IEA countries, 2019

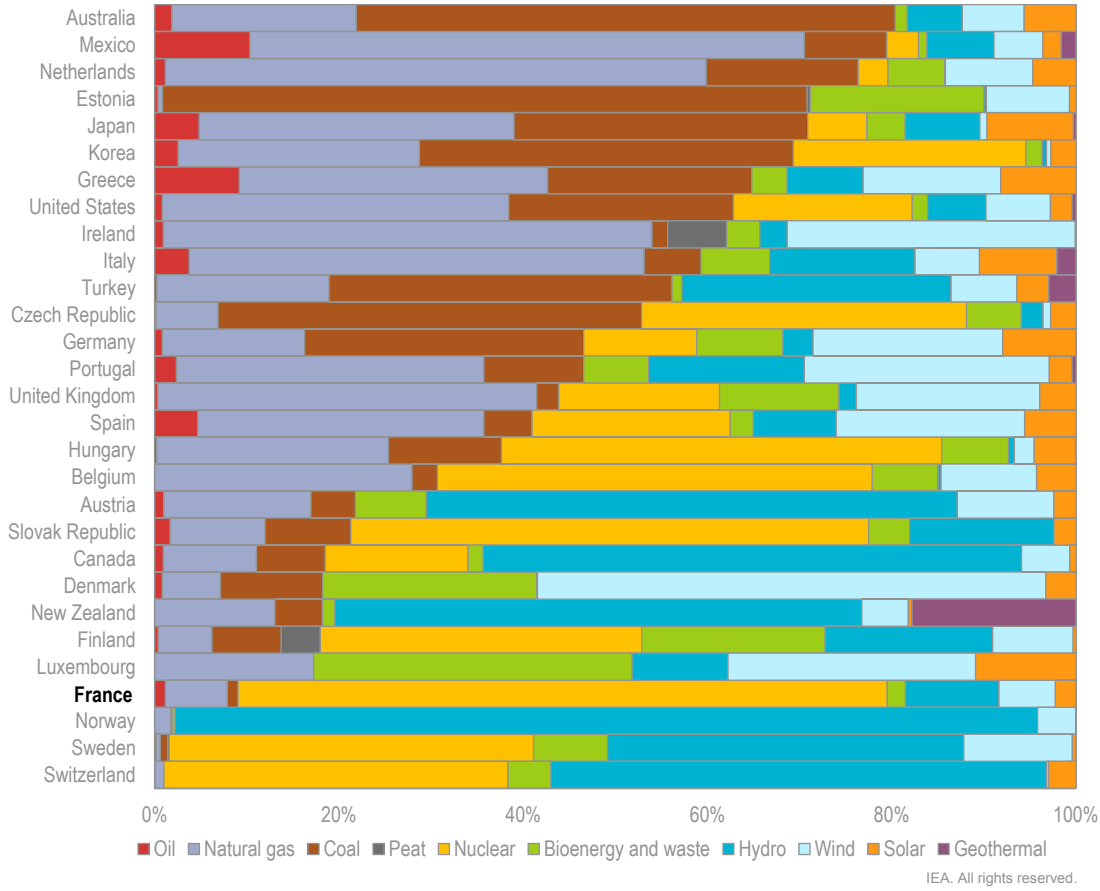


France's share of electricity in total final consumption is higher than the IEA30 average.

Note: Data for Turkey are unavailable for 2019.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 7.6 Electricity generation for IEA countries, 2020



France has a low diversity of power generation, with the highest share of nuclear and one of the lowest shares of wind and solar in electricity generation by international comparison.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Electricity policy

France's electricity policy is governed by the national planning frameworks. The Energy and Climate Law of 2019 set the goal of reducing the share of nuclear in the electricity mix to 50% by 2035. The latest two successive five-year energy investment plans (*programmation pluriannuelle de l'énergie*, PPE) adopted in April 2020 set the goals for the electricity mix up to 2028, with a major role for renewable energy, which shall contribute 40% in 2030 and 45% by 2035. In line with the National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone, SNBC), France aims to decrease coal use across the economy, notably in the power sector. The SNBC and the PPE articulate the policy goal to phase out the remaining four coal power plants by 2022 and end coal use in district heating by supporting the switch to biomass/waste within five years (and reduce coal use by 75% in industry by 2028, except in the steel sector). However, beyond 2035, there is no specification of the sources for the future electricity mix.

Market reforms

Generation and wholesale market

France is part of the EU common wholesale electricity market. Thanks to the market coupling of north-west Europe (15 countries including France) with south-west Europe (Spain and Portugal) in 2014, France is part of a wider EU electricity market place. Three electricity exchanges operate in France: the European Power Exchange (EPEX spot) and NordPool EMCO AS for spot products and the European Energy Exchange (EEX) for derivatives.

The market design is adapted to the French historic context. While generation and retail are fully open to competition, in line with EU directives, the French national utility EDF holds a strong position in the market. By owning and operating all nuclear reactors and most of the hydro power plants (in total 80% of generation capacity), plus all transmission and distribution network operators (RTE and Enedis are subsidiaries of EDF but operationally highly independent), and 70% of the residential retail segment (CRE, 2019), EDF has been able to dominate the French electricity market for a long time. EDF is also a major market player in the field of electricity generation from renewable assets under its new arm "EDF Energies nouvelles". The nuclear developer Framatome, which is another subsidiary of EDF, was created during the recent reorganisation of the French nuclear industry.

EU rules oblige the French government to tender out the 29 hydropower concessions (large-scale plants), which expired by the end of 2020 for competition and require EDF to offer nuclear generation to competitors at historic costs (*accès régulé à l'électricité nucléaire historique*, ARENH).

The CRE considers that EDF does not abuse its market power and noted a decline in EDF's retail margins. The margin decreased from 6% in 2008 to 1.5% in 2019, alongside the decrease in spot prices across the European wholesale market in recent years up to 2020 (CRE, 2019).

Hydropower

With regard to hydropower, around 29 concessions expired between 2011 and 2021 without being subject to competition. In 2015, the European Commission (EC) initiated a case against France, noting EDF's dominant position in the hydropower sector. Other than power production, hydroelectric dams participate in the provision of reserve and ancillary services and the capacity market (through the capacity obligations). In 2019, the EC issued formal notice to France, as well as to other major European countries, to require compliance with Community law on the allocation of hydropower operating rights.

In view of the social, economic and ecological issues linked to hydropower, successive governments have not tendered hydropower concessions, but discussed a series of reforms. Under the Energy Transition for Green Growth Act (2015), local communities can be a concession partner (as part of a hydroelectric semi-public company). The regrouping of concessions which are hydraulically linked implies the definition of a new common expiry date. This new date may be later than the expiry date initially taken for an ungrouped concession. A new tender will also be needed in such cases after the expiry of the new date. As part of the reflections on the reorganisation of the EDF group (see Box 7.1), the government is also exploring the option of allocating concessions without competition to dedicated public structures, controlled by the state, either in-house or in so-called *régies*.[4] France argues it would optimise the operation of the dams and boost investment, while redistributing financial resources to the regions through new royalties. The discussions on the conditions to be met for a new structure are still ongoing with the EC.

Nuclear energy

The Law for the New Organization of the Electricity Market (NOME) introduced in 2010 the regulated access tariff (ARENH, 2011; a transitionary mechanism until the end of 2025) for competitors of EDF to gain access to electricity generated by the nuclear plants at a regulated tariff. Each year EDF must ensure that alternative suppliers have access to a large share of electricity produced by EDF's nuclear plants (100 TWh/year[5]) at the cost-based regulated tariff. The CRE fixed the regulated rate of the ARENH at EUR 42 per megawatt hours (MWh) since 2012, allowing EDF to recover the annual depreciations evaluated at historic costs of investment for 25% of its ageing nuclear fleet.

The price of the ARENH has been kept constant since its introduction and is a maximum price for competitors to get access to 100 TWh/year. It is not a guaranteed price for EDF: if market prices are lower, competitors do not buy electricity from EDF through the ARENH, but rather buy it on the market. Until 2018, competitors hardly bought electricity from EDF at the fixed tariff, as wholesale electricity prices in France and Europe were below the fixed tariff, creating substantial revenue shortages for EDF's refurbishment plans. Since 2018, this trend has reversed, as wholesale market prices have been mostly above the ARENH price, and competitors regained interest in EDF's "cheaper" energy under the ARENH. The

[4] Under French law, a *régie* is a public authority in charge of the management of a public service or a mode of management of a public service. A *régie* is different from a delegated public service, which includes a contractual relationship.

[5] The Energy and Climate Act of 2019 allows the government to raise the ceiling of the amount available under the ARENH up to 150 TWh. Any modification of the ceiling requires approval from the European Commission, which also includes the level of the ARENH.

CRE and the Competition Authority underline that alternative suppliers have entered the market thanks to the ARENH and EDF's retail share came down to 70% in 2019 (from 90% in 2015).

The reform of the scheme is under discussion in France. A new scheme was under consultation in 2020. According to the proposed scheme, all of EDF's production would sell at market prices and additional payments to or from EDF would be made *ex post* to close the gap between the market price and a pre-set price that would cover all costs (contract for difference). The scheme would be regularly revised and be more symmetrical, with a market-based strike price. The methodology would be established by the CRE and would need approval from the EC.

In terms of the economics, a recent analysis by the IEA and the Nuclear Energy Agency (NEA) of the levelised costs of electricity in France shows that as far as instalment of new capacity is concerned, nuclear new build technology incurs costs above USD 5 000/kilowatt electrical (kW_e), while solar technology remains the lowest (below USD 2 000/kW_e). However, such capital cost comparisons do not reflect the system value and differences in the load factor, which is 85% for nuclear and 18% for solar PV. The study also showed that the long-term operation of the French nuclear power plants has investment costs of USD 673/kW_e, and is a highly cost-effective measure for France, judging by the levelised costs of electricity (see also Chapter 8).

Box 7.1 The restructuring of the French utility EDF

In 2020-21, France has discussed the restructuring of EDF, following a proposal by the French government and EDF for the so-called Projet Hercule, later renamed Grand EDF. This proposal builds on a plan to create two distinguished entities (EDF bleu and EDF vert). The first entity, EDF bleu, would regroup dispatchable low-carbon assets (i.e. nuclear, hydroelectric power plants and gas-fired power plants) as well as the transmission system operator RTE. It would also retain majority ownership in the second entity, EDF vert, which would regroup renewables, the electricity distributor Enedis and energy services. The second entity would be considered a subsidiary of the integrated structure, with its capital open to outside investors.

According to a hearing at the French parliament in February 2021, the government has three priorities: 1) maintain an integrated group (EDF vert remaining fully integrated in the group); 2) safeguarding employees (public service, highly educated engineers); and 3) protecting consumers against price increases in the EU market (fluctuation of CO_2 prices, higher gas or coal prices, etc.) with regulated tariffs by EDF. The government is focusing on a strong integrated player (national champion) to lead the energy transition, including investments in renewables and new nuclear and the modernisation of the historic fleet.

The project has met opposition by the trade unions, some local municipalities (owners of the distribution grids and some operators of hydroelectric plants) and is under discussion with the European Commission as far as competition, state aid and the regulatory framework are concerned (notably price and network regulation and the future of the regulated access tariff for nuclear). Discussions between Brussels and the Ministry of the Ecological Transition continued for more than a year. In May 2021, Grand EDF was put on hold until after the presidential elections in 2022.

Retail market

France's retail market consists of 38.2 million customers, with an annual consumption of 412 TWh. The market has been open for competition since 2007; in France, consumers can choose between market offers and the regulated tariff, set by the government. Only incumbent suppliers (EDF and local distribution companies [ELDs]) can supply electricity at the regulated rate (other suppliers cannot), but they can also compete with the other suppliers and also make market offers.

Since the opening of the market in 2007, there is a considerable amount of choice in France, with the emergence of competitive market offers, price comparison tools and an ombudsman who supports consumer empowerment. According to the CRE, in 2020, 31 suppliers served residential segments and 38 the non-residential sectors. The four largest suppliers are EDF, Engie, Total Direct Energie and Eni.

From 2014 to 2020, the switching rate increased from 1% to 3% per year, with a small dip during the COVID-19 pandemic. Consumers are either not aware that they can switch away from regulated tariffs or are inert and do not want to switch. A small proportion of the French household market has switched away from EDF, whose market share has remained around 70%, despite several new entrants and alternative suppliers being able to offer competitive prices to consumers in France. The CRE finds the retail market for residential consumers highly concentrated, with a Herfindahl-Hirschman Index[6] of 5 000 (CRE, 2020).

Regulated tariffs

In 2016, the government abolished regulated tariffs for large industry and commercial consumers (green and yellow tariff bands). As of 2021, only residential consumers and microenterprises remain eligible to benefit from regulated tariffs (blue tariffs), if they choose to do so. For eligible consumers, these regulated tariffs are considered last resort tariffs.

France has introduced market offers which often have slightly lower prices than the regulated tariff. This was certainly the case when wholesale prices were low prior to 2018. The consumers remaining on the regulated tariff may end up paying a higher price per kWh due to this pass-through of the wholesale price levels. While the incumbent can also offer market prices and compete with alternative suppliers in France, the revenues from the regulated tariff are only available to the incumbent supplier.

The calculation of the regulated tariffs changed in 2014 to a method that allows alternative suppliers to compete with the incumbent on price. Before 2014, it was based on the accounting costs of the integrated operator. Tariffs now reflect the costs incurred by an "average" supplier. Regulated tariffs are now established by the sum of the price of regulated access to incumbent nuclear electricity (ARENH); the cost of the electricity supply

[6] HHI = The Herfindahl-Hirschman Index or HHI is a measure for industry concentration taking into account the size of firms in relation to the industry. It is calculated by adding the sum of the squares of the percentage market shares of each market participant. For example, a market consisting of five competing firms, each with a 20% share of the market, would have an HHI score of 2 000 (i.e. 400 x 5). HHI is typically used to help assess the degree of market dominance and potential for market power abuse. Views vary on the interpretation of HHI scores. This study uses the scale developed by the European Union, with scores of 750-1 800 considered indicative of moderate concentration; scores of 1 800 to 5000 indicative of high levels of concentration and scores above 5 000 indicative of very high concentration consistent with the presence of substantial potential market power.

component, which includes the capacity guarantee, transmission costs and marketing costs; as well as a rate of return on investment. Since 2015, the CRE proposes the regulated electricity sale tariffs to the Ministers for Economy and Energy, along with reasoned arguments. The government then has three months to contest or adopt the proposals.

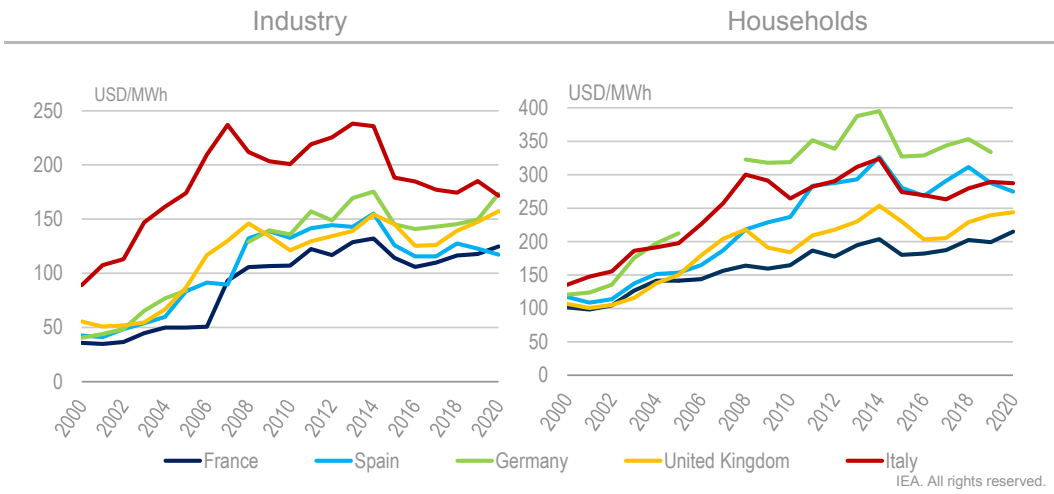
In 2021, the government has no plans to end the price regulation for households, but intends to review regulated tariffs by 2022. Under EU rules, the government has to review regulated tariffs in 2022 and 2025, based on an assessment by the CRE and the Competition Authority of the contribution of the tariffs to the general economic interest (price stability, supply security, social and territorial cohesion), their impact on the retail market and for the category of consumers for whom regulated prices are deemed necessary. In its review of 2021, the CRE concludes that it is too early to phase out regulated tariffs and that the introduction of dynamic pricing should be confined to market offers alone (CRE, 2021).

In 2021, the government announced measures to limit the increase in the electricity tariff to 4% in February 2022 to shield the electricity tariffs for households against the energy price hikes in the fall of 2021. An expansion of the energy voucher could also be considered. In 2020, the government issued a one-off contribution to the energy bill with an energy voucher of EUR 100 to vulnerable consumers (5.8 million beneficiaries).

Retail prices and taxes

France's electricity prices followed similar price trends as its neighbouring countries during the period 2000-20, both for industry and households. France remained the country with the lowest prices, compared to Spain, Italy, Germany and the United Kingdom (Figure 7.7), until 2020, when the industry price ranked slightly higher than Spain's. However, taxes on electricity in France are among the highest in the EU.

Figure 7.7 Electricity prices for France and selected IEA countries, 2000-20



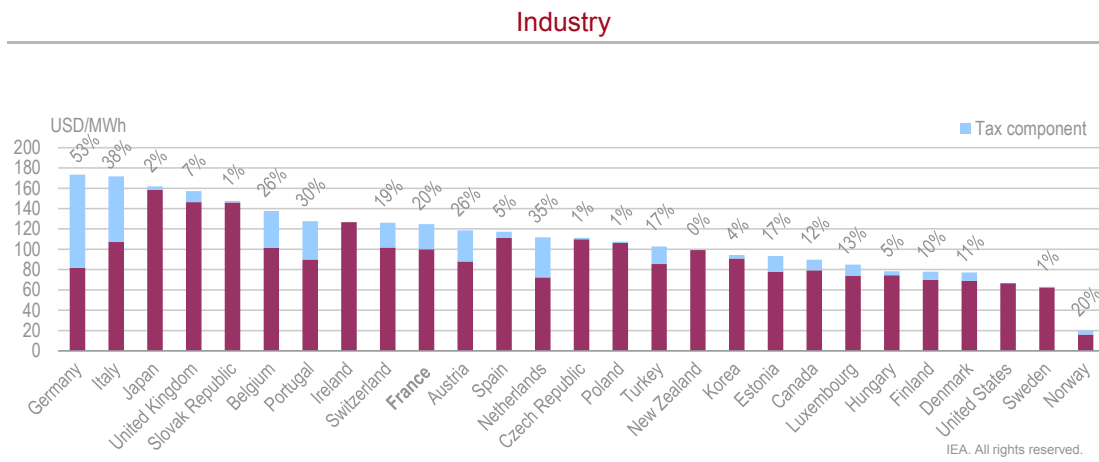
France's electricity prices have been among the lowest of its neighbouring countries.

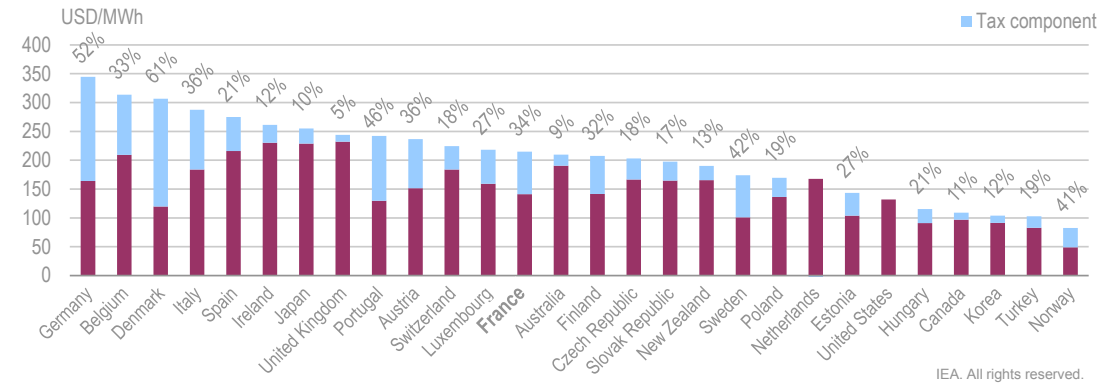
Note: MWh = megawatt hour.

Source: IEA (2021b), Energy prices and taxes 2020, *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2020, industry electricity prices in France reached USD 125/MWh, the tenth-highest among IEA countries, with a 20% tax share (Figure 7.8). Household electricity prices were USD 215/MWh, 13th highest among IEA countries, with a tax share of 34%.

Figure 7.8 Electricity industry and household prices in IEA countries, 2020





France's electricity prices are close to the IEA average, but have higher than average tax shares.

Notes: MWh = megawatt hours. Tax Information is not available for Ireland or the United States. 2020 industry data are not available for Australia or Greece. 2020 household data are unavailable for Greece. Industry data are not available for Australia, Mexico or New Zealand. Household data are not available for Mexico.

Box 7.2 Towards a consumer-centred clean energy transition

International experience suggests that empowering consumers and increasing their participation is critical to ensure a people-centred energy transition. The International Energy Agency considers the following principles vital for empowering consumers in the transition:

- Increasing customer exposure to dynamic and time-of-use pricing while protecting vulnerable consumers through targeted transfers that do not unduly distort efficient price formation.

- A competitive, dynamic retail market to encourage the development of innovative products and services that can harness demand response effectively and at least cost.
- Ready access to detailed, real-time customer information while ensuring privacy, to help stimulate competition, facilitate competitive entry, support the emergence of innovative business responses and improve customer choice.
- A knowledgeable and well-informed customer base that has the capability and opportunity of taking full advantage of the available choices.
- Market processes for contracting, switching and billing that are as simple and seamless as possible to keep transaction costs to a minimum.
- Legal and regulatory governance frameworks that reduce uncertainty; establish clearly specified rights, responsibilities and obligations on contracting parties; promote greater harmonisation of standards and functionality specifications; and maximise scope for participation among potential service providers and customers.
- Enabling technologies that provide cost-effective, real-time metering information, verification and control capability to support the introduction of real-time pricing, the development of a wider range of innovative demand-response products, and more effective customer choice.

Electricity security and emergency measures

Framework for security of electricity

The legislative framework for electricity security is based on the French Energy Code and the provisions of EU Regulation 2019/941 on risk preparedness in the electricity sector. The transmission system operator, RTE, is responsible for assuring real-time power system adequacy as well as the security, safety and efficiency of the power network.

RTE publishes an annual safety assessment of the power system which gives an overview of the power system's security levels. RTE also publishes an annual adequacy assessment (*bilan prévisionnel*), that contains an in-depth study of the supply-demand balance for the coming five to ten years and quantifies the average disruption duration, analyses risk scenarios, and evaluates the electricity generation or demand-response capacities needed to ensure security of electricity supply.

At the European level, RTE works with the regional co-ordination centres (CORESO, TSC). RTE is the biggest TSO in continental Europe, so it has an important role in the European system security. This was highlighted during the 8 January 2021 incident, when the Continental Europe Synchronous Area was separated into two areas (the North-West Area and the South-East Area) due to cascaded trips of several transmission network elements. RTE and Terna (Italy) automatically disconnected 1.7 GW of industrial consumers (out of a total system load of about 200 GW in the North-West Area) to prevent any further frequency drop and avoid activating load shedding, which is undesirable.

France has a legal requirement to maintain security of electricity supply to a three-hour loss of load expectation (LOLE) standard (Article D. 141-12-6 of the Energy Code). In the models produced by RTE, a disruption expectation of three hours per year represents a

consumer cut-off expectation of less than two hours. The LOLE is at a level comparable to that of other European countries. The Energy Code (Article D. 141-12-6) defines the notion of "disruption" as the use of exceptional (contracted or not) means to keep the stability of the system, such as calls for voluntary reduction of electricity consumption by citizens, asking for help from other TSOs outside of the market, reducing margins or voltage, and load shedding. The definition used by RTE to build its models refers to situations in which the normal operation of the market no longer ensures a balance between supply and demand.

Capacity market

France's electricity generation has been designed to meet peak, not average, annual demand. The French electricity system has a peak load during winter months, which over the past 20 years has fluctuated between 80 GW and 102 GW. Security of electricity supply needs to be ensured for winter (evening) electricity peak demand, which reached a historic peak on 8 February 2012 of 102 GW. For every 1°C temperature drop, power demand increases by 2.4 GW, mainly driven by electric heating.

Up to 2030, peak electricity demand is expected to be subdued due to greater energy efficiency in buildings, the deployment of heat pumps (which provide more regular power demand and thermal inertia) and demand-side flexibility development. At the same time, the increasing electrification of the transport and residential sectors will push total demand growth. Winter evening peaks will continue to be an issue, notably with higher shares of renewables, as on some winter days there is very little wind power generation (doldrums).

With a view to manage reliability concerns, France has been successful in putting in place a capacity mechanism and activating large demand response.

In 2017, France implemented a capacity mechanism (decentralised capacity market with capacity obligations), based on the established three-hour LOLE security of supply level. On the basis of the security of supply criterion, suppliers need to acquire enough capacity certificates to meet the peak consumption of their customers. Producers committed to make their capacities available during consumption peaks are granted certificates, which they can sell to retailers.

In 2020, the government revised the rules governing the capacity mechanism to align it with the European framework. The capacity mechanism is open to generators and demand-response operators in neighbouring countries, subject to the availability of expected capacity of the interconnector at peak time (around 7 GW in total). France introduced long-term tenders for new capacities, which are organised on a yearly basis by RTE, four years prior to each delivery year and remain open for a period of six months. The first tenders were conducted in 2019. Participation in these tenders was restricted to technologies less than 200 grammes of carbon dioxide per kilowatt hour, which rules out new fossil fuel-fired power plants.

The new capacity selected in the tender rounds covering the 2021-27 and 2022-28 periods totalled 377 MW, mainly demand response and battery storage. Prices in the capacity auctions for the delivery year 2020-21 have been in the range of EUR 15-30/kW, but the auction in 2019 gave a price of EUR 0/kW. That was the first delivery during which interconnector capacities were offered to the market (before then, the whole contribution of interconnectors was implicitly taken into account as a reduction of the capacity obligation of suppliers). This structural change has not been anticipated by market participants, and

resulted in a price of EUR 0/kW during one auction. New build plants can offer fixed contracts for up to seven years, which is shorter than in other markets, weakening the case for new build capacity. Tenders so far have triggered load reduction and battery storage, but no new generation capacity. In 2021, upon the request of the Ministry of the Ecological Transition (General Directorate for Energy and Climate Change), RTE carried out a review of the capacity mechanism (RTE, 2021d).

Medium-term system adequacy

According to RTE's latest five-year supply/demand outlook (RTE, 2021e), the system operator is sounding the alarm about a very difficult adequacy situation in the coming years, distinguishing three main periods until 2030:

- **Vigilance until 2024:** low margins due to the lower availability of the nuclear fleet (the COVID-19 crisis caused delays in maintenance work), the delay of the Flamanville EPR (European pressurised reactor) and delays for new renewables (mainly offshore wind farms and solar and onshore wind to a lesser extent). Winter 2021-22 will be under "special vigilance".
- **Transition period 2024-26:** The electricity system is returning to acceptable operating margins, without being comfortable, thanks to the commissioning of the Flamanville EPR, offshore wind farms and onshore renewable energies, and the development of demand response and interconnections.
- **Significant improvement period 2026-30:** RTE expects an increase in margins and the level of security of supply compared to today, strengthening the resilience of the electricity system for climatic or industrial hazards.

RTE has changed its outlook from 2020 to 2021 by lowering the alert level to vigilance, as it is optimistic about the commissioning of new renewable capacity and a slower rebound of electricity demand after the COVID-19 pandemic than expected. Up to 2024, several levers may be activated to improve the adequacy situation: controlling consumption, optimising the schedule for nuclear reactor shutdowns and maintaining availability as well as using the Cordemais coal-fired power plant for residual operation a few hours a year if necessary until the Flamanville EPR and offshore wind park at Saint-Nazaire come into service.

Future electricity mix beyond 2035 and system integration

In the coming years, France needs to decide on its future electricity mix, a decision that involves technical, economic, social and environmental aspects. The 2020 PPE does not define the sources of the mix after 2035, when nuclear is expected to reach 50% of electricity supply (down from 70.6% in 2019) with the shutdown of 14 reactors (including 2 at Fessenheim in 2020).

Much will depend on the evolution of electricity demand (and exports). Already by 2030, electric heating will further increase as the new Environmental Regulation (RE2020) foresees the phase-out of gas boilers in the residential sector. The National Low-Carbon Strategy (SNBC) expects an increase in electricity net exports by 2030.

Under France's PPE, renewable generation (wind and solar) is expected to grow from 59 TWh in 2019 to 223 TWh in 2035. Replacing nuclear with renewable energy requires a substantial change in power system operation, including the need for modulation to follow

net load variations. In the coming decade, the system will need to operate with co-existing ageing reactors and new renewable capacity.

The Ministry of the Ecological Transition tasked RTE to assess a series of scenarios for France's future energy mix, including 100% renewables and no nuclear in 2050 as well as a 50% share of nuclear production for the longer term. In 2021, RTE consulted on a comprehensive set of decarbonisation scenarios. Results were published in October 2021 (RTE, 2021d). France is expected to see an increase in electricity consumption to 645 TWh by 2050 in the reference scenario due to greater electrification of the transport and industry sectors as well as hydrogen production (RTE, 2021a).

RTE expects the power system to be able to integrate the planned additions of renewable energy up to 2030. However, much will depend on the timetable for nuclear closures. With 15 million electric vehicles expected in 2030, the power system can cover the demand, according to RTE. New flexibility needs arise beyond 2030 to 2050: 40-60 GW of additional low-carbon generation is estimated by 2050. Their system integration will require that dynamic pricing, smart charging, and batteries and demand-side response are activated.

As part of the scenarios for the future of France's electricity mix, the IEA and RTE conducted a technical feasibility study of system integration needs for France with very high shares of variable renewables in the horizon to 2050 (IEA/RTE, 2021). The report is articulated around four essential conditions to operate such a system. First, the system needs significant "sources of flexibility" from large-scale storage, demand management or strong cross-border interconnection. Second, the stability of the frequency needs to be maintained. While there is consensus among experts that it is theoretically possible, large-scale demonstrations are required to confirm this condition is met in real life. Third, the network operator must have operational reserves to be able to intervene to balance the system. Finally, the electricity networks will have to be adapted in the medium term.

RTE studied the total cost of six detailed scenarios with different shares of nuclear and renewables with a view of achieving carbon-free electricity by 2050 (see also Chapter 5). RTE clearly states France can best achieve the EU -55% pledge in an economic manner by accelerating investment in renewables and extending the lifetime of existing nuclear reactors. Achieving net zero without investment in renewable energy would be impossible according to RTE (RTE, 2021b).

The system integration of the rising shares of variable renewables requires robust efforts to flexibilise the system with stronger grids and interconnections, demand response, storage, and hydrogen, which altogether will result in major changes to the system operation.

Electricity grids and interconnections

RTE's 2019 Ten-Year Network Development Plan (which includes an environmental assessment) underlines the need for network investments in replacements and a 30% increase in grid expansions by 2030. The grid needs to be adapted to accommodate new flows (like offshore wind) by increasing the capacity of existing lines, building new ones and dismantling lines that would be less useful. RTE also needs to adapt the grid's digital framework, while raising cybersecurity standards.

RTE's Network Development Plan foresees investments in new interconnections, thus doubling France's interconnection capacity by 2035. For 2030, France aims to double its import capacity (26 GW, or 16.5% of interconnectivity) to above the 15% EU 2030 target.

Under the EU Clean Energy Package, at least 70% of interconnection capacity must be made available to the market for cross-zonal trade by 2025 at the latest, unless the country asks for a derogation justified by operational security constraints and puts in place an action plan to alleviate those. In the case of France, DC borders (with Great Britain) comply with the target, but there are limited data available on how this target will be implemented on AC and hybrid borders. A derogation is in place and will probably be applied until the Swiss transmission system is integrated into the co-ordinated capacity calculations of the adjacent regions.

Demand response ("effacement")

France has strongly expanded demand response across the entire electricity market and is a leader in demand response in Europe. In 2019, France had demand-response capacity of 2.9 GW, with 2.3 GW from the capacity mechanism and 0.6 GW from suppliers which rely on dynamic pricing. Bigger electricity suppliers can offer demand response in the energy market depending on wholesale market prices (the so-called NEBEF mechanism). Besides, RTE has in place interruptibility schemes with industry (see below on emergency response). The PPE plans for 6.5 GW of demand response by 2028 through tenders. A new network tariff regulation (TURPE 6) has come into force in August 202, which will enable the system operator to offer differentiated network tariffs to suppliers (seasonal, hourly, voltage-specific).

Demand from residential consumers, and their electric heating demand, is not controllable and does not respond to price signals today. Traditionally, France had a diverse set of time-of-use pricing, which should rebound with the full roll-out of smart meters. Since 2015, France is in the process of rolling out smart meters and targets 35 million by the end of 2021. Enedis' Linky technology is being deployed, which is also deployed by ELDs in their areas. As of 2019, more than 28 million smart meters had been installed.

Storage

Today, storage facilities cannot participate in balancing reserves (Manual Frequency Restoration Reserve) due to IT constraints in RTE's system. RTE and Enedis have launched calls for tenders enabling storage (and flexibility providers) to offer local flexibility services, notably under the capacity market. France is working on reducing the barriers to the roll-out of storage, including the introduction of a legal framework, the simplification of the network connection rules and the clarification of tax rules.

Generation flexibility

The French nuclear fleet is highly flexible, a unique feature by international comparison. The system also has some 4.3 GW of pumped hydro capacity, 13 GW of hydropower plants and some 13-20 TWh of thermal storage (hot water tanks). The introduction of hybrid renewable plants (equipped with batteries and flywheels or super capacitators) is only at the development stage.

Hydrogen

As part of France's national hydrogen strategy, the government announced an investment of EUR 7 bln into 6.5 GW of electrolyser capacity by 2030, including EUR 2 bln from the Recovery Plan. France has around 160 hydrogen projects at various stages of development and operation (from production facilities to bus refuelling stations and test hubs injecting hydrogen into the gas grid). The government confirmed that hydrogen production will be a competitive business, using renewable electricity or nuclear as a source.

French industry is scaling up hydrogen developments, including at the ports and in the gas grids. The HyDeal Ambition project brings together European gas TSOs which are getting ready to support hydrogen trade with new dedicated hydrogen pipelines, laid along the right of way of existing gas pipelines across Western Europe and North Africa (see Chapter 9). To date, the French government has not supported hydrogen imports from Spain (via the gas network).

Crisis management and emergency response

In case of a crisis and depending on its scale, the National Electricity Continuity Plan or Organization of the Civil Security Response's plans (plans ORSEC) – in force in each French department – are activated to conduct crisis management.

At the national level, the prime minister is the crisis co-ordinator. He can entrust operational management of the governmental crisis unit to any minister, depending on the situation and sectors affected. Most of the time, the delegation goes to the Minister of the Interior for a crisis on French territory or to the Minister for Europe and Foreign Affairs for an international crisis. At departmental level, the *préfet* of the department oversees crisis management and co-ordinates all operational aspects of the situation, including law enforcement management. When a crisis concerns two or more departments, the respective "*préfet de zone de défense et de sécurité*" (out of 12 established across the country), takes the leadership of crisis management.

In case of a crisis, RTE, the sole balance responsible party, can resort to exceptional measures to ensure the security of supply (LOLE) standard, such as (in order of escalation):

- calls for voluntarily reducing electricity consumption by citizens (EcoWatt, media campaigns)
- solidarity and co-operation between system operators from different countries, such as reconciliation of flows and emergency import capacity increases
- interruptible contracts of electricity supply to the largest industrial consumers
- 5% reduction of voltage in the distribution network
- reduction of operational margins (secondary and tertiary reserves)
- as a last resort, rolling load shedding and emergency curtailment of consumers.

Interruptibility schemes are used to address three different situations: 1) frequency control reserve to avoid frequency dropping below 49.82 hertz (Hz); 2) to remedy balancing issues by the national control centre (mFRR); or 3) to reduce congestion. Industry players that

agree to such contracts must make a demand reduction available within 5 seconds after receiving the interruption order from RTE for 7 500 hours a year. The volume of the scheme was increased to 600 MW in 2014. Today, 1 600 MW of interruptible capacity is contracted between RTE and industry players each year. Non-contractual levers are last resort actions that may only be used in exceptional circumstances and are subject to possible liability responsibility of RTE.

Assessment

France is Europe's largest net exporter of electricity, with exports to Belgium, Germany, Italy, Spain and the United Kingdom, and has the highest share of nuclear generation (71% in 2019) among IEA countries, followed by hydropower (10%). France is embarking on a major transition, with a legislated decline of the share of nuclear from 70% in 2019 to 50% by 2035, under the 2019 Energy and Climate Law, while aiming to double the share of renewable electricity from 22% in 2019 to 40% of total electricity generation by 2030 and closing its remaining coal plants by 2022.

In the next five years, France must take major decisions to support the transition of the French power system in the longer term. France will need to firm up plans for its nuclear work programme while continuing to promote investment in renewable energy and its system integration.

In the electricity sector, France will need to tackle market reforms in four critical areas: 1) restructuring EDF, the future of the ARENH price mechanism and the future of regulated tariffs; 2) a decision on the role of nuclear in the generation mix beyond 2035 while limiting the environmental impacts and pursuing climate objectives; 3) ensuring short- to medium-term electricity security during the transition; and 4) expanding the flexibility of the power system through demand response, the development of interconnections with neighbouring countries and the potential future contribution of hydrogen.

Electricity market reforms

EDF remains the largest electricity generator and retailer in France, owning and operating all nuclear generation capacity and most hydropower generation capacity, for a total of 80% of all generation capacity. Since 2007, wholesale and retail markets are open to competition and France is part of a wider EU electricity marketplace. Efforts to increase competition in the French market, driven partly by European Commission investigations on the side of nuclear or hydro power, are only slowly showing an impact.

On the side of nuclear, EDF has to make 100 TWh/year of the nuclear electricity it generates available to alternative suppliers on the wholesale market at a set price (ARENH) of EUR 42/MWh. When market prices were largely below the ARENH, competitors would turn to the market and not use the ARENH, meaning that EDF's nuclear cost was not recovered. There is no guarantee for EDF to cover its cost. With price levels above the ARENH in recent years, competitors used access to cheaper energy under the ARENH mechanism. The opening up of the hydropower concessions has been prepared for a long time, but there is no indication that the latest proposal for reform (transfer to a public entity, a so-called *régie*) will be approved by the European Commission.

As the ARENH is supposed to end in 2025, France needs to level the playing field beyond the lifetime of the ARENH to continue to support competitive retail and wholesale markets.

In accordance with European law, concessions for hydroelectric power must be renewed through competitive tenders. As future concessions expire, a competitive process should be initiated to ensure the future management and investment in these sites in a way that supports a competitive market.

In 2020-21, France discussed the restructuring of the EDF group, the so-called “Projet Hercule” or Grand EDF, involving the reorganisation of its generation, transmission, distribution and retail activities. The renewal of the majority of France’s distribution concessions is under way. Enedis has anticipated the renewals and the majority of distribution concessions have been renewed since 2018. As of December 2020, out of 370 target concession contracts (after merger of contracts), 257 had been renewed. There is a need to resolve the financing of upgrades of the existing nuclear fleet (through the reform of the ARENH) and the financing of new nuclear reactors. Importantly, the solutions to these issues should not hamper the energy transition or competition in the electricity markets.

The retail market was fully opened to competition on 1 July 2007, but in 2021, EDF retains a 70% share of the residential supplier market, down from 82% in 2017. Commendably, France abolished regulated tariffs for large consumers in 2015 and for medium-sized consumers in 2021. There are around 30 suppliers, with 4 large ones (EDF, Engie, Total Direct Energie and Eni). Thanks to the introduction of market offers, there is considerable and increasing choice, as small and residential consumers can choose between market products and regulated tariffs, set by the government and provided by the incumbent suppliers. The incumbent supplier status and regulated tariffs are limited to EDF and about 130 local distribution companies (the so-called ELDs). Most of them belong to municipalities.

The IEA encourages further market opening by reviewing regulated tariffs. Despite the plans set out under the 2019 Energy and Climate Law to end regulated tariffs for medium-sized non-residential consumers, there are no plans to end them for residential consumers. The government will review the tariffs in 2022 and 2025 based on input reports from the CRE and the Competition Authority. The review should examine the role of the regulated tariff in the market, what it is trying to achieve, and whether the tariff is necessary to achieve the objectives and measures to boost consumer engagement, a core pillar of the people-centred energy transition.

While a number of EU countries still have regulated tariffs, several are working to phase out regulated prices, identify the vulnerable consumers and transfer them to targeted social aid schemes. For instance, Lithuania has a roadmap to lower the threshold of consumers under regulated prices over three years and achieve full market opening, as the conditions for competition improve with the roll-out of smart meters and the introduction of dynamic prices in the country. The Spanish regulator, CNE, has introduced dynamic pricing components in the regulated tariffs. In the United Kingdom, suppliers are required to put customers on their cheapest tariff option following the end of a customer’s contract.

Given the higher costs to consumers of the regulated tariff, the government should review the need for regulated prices. By international comparison, regulated tariffs are often seen as a way to protect consumers from excessive costs by acting as a price cap, but this does not appear to be the role of the tariff in France. Regulated tariffs applicable to the entire population are inefficient for addressing energy poverty.

Several lessons learnt can be explored in France: positive experience was gained from the gradual -of regulated tariffs in the French gas market (see Chapter 9), as competition increased. France was one of the pioneers of demand response and time-of-use tariffs and is in the process of completing the roll-out of smart meters. In 2019, around 28 million smart meters had been installed and 35 million are envisaged by end of 2021. This presents an opportunity to introduce dynamic prices, offers for smart charging or grid dispatch of electric vehicles, week-end tariffs and super off-peak hour products. The smart meter deployment is an important milestone for introducing more dynamic components in the tariffs and for lifting regulated prices where competition emerges. The government has put in place targeted social protection schemes, the energy cheque, which could form a valuable basis for the gradual phase-out of regulated prices for the energy poor. CRE has carried out an evaluation of the regulated tariffs in France and concluded that there is still a need for such tariffs and that the split between market offers and regulated prices works well to increase competition (CRE, 2021).

The EU Electricity Directive requires governments to facilitate and speed up switching of suppliers within 3 weeks and by 2026 within 24 hours. The EU Clean Energy Package requires that any consumer requesting it should be given a smart meter and access to dynamic pricing. Dynamic pricing refers to time-of-use and peak pricing products, which are important for demand-response products. They may be linked to the wholesale prices in some cases, like in the Nordic markets.

Electricity security

Regarding security of supply in the short term, the TSO anticipates the need for a specific vigilance up to 2024, in the light of the expected closure of around 5 GW of capacity, including 3 GW of coal, and the actual closure of the Fessenheim nuclear reactors while the EPR of Flamanville is still not operating. Over the same period, new renewables capacity will come online; however, the maintenance schedules of the nuclear fleet need to be adjusted due to the impacts of the COVID-19 pandemic, while demand is not expected to rebound to pre-COVID levels.

To ensure the short-term supply-demand balance up to 2024, the TSO identified three levers that could improve the security of supply at national level. These were: 1) controlling demand, especially during peak periods; 2) optimisation of the schedule and duration of nuclear reactor downtimes; and 3) maintaining the Cordemais coal-fired power plant with restrictions.

In the medium term, the share of nuclear is supposed to decline from 70% of electricity generation in 2019 to 50% by 2035, while electricity demand will increase. In practice, this will mean the closure of 14 nuclear reactors (including the 2 at Fessenheim). The target is for renewable generation to double its contribution to total final electricity generation, from 22% today to 40% by 2030. Energy efficiency is the central pillar of France's National Low-Carbon Strategy, targeting a 20% decrease of final energy consumption by 2030 and 50% by 2050. However, its contribution so far remains well below expectations.

There is a particular challenge for France to achieve the diversification objective of its electricity mix without any additional conventional plants, as security of supply requirements are not an adjustment variable. The role of nuclear energy remains an important variable. The PPE explicitly states that no nuclear reactor should be shut down

if it would mean that security of supply requirements are not respected. Hence, the deployment of renewables and energy efficiency constitutes a major stake to implement France's energy strategy.

Comparing the potential stress in the capacity margin reported by RTE and the lack of new capacity brought forward by the capacity market's long-term tenders calls into question the ability of the capacity market to bring forward the capacity needed to provide security of supply. Given the potential for future adequacy constraints, a review of the capacity market should be undertaken. In 2021, the analysis lead by RTE concluded that the French capacity mechanism has positively contributed to the French security of supply by avoiding the decommissioning of several GW of dispatchable plants (RTE, 2021c). The government's review should further improve the mechanism. Some simplification and improvement in price formation could be brought to the mechanism. Low capacity market prices and relatively short contracts show that the capacity mechanism may need some adjustments. Moreover, the situation of the wholesale markets has changed, with a rise in wholesale prices following the rise in carbon prices across the EU, and greater interaction with nuclear and renewable support schemes. The CRE is evaluating the capacity mechanism which, in addition to the RTE assessment, will feed into the discussion of reforms of the mechanism for the period after 2025.

As the deployment of renewables increases and they make up a higher proportion of generation capacity, challenges will arise as to how the electricity network is operated. It may require the definition of security of electricity supply to evolve in the medium term (from the early 2030s onwards). Typically, security of supply has been an adequacy issue, meaning: is there sufficient supply to meet peak demand? To date, managing other system requirements, such as frequency and inertia, have been possible using the technologies that are deployed.

As the technology mix changes, the factors which influence adequacy will shift from being mainly impacted by extreme cold spells or simultaneous unavailability of the nuclear fleet to include other factors, such as low wind speeds and low availability of wind or solar ("duck curve"). The system will need to become more flexible to accommodate this, meaning greater levels of interconnection, storage and demand-side response will be needed. The ability of the changing technology mix to provide frequency and inertia services will also change, and likely mean that new approaches to network "operating tools" are needed. Similarly, the risks the system is exposed to may change; for instance, as more capacity becomes connected at the distribution level.

The government has the stated ambition to increase the deployment of renewables in the French electricity system. It would be prudent to move beyond assessing the technical feasibility of system integration needs and to begin identifying, demonstrating and implementing the specific changes that will be required for system operation, as outlined in the IEA/RTE joint report in 2021.

One area is grid investment: RTE identified the need for investments in grid replacements. A 30% increase of grid capacity plus the doubling of interconnection capacity by 2030 needs to be started now to be in place by 2025. To maintain the security of the French network, and the broader security of the European-wide network, the question of how grid balancing services can be provided with a high volume of renewables must be addressed. The importance of energy storage, including from

hydrogen electrolysers, battery storage or traditional pumped hydro, will require the completion of the regulatory framework for storage in France.

Electricity emergency response

Peak winter demand by far exceeds average power consumption. To date, the maximum power demand experienced was 102.1 GW, reached on 8 February 2012 during an exceptional cold snap. Based on the last 20 years, peak demand has varied between 80 GW and 102 GW, as it is highly sensitive to temperature. The number of instances where demand has exceeded domestic supply rose sharply in 2017, to 63 half days from 40 half days the year before. The number of occurrences stayed at around 63 half days between 2017 and 2019.

RTE relies on several response measures to maintain system balance, such as calls for citizens to voluntarily reduce electricity consumption, requests from other European transmission operators within the framework of emergency contracts, activation of interruptible capacities in large-scale industry, reduction of voltage on the distribution networks and ultimately targeted load sheading. While this is a diverse portfolio, RTE's crisis response may require a review as France and neighbouring countries are undergoing their energy transitions in the coming five years.

Concerning the contribution from demand response by voluntary demand reduction on behalf of citizens, it is uncertain if consumers are actually cutting consumption. And new trends of higher electrification (heat pumps and electric vehicles) and smart meters can increase system flexibility and new pricing structures may offer new levers for RTE, including storage.

Even though France is a highly interconnected country and RTE plans to double interconnection capacity by 2035, neighbouring countries are on similar pathways to replace existing ageing nuclear and coal generation. This may impact interconnector flows in the future, and neighbouring countries may call upon France more heavily. It is good news that new interconnections to Italy and the United Kingdom will be completed in 2021.

RTE also plays a role in maintaining European-wide electricity system security and responding to unusual system conditions, working with the various regional co-ordination centres. The availability and utilisation of interruptible load in France helped to correct for the January 2021 fault in the Continental Europe Synchronous Area. This was different from the winter of 2006, which saw 15 million residential customers disconnected. This shows the substantial developments that have been made on co-ordination and response to unusual system events by the continental TSOs, including RTE.

The risk assessment of electricity security of supply is currently set out in several documents: the National Plan of Electricity Continuity and the Organisation of Civil Security Response, which sets out the emergency response in a crisis; and the French Energy Code, which sets the obligations for a network operator. Other documents refer to different levels of application, i.e. European, national, zonal, departmental and for specific sites. Bringing these documents together to show a clear and unified description of the risks to the electricity system, mitigations and emergency response measures will help emergency response planning. This is planned as part of the application of Regulation (EU) 2019/941 in France; the government must publish a risk preparedness plan by 5 January 2022.

It is not clear from the existing documents to what extent consequential impacts are being considered in emergency response planning. For example, if there is an incident on the electricity system, what will the impact be on the gas or transport infrastructures? The government should focus its attention on these cross-sector dimensions, notably amid new emerging threats.

Recommendations

The government of France should:

Electricity markets and security

- ☐ Take a timely decision on the future of the electricity generation mix to maintain a decarbonised, affordable and secure electricity mix after 2035 in light of the legal targets to reduce the share of nuclear to 50% by 2035 and increase renewable energy.
- ☐ Ensure a level playing field and support competition in wholesale and retail electricity markets during the energy transition, by reforming the regulated access tariff to continue ensuring competitive access to nuclear capacity and by implementing competitive tenders following the expiration of hydropower concessions.
- ☐ Adapt the electricity retail market design to support the energy transition by:
  - > Reviewing the role and impact of regulated tariffs and consider a roadmap for their phase-out while introducing dynamic price components, based on experience in other countries.
  - > Continuing to enhance competition and transparency in the retail market while reducing barriers and keeping the cost of switching low.
  - > Utilising the wide roll-out of smart metering to bring forward smart/time-of-use tariffs, particularly to incentivise demand reduction at times of peak demand.
- ☐ Review the capacity mechanism to address the short- to medium-term adequacy gap outlined by RTE and ensure the mechanism can bring sufficient capacity forward at the lowest cost to the consumer.
- ☐ Progress to demonstrating, and ultimately implementing the technical changes required to operate the network with a mix of demand response and dispatchable capacity alongside high volumes of variable renewable capacity.

Electricity emergency response

- ☐ Ensure that the tools and levers available to the transmission system operator to utilise both flexible and dispatchable capacity are adequate to mitigate against the uncertainties of capacity closures and commissioning of new capacity during the transition, and maintain the reliability of the system to the required standard.
- ☐ Consider the interactions between the electricity, gas and oil sectors, and consequential impacts to other sectors when developing emergency response policies.

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8. Nuclear

Key data (2020)

Number of reactors: 56, at 18 sites

Installed capacity: 63.2 GW*

Electricity generation: 354 TWh, -17% since 2010

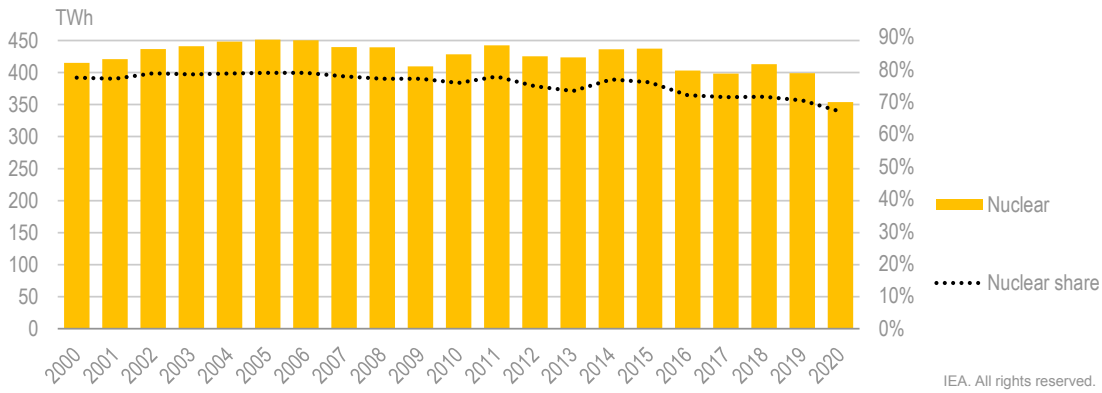
Share of nuclear: 67% of total electricity generation (70% in 2019, 76% in 2010)

* Nuclear capacity stood at 61.3 GW at the end of 2020 after the shutdown of the two reactors at Fessenheim.

Overview

The role of nuclear energy is considerable in France's electricity mix. Nuclear energy from 56 reactors with an installed capacity of 63.2 gigawatts (GW) ensured 67% of French electricity generation, which amounted to 354 terawatt hours (TWh) in 2020 (Figure 8.1). The role of nuclear has decreased from a high of 78% of electricity generation and 450 TWh of generation in 2006. An additional European pressurised reactor (EPR) is currently being prepared for commissioning at the Flamanville site.

Figure 8.1 Nuclear power generation in France, 2000-20



The share of nuclear in electricity generation is decreasing, and was 67% in 2020.

Note: TWh = terawatt hour.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

All reactors are operated by Électricité de France (EDF), the main utility in France, at 18 different sites. Nuclear energy plays a key role in the government's effort to reduce greenhouse gas (GHG) emissions to achieve climate neutrality by 2050 based on low-carbon, affordable and secure electricity supply and energy independence. This role is enhanced by the fact that nuclear power plants in France not only run in baseload mode, but can operate flexibly. They thus contribute actively, together with renewables, hydropower and demand response, to balancing demand and supply at the system level.

The role of nuclear in France's energy transition

The 2015 Energy Transition for Green Growth Act stipulated that the share of nuclear energy in the electricity supply shall be limited to 50% by 2025; the 2019 Energy and Climate Law extended the target year to 2035, as the 2025 objective was unachievable given the pace of renewable energy development. A 50% share of nuclear in electricity generation in 2035 would translate into a nuclear power capacity of around 52 GW reached by shutting down 14 reactors of 900 megawatts (MW) and commissioning the EPR in Flamanville.

Under France's National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone [SNBC]), a decarbonised electricity sector is expected to help otherwise hard-to-abate sectors, such as heavy industry, transport or buildings, to reduce their emissions through electrification and sector coupling, including hydrogen.

There is limited visibility as to the future role of nuclear beyond 2035. The multiannual energy plan (*la programmation pluriannuelle de l'énergie* [PPE]) with two five-year periods confirms that no additional nuclear capacity is needed before 2035, but calls for the full assessment of a nuclear work programme by mid-2021. If France decides to maintain the share of 50% after 2035, long-term operation of existing plants and new builds are likely to be required.

Careful socio-economic assessments of the long-term electricity and energy mix and their costs under different scenarios are an essential basis for any timely and well-founded decision. Several stakeholders are contributing to such assessments. Mandated by the government, the transmission system operator RTE finalised a study on the feasibility and costs of several scenarios with different shares of renewables and nuclear energy that would all satisfy the objective of achieving net zero carbon emissions in 2050. The final scenarios by RTE presented in October 2021 serve as a basis for the political decision.

Outlook for nuclear energy

The role of nuclear energy is best understood by looking at three different time horizons.

In the short run, low-carbon nuclear energy provides the all-important backbone of the French electricity supply. In addition to large amounts of electricity, dispatchable nuclear power generation provides flexibility at the level of the season, the week and, sometimes, the day as well as system services, such frequency stabilisation and inertia. As the share of nuclear power in the electricity supply is planned to decrease, EDF will likely have to shut down 14 nuclear reactors by 2035, including the 2 reactors that were closed in 2020 at the Fessenheim site in the Alsace region after 42 years of operation.

Two to four reactors are planned to be closed by 2028. Other closures will most likely involve those reactors reaching their fifth decennial safety review. Reactor closures are expected to be well distributed throughout France and no further nuclear site will be fully closed down. This is due to a desire to limit the social impacts, leave the door open for new builds and distribute economic impacts (Table 8.1).

Table 8.1 Nuclear power reactors in France

Name	Type	Status	Reference unit power (MW)	Gross electrical capacity (MW)	First grid connection
Belleville-1	PWR	Operational	1 310	1 363	1987-10-14
Belleville-2	PWR	Operational	1 310	1 363	1988-07-06
Blayais-1	PWR	Operational	910	951	1981-06-12
Blayais-2	PWR	Operational	910	951	1982-07-17
Blayais-3	PWR	Operational	910	951	1983-08-17
Blayais-4	PWR	Operational	910	951	1983-05-16
Bugey-2	PWR	Operational	910	945	1978-05-10
Bugey-3	PWR	Operational	910	945	1978-09-21
Bugey-4	PWR	Operational	880	917	1979-03-08
Bugey-5	PWR	Operational	880	917	1979-07-31
Cattenom-1	PWR	Operational	1 300	1 362	1986-11-13
Cattenom-2	PWR	Operational	1 300	1 362	1987-09-17
Cattenom-3	PWR	Operational	1 300	1 362	1990-07-06
Cattenom-4	PWR	Operational	1 300	1 362	1991-05-27
Chinon B-1	PWR	Operational	905	954	1982-11-30
Chinon B-2	PWR	Operational	905	954	1983-11-29
Chinon B-3	PWR	Operational	905	954	1986-10-20
Chinon B-4	PWR	Operational	905	954	1987-11-14
Chooz B-1	PWR	Operational	1 500	1 560	1996-08-30
Chooz B-2	PWR	Operational	1 500	1 560	1997-04-10
Civaux-1	PWR	Operational	1 495	1 561	1997-12-24
Civaux-2	PWR	Operational	1 495	1 561	1999-12-24
Cruas-1	PWR	Operational	915	956	1983-04-29
Cruas-2	PWR	Operational	915	956	1984-09-06
Cruas-3	PWR	Operational	915	956	1984-05-14
Cruas-4	PWR	Operational	915	956	1984-10-27
Dampierre-1	PWR	Operational	890	937	1980-03-23
Dampierre-2	PWR	Operational	890	937	1980-12-10
Dampierre-3	PWR	Operational	890	937	1981-01-30
Dampierre-4	PWR	Operational	890	937	1981-08-18
Flamanville-1	PWR	Operational	1 330	1 382	1985-12-04
Flamanville-2	PWR	Operational	1 330	1 382	1986-07-18
Golfech-1	PWR	Operational	1 310	1 363	1990-06-07
Golfech-2	PWR	Operational	1 310	1 363	1993-06-18
Gravelines-1	PWR	Operational	910	951	1980-03-13
Gravelines-2	PWR	Operational	910	951	1980-08-26
Gravelines-3	PWR	Operational	910	951	1980-12-12
Gravelines-4	PWR	Operational	910	951	1981-06-14

Name	Type	Status	Reference unit power (MW)	Gross electrical capacity (MW)	First grid connection
Gravelines-5	PWR	Operational	910	951	1984-08-28
Gravelines-6	PWR	Operational	910	951	1985-08-01
Nogent-1	PWR	Operational	1 310	1 363	1987-10-21
Nogent-2	PWR	Operational	1 310	1 363	1988-12-14
Paluel-1	PWR	Operational	1 330	1 382	1984-06-22
Paluel-2	PWR	Operational	1 330	1 382	1984-09-14
Paluel-3	PWR	Operational	1 330	1 382	1985-09-30
Paluel-4	PWR	Operational	1 330	1 382	1986-04-11
Penly-1	PWR	Operational	1 330	1 382	1990-05-04
Penly-2	PWR	Operational	1 330	1 382	1992-02-04
St. Alban-1	PWR	Operational	1 335	1 381	1985-08-30
St. Alban-2	PWR	Operational	1 335	1 381	1986-07-03
St. Laurent B-1	PWR	Operational	915	956	1981-01-21
St. Laurent B-2	PWR	Operational	915	956	1981-06-01
Tricastin-1	PWR	Operational	915	955	1980-05-31
Tricastin-2	PWR	Operational	915	955	1980-08-07
Tricastin-3	PWR	Operational	915	955	1981-02-10
Tricastin-4	PWR	Operational	915	955	1981-06-12
Flamanville-3	PWR	Under construction	1 630	1 650	
Bugey-1	GCR	Permanent shutdown	540	555	1972-04-15
Chinon A-1	GCR	Permanent shutdown	70	80	1963-06-14
Chinon A-2	GCR	Permanent shutdown	180	230	1965-02-24
Chinon A-3	GCR	Permanent shutdown	360	480	1966-08-04
Chooz-A (Ardennes)	PWR	Permanent shutdown	305	320	1967-04-03
Super-Phenix	FBR	Permanent shutdown	1 200	1 242	1986-01-14
Fessenheim-1	PWR	Permanent shutdown	880	920	1977-04-06
Fessenheim-2	PWR	Permanent shutdown	880	920	1977-10-07
G-3 (Marcoule)	GCR	Permanent shutdown	40	43	1960-04-04
G-2 (Marcoule)	GCR	Permanent shutdown	39	43	1959-04-22
El-4 (Monts D'arree)	HWGCR	Permanent shutdown	70	75	1967-07-09
Phenix	FBR	Permanent shutdown	130	142	1973-12-13
St. Laurent A-1	GCR	Permanent shutdown	390	500	1969-03-14
St. Laurent A-2	GCR	Permanent shutdown	465	530	1971-08-09

Note: MW = megawatt. PWR = pressurised water reactor. GCR = gas cooled reactor. FBR = fast breeder reactor. HWGCR = heavy water gas cooled reactor.

Source: IAEA (2021), France, *Power Reactor Information System*, https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=FR.

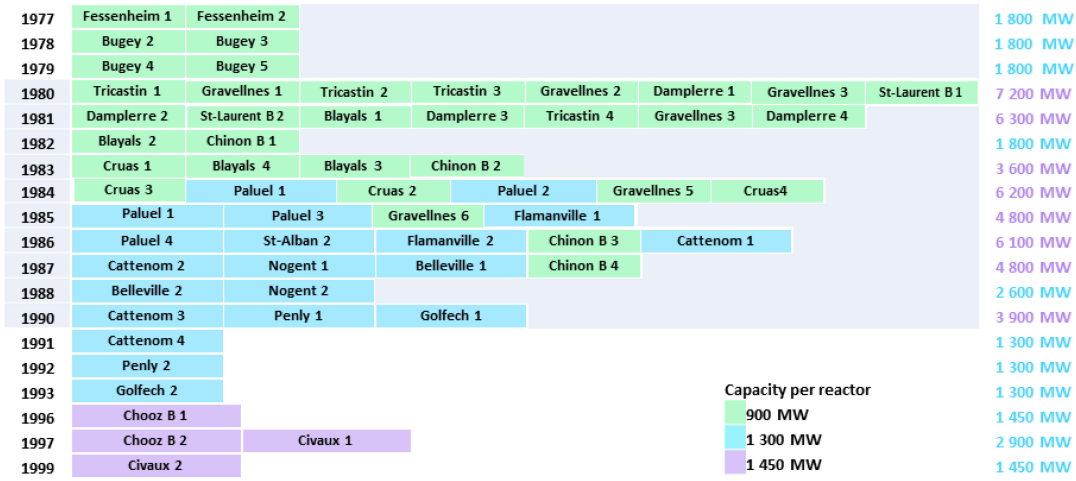
By 2050, the electricity sector will need to be decarbonised in line with France's net zero by 2050 target. In most scenarios, nuclear energy will continue to play an important role. France RTE has also carried out scenario-building exercises assuming a complete phase-out of nuclear power, with electricity production relying primarily on variable renewables and hydroelectricity (RTE, 2021). RTE confirms that investment in renewables and extending the lifetime of existing nuclear is the most economical solution in meeting net

zero. The public debate has changed in 2021, with nuclear new builds and small modular reactors alongside renewable energy taking the centre stage of the energy policy debate with the new Investment Plan by 2030 and announcements by President Macron.

Modernisation and long-term operation

Planning for the future contribution of nuclear energy to low-carbon electricity generation will need to take into account that the average age of the reactors composing the French nuclear fleet is 35 years. The oldest plant (Fessenheim) was connected to the grid in 1977 and after a pace of rapid build-up with up to eight reactors commissioned per year in the 1980s, the most recent one (Civaux-2) came into operation in 1999 (Figure 8.2).

Figure 8.2 History of commissioning pressurised water reactors in France, 1977-99



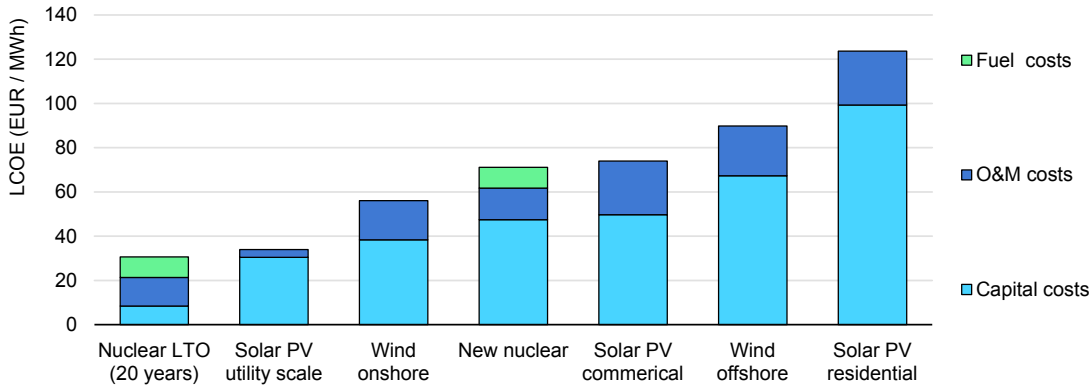
Note: MW = megawatt.

Regarding long-term operations, EDF is currently engaged in a vast programme of refurbishing its nuclear reactor fleet and preparing it for operations beyond 40 years (the so-called *Grand carénage*).

The French regulatory system does not set a plant lifetime, but requires the licensee to perform an in-depth safety review every ten years. Each review lasts several months and includes several safety improvements. In February 2021, the Nuclear Safety Authority defined the safety improvements to be deployed by EDF on the 32 900 MW pressurised water reactors (Fresard, 2021). Until 2036, each reactor will be individually reviewed and safety improvements implemented. From 2025 onwards, the 20 1 300 MW pressurised water reactors will undergo the same periodic safety review. EDF estimates the cost of the *Grand carénage* programme at EUR 49.4 billion for the 2014-25 period alone.

Long-term operations of nuclear plants under stringent safety requirements are a cost-effective manner of producing low-carbon electricity. The IEA/NEA publication *Projected Costs of Electricity: 2020 Edition* thus indicates for France costs of around USD 30/MWh for continuing operation for a minimum of either 10 or 20 years (Figure 8.3) at a broad range of discount rates (IEA/NEA, 2020).

Figure 8.3 Projections for the levelised cost of electricity in France by technology



Notes: LCOE = levelised cost of electricity. MWh = megawatt hour. O&M = operating and maintenance. LTO = long term operation. PV = photovoltaic. Data are based on a 7% discount rate and costs are projected for the year 2025 based on data submitted by the Ministry of the Ecological Transition.

Source: IEA/NEA (2020), *Projected Costs of Generating Electricity 2020*, www.iea.org/reports/projected-costs-of-generating-electricity-2020.

The outlook for nuclear new build

France is considering the construction of several new nuclear reactors. The French nuclear industry stressed the importance of undertaking nuclear new build as part of a long-term programme that commits to several new constructions to allow for scale effects. EDF proposed to the government the construction of six EPR2. The EPR2 builds on the original EPR design, of which two reactors are already generating electricity in the People's Republic of China (Taishan) and four more are under construction in France (Flamanville), Finland (Olkiluoto) and the United Kingdom (Hinkley Point). While the two Taishan reactors are operating well, the Flamanville and Olkiluoto projects have been hampered by delays and cost overruns. A 2019 report on the EPR construction at Flamanville, commissioned by the French government, identified skill shortages in the project owner, lack of design maturity and project management issues as key drivers for delays and costs increases (Folz, 2019). These conclusions are well aligned with the findings of a recent analysis on cost reductions in nuclear new build (NEA, 2020). EDF has responded to the report's findings with a number of internal and industry-wide reforms, including the EUR 100 million Excell plan for the development of excellence, high-quality skills, competence and reinforcement of project governance.

In October 2021, France announced a EUR 30 bln investment plan for 2030, which targets French industrial development in the energy, automotive and space sectors, including EUR 8 bln dedicated to energy technology investment in hydrogen and small modular reactors; EUR 4 bln for electric and plug-in hybrid vehicles.

At the international level, EDF is learning from its experience in the construction of EPRs. The Hinkley Point project, which started construction in 2017, is implementing a strategy of systematically taking the lessons of prior EPR projects into account. Similar learning benefits are also expected for the second new build project in the United Kingdom of two new EPRs at Sizewell in Suffolk. In addition, EDF is currently exploring possibilities for additional nuclear new build projects, including in the Czech Republic, India and Poland.

Preparations to enable choices at the political level for the construction of new nuclear power plants in France are under way and a final decision on this major new build programme should be taken after the 2022 presidential election. A detailed governmental report laying out all the aspects relevant for a decision is expected in the fall of 2021. In case of a positive decision, construction of the first two reactors might begin shortly afterwards, with completion expected in 2035-36. In EDF's view, the two remaining pairs should follow in intervals of about four years. The second pair could thus be completed by 2039-40 and the final pair in 2043-44.

EDF proposes the development of the EPR2 model and the construction of three pairs of reactors for a total of EUR 52 billion (bln) overnight (excluding all financing costs).[1] In addition to ensuring long-term availability of domestic supply of firm, low-carbon electricity, a major nuclear new build programme would also maintain advanced technical capabilities in an industry with export potential. In addition to the 1 650 MW EPR2, France also supports the global development of small modular reactors. The Nuward reactor, with two modules of 170 MW, is primarily aimed at replacing coal-fired power plants on the international market.

Financing nuclear and electricity market design

Nuclear energy has a profound impact on the design of the French electricity market. Like most other low-carbon technologies such as wind, solar photovoltaics (PV) and hydroelectricity, nuclear energy has comparatively high fixed and low variable costs. In the past, regulated electricity tariffs provided the visibility and revenue certainty that investors require. However, in the European electricity markets the wholesale electricity price is set at variable costs of the marginal plant.

A 2010 agreement between the French government and the European Commission translated into the Law for the New Organization of the Electricity Market (NOME). It attempted to strike a balance between an element of full cost recovery at predictable prices and competition. It specifies that each year, EDF is obliged to sell up to 100 TWh, roughly one-quarter of its nuclear energy production, at a fixed price to alternative energy suppliers under a procedure called the "regulated access to historical nuclear electricity tariff" (*accès régulé à l'électricité nucléaire historique*, ARENH). The relevant price that has been set by the regulator since 2012 is EUR 42/MWh. The French government is currently considering raising the ceiling of the ARENH to 150 TWh and the relevant price to EUR 48/MWh, according to the Energy Regulatory Commission (CRE) for historic fleet and Flamanville, but this would require prior approval by the European Commission (see Chapter 7).

A key objective of the NOME Law was to foster competition at the retail level. Considerable progress has been made in this area (see also Chapter 7). However, the ARENH mechanism quickly showed its limits. It was conceived as a compromise between a desire for price stability and the fostering of competition, while obliging EDF to sell the remainder of its production on the competitive wholesale market. As wholesale electricity prices fell below EUR 42/MWh, primarily due to an influx of large amounts of wind and solar PV at the European level and low CO_2 prices in the EU Emissions Trading System (ETS), EDF's

[1] www.concerte.fr/system/files/document_travail/2020-06-30_Presentation_GT-couts.pdf.

competitors no longer felt obliged to buy electricity under the ARENH. Additional factors in the collapse of wholesale market prices were capacity investments made on overly optimistic assumptions about the evolution of electricity demand as well as the collapse of the prices for CO_2 emissions allowances in the EU ETS in the aftermath of the 2008 financial and economic crisis. Amid rising competition and the number of alternative suppliers, many returned to EDF as prices rose again above EUR 42/MWh later in the decade, some expressing the wish to go beyond the originally set quantitative limit of 100 TWh. In fact, the ARENH has been a source of recurrent misgivings for both the seller and buyers.

The ARENH agreement was always conceived as transitional and is slated to elapse in 2025. The mechanism is currently being renegotiated between the French government and the European Commission. Its objective remains the same: finding a compromise between competition in the wholesale and retail markets on the one hand and a level of revenue certainty for nuclear electricity on the other. In addition to a revision of the level of the reference price itself, alternative market designs, such as a contract for difference with a fixed strike price, are under consideration.

However, the current renegotiation of the ARENH is part of a wider set of considerations that underline the special status of nuclear energy at the heart of the French energy system. The ARENH or any successor arrangement only concerns electricity from existing nuclear power plants with “historic” costs. New nuclear power plants built after the commissioning of the Flamanville EPR would require their own, possibly not altogether different, pricing arrangements, including a contract for difference. The French Treasury is also considering including the construction costs of new plants into a regulated asset base. This financing model, which is also under discussion for new nuclear reactors and other infrastructure projects in the United Kingdom, allows including construction costs into regulated consumer tariffs before operations at the facility actually begin, thus socialising construction risks and lowering the cost of capital for the project owner.

Moreover, future pricing arrangements are likely to go hand-in-hand with a major restructuring of EDF. While the government has indicated its broad priorities for the company, like maintaining an integrated group, safeguarding employment and protecting residential consumer through regulated tariffs, there are currently few certainties and even fewer details. One scenario under the restructuring plan called Grand EDF (previously called Projet Hercule) considers the creation of two distinct operational entities. The first entity, EDF bleu, would regroup dispatchable low-carbon assets, i.e. nuclear, hydroelectric power plants and gas-fired power plants, as well as the transmission system operator RTE. It would also retain majority ownership in the second entity, EDF vert, which would regroup renewables, Enedis, the electricity distributor and energy services. The second entity would be considered an independently operating subsidiary with its capital open to outside investors.

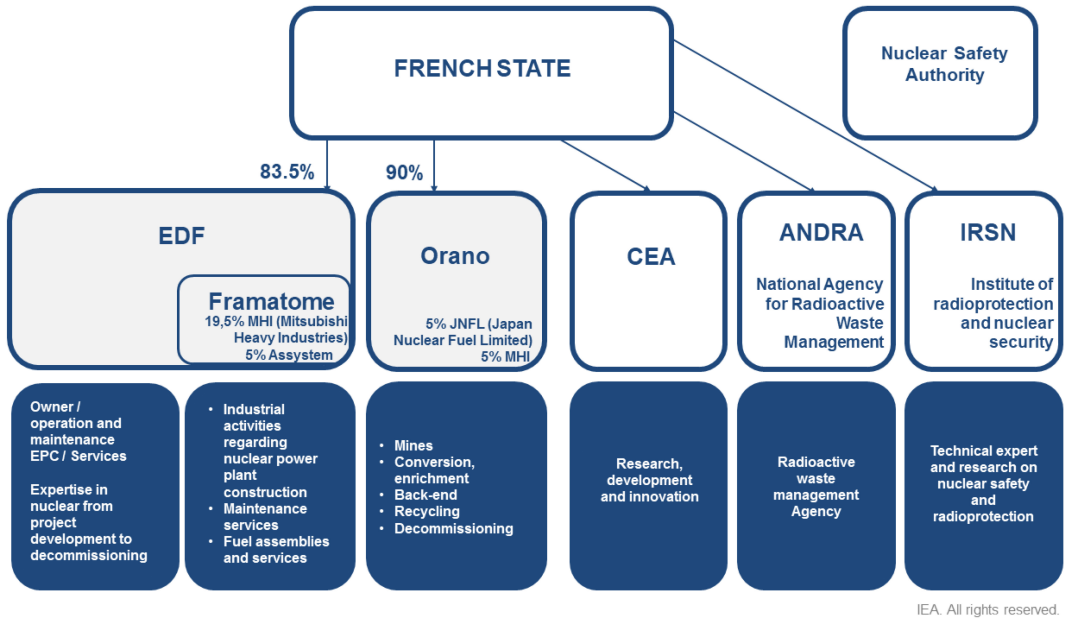
EU sustainable finance rules also impact the financing of new nuclear in the EU. The Sustainable Finance Taxonomy (Taxonomy Regulation) was formally adopted by the European Parliament on 18 June 2020. It stipulates requirements for projects to qualify as environmentally sustainable economic activities. The taxonomy creates a classification system designed to foster six EU environmental objectives, of which climate change mitigation has received particular attention. Screening criteria to assess the environmental sustainability of different activities were developed with the help of a Technical Expert Group on sustainable finance. In the energy field, the inclusion of both nuclear energy and

natural gas were intensely discussed. In 2020, the Technical Expert Group signalled that it lacked the technical expertise to reach a conclusion on the applicability of the do no significant harm (DNSH) criterion to nuclear energy. The European Commission requested a report on the issue from its "science and knowledge service", the Joint Research Centre. In April 2021, the Joint Research Centre concluded that nuclear energy complied indeed with the DNSH criteria. Following the publication of the Joint Research Centre's report, the European Commission asked for the opinions of two expert bodies (the Group of Experts on Radiation Protection and Waste Management under Article 31 of the Euratom Treaty and the Scientific Committee on Health, Environmental and Emerging Risks), which agreed with most of the Joint Research Centre's findings. The European Commission had previously committed, as soon as this dedicated process was complete, to follow up in 2022 based on its results in the context of this Taxonomy Regulation.

The nuclear fuel cycle, research and development

France's nuclear industry is active in all segments of the nuclear fuel cycle. EDF sources its nuclear fuel primarily from Orano. Orano's creation in 2018 resulted from the restructuring of the AREVA group. The restructuring was a complex process during which the French state invested EUR 12 bln in its nuclear industry. This included also recapitalising EDF. A key result is that Orano focuses exclusively on the nuclear fuel cycle and operates international mining assets, conversion, enrichment and reprocessing facilities in France. France's current fuel cycle strategy is set to remain in place until 2040, when new investments will be required, in particular for reprocessing at La Hague.

Figure 8.4 Key actors in the French nuclear sector



Notes: EPC = Engineering, procurement and construction

Source: Ministry of the Ecological Transition.

A second key element of the restructuring process was the creation of reactor developer Framatome, active in reactor core design and fuel fabrication. It regroups, *inter alia*, the

previous activities of both AREVA and EDF in these areas. EDF owns 75.5% of Framatome with Mitsubishi Heavy Industries (19.5%) with the engineering company Assystem (5%) holding the balance.

The French government terminated the Astrid sodium fast reactor programme, but continues to pursue research and development efforts in this area, keeping the option open for the second half of the century. France has also initiated a research and development programme on the multi-recycling of MO_X fuels in pressurised water reactors. MO_X fuel is currently used in the older generation 900 MW reactors. However, at least some of these are likely to be included among the reactors slated for closure in the coming years. To compensate for the loss of load at La Hague after the end of Astrid, MO_X fuel will be used in some of the newer 1 300 MW reactors from 2028 onward, which requires the completion of the requisite regulatory and administrative procedures.

At the backend of the nuclear fuel cycle, France is actively developing the Cigéo deep geological repository for high-level wastes from the treatment of spent nuclear fuel and intermediate-level long-lived radioactive wastes (ILLW). Together with Finland and Sweden, this makes France a global leader in implementing a definite solution for the long-term storage and disposal of its spent nuclear fuel high-level nuclear wastes. Surface facilities for intermediate-level short-lived waste and very low-level waste from decommissioning are operational, but may require additional capacity in due time.

Overseen by Andra, the National Agency for Radioactive Waste Management, the Cigéo facility in the Meuse Department in eastern France will offer disposal facilities at a depth of 500 metres for 85 000 tonnes of high-level nuclear wastes. Its total undiscounted costs over 120 years are estimated to be EUR 25 billion and are fully provisioned by the producers of high-level wastes and ILLW, EDF, Orano, and the Alternative Energies and Atomic Energy Commission (CEA). At the time of writing, the detailed design study as well as the environmental and socio-economic impact assessments were completed, while the assessment of the safety case was ongoing. The Declaration of Public Utility, required by French law for large infrastructure projects, was submitted in August 2020, and the application for a construction licence is expected for the end of 2021 or the beginning of 2022.

France enjoys a well-developed infrastructure for a broad range of basic and applied research both in universities and in a number of national research facilities. Nuclear energy-related research is primarily regrouped in the CEA. With an annual budget in the field of nuclear energy of EUR 460 million, the CEA engages in research on a broad range of reactor types as well as on different stages of the fuel cycle and materials' performance. Among different reactor types, the CEA works on Generations II, III and IV (including fast breeder reactors), as well as small modular reactors. In addition, the 100 MW Jules Horowitz research reactor is under construction in Cadarache, in southern France. It will be used primarily for radioisotope production and research on material irradiation. Finally, the CEA also maintains active programmes on energy storage, virtualisation, nuclear fusion and the socio-economic analysis of low-carbon energy systems.

Assessment

The role of nuclear energy is part and parcel of France's energy transition. Today, nuclear energy from 56 reactors with together 63 GW ensures around 70% of the French

low-carbon electricity supply. With around 400 TWh, France comes second to the United States in terms of electricity generation from nuclear. Thanks to the role of nuclear energy, France has the lowest emissions per kilowatt hour (kWh) of any large economy, with 47 g/kWh. France's low emissions intensity also means that electrification (electric vehicles, heat pumps) will have greater emissions benefits.

A decarbonised electricity sector is essential for achieving climate neutrality by 2050, notably to help hard-to-decarbonise sectors such as heavy industry, transport or housing to reduce their emissions through electrification and sector coupling as well as hydrogen. Going forward, nuclear energy is a key element for achieving net zero carbon emissions in France's energy sector by 2050 and consensus is emerging of the importance of both renewable and nuclear energy.

This is also in line with the findings of the IEA's net zero by 2050 roadmap for the global energy transition. Wind and solar will play the biggest roles, but nuclear power doubles to 2050 in the IEA's net zero roadmap (IEA, 2021). While wind and solar increases 20-fold by 2050 in the net zero emissions scenario, nuclear power also makes a significant contribution: its output rises steadily by 40% to 2030 and doubles by 2050. To achieve this doubling, global nuclear capacity additions need to reach 30 GW per year in the early 2030s, five times the rate of the past decade.

Under the French 2019 Energy and Climate Law, the government targets a reduced nuclear share of 50% by 2035, with renewables making up the difference. In addition to the two already closed reactors at Fessenheim, EDF will have to shut down 12 other nuclear reactors to reach the 50% objective. A schedule of reactor closures has been defined. The PPE is clear on the criteria to be respected for reducing the share of nuclear power to 50%, requiring no increase in CO_2 emissions and no increased risk for the security of supply (based on actual criteria). Progress of reaching the 50% objective also depends on the construction and connection of France's offshore wind parks, the evaluation of affordability and energy prices, and the evolution of electricity trade with neighbouring countries (Belgium, Germany, Italy, Switzerland and United Kingdom).

Under the PPE, there is little visibility as to the future role of nuclear beyond 2035, as the PPE requires a full assessment of a nuclear work programme, which is ongoing at the time of writing. The IEA recommends a socio-economic assessment of the long-term electricity and energy mix and its costs under different scenarios. Such an assessment should be the basis for a timely and well-founded decision on this matter. RTE has been tasked by the government to study different scenarios for 2050 and is currently finalising its report for publication.

France's nuclear fleet is ageing, with an average age of 35 years. Maintaining the contribution of nuclear energy at 50% thus requires either the long-term operation of existing reactors, the construction of new ones or a combination of both. As far as long-term operations are concerned, EDF is engaged in a EUR 49.4 billion programme of refurbishing its nuclear reactor fleet for operations beyond 40 years (the so-called *Grand carénage*). In 2020, a 900 MW reactor achieved its fourth periodic safety review for the first time. From 2025 onwards, the 20 1 300 MW reactors will undergo the same periodic safety review. Each one will undergo a safety review, which also entails a period of maintenance and safety upgrades for the concerned reactors. The Nuclear Safety Authority also requires annual reports from EDF to confirm its industrial capacity to operate the long-term operations programme.

With regard to new build, EDF proposes the construction of six new EPR2 reactors. The EPR2 builds on the EPR design of which two reactors are already operating in China and four more are under construction in France, Finland and the United Kingdom. A major nuclear new build programme would also maintain advanced technical capabilities in an industry with export potential. A decision is expected in 2023, after the commissioning of the Flamanville EPR, so after the 2022 French presidential elections.

The financing of EDFs long-term operations programme and/or new builds remains the main challenge for nuclear in France and may require changes to the French regulatory framework. France has a specific market design due to the historic position of EDF as owner and operator of the French nuclear fleet. A 2010 agreement between the French government and the European Commission specified that each year EDF would offer up to 100 TWh, roughly one-quarter of its production, to alternative energy suppliers, at a fixed price of EUR 42/MWh under the ARENH. The 2019 Energy and Climate Law allows, in principle, the government to increase the threshold to 150 TWh. However, this would require approval by the European Commission, so decisions on the amount of TWh and the level of the fixed price will not take place before current negotiations about a successor mechanism to the ARENH, which had always been conceived as a transitional mechanism to end in 2025, have been concluded.

The current design of the ARENH has reached its limits. As European wholesale prices fell below EUR 42/MWh, EDF's competitors no longer felt obliged to buy electricity under the ARENH. This reduced its role to boost competition and provide EDF with revenues to finance its long-term operations programme. As prices rose again later in the decade, EDF's competitors requested capacity even beyond the originally set 100 TWh per year limit. Current high-carbon and electricity prices provide also a whole new set of circumstances for assessing the effectiveness of the ARENH.

The financing of a nuclear programme and the long-term operations is a major challenge. The ARENH or any successor arrangement only concerns electricity from existing nuclear power plants with "historic" costs. New nuclear power plants would require their own, possibly not altogether different, pricing arrangements. A contract for difference with a fixed strike price is one option, as is the use of regulated prices based on an asset-based regulation. Moreover, any future pricing arrangements might need to take into account a major restructuring of EDF under the Grand EDF initiative (formerly Projet Hercule), which is on hold until after the 2022 presidential elections) and will have an impact on the overall structure of the French electricity sector.

Investment in the French nuclear energy industry will depend on a complex interplay of national initiatives, European rules on state aid, and sustainable finance and negotiated compromises. The new EU taxonomy for sustainable finance aims at guiding public and private financial flows in energy transitions towards low-carbon technologies. While there has been an intense debate over nuclear energy under the DNSH provision of the Taxonomy Regulation, a recent report by the European Commission's Joint Research Centre concluded that nuclear energy, notably radioactive waste management, fully satisfied the DNSH criterion.

France's nuclear industry has undergone a major restructuring. Uranium and nuclear fuel are produced by Orano, which operates conversion, enrichment and reprocessing facilities. Its creation in 2018 resulted from the restructuring of the AREVA group during which the French state invested EUR 12 bln in its nuclear industry. This also included the

creation of the reactor developer Framatome, three-quarters of which are owned by EDF, with Mitsubishi Heavy Industries and the engineering company Assystem as minority shareholders. Nuclear energy-related research is primarily regrouped in the Alternative Energies and Atomic Energy Commission. Since the last review, the French government terminated the Astrid (Advanced Sodium Technological Reactor for Industrial Demonstration) programme. Astrid was a proposal for a 600 MW sodium-cooled fast breeder reactor (Generation IV) by the Alternative Energies and Atomic Energy Commission.

With a large and ageing nuclear fleet, decommissioning and nuclear waste management are priorities for France. Alongside Finland and Sweden, France is a global leader in implementing a definite solution for the long-term storage of its nuclear wastes. Overseen by Andra, Cigéo is a deep geological repository for high-level wastes from the treatment of spent nuclear fuel and intermediate-level long-lived radioactive wastes. The application for a construction licence is expected for the end of 2021 or the beginning of 2022. The government should complete the implementation of a long-term solution for the storage of nuclear wastes. The costs of the Cigéo underground storage facility and its important role in the nuclear fuel cycle should continue to be communicated in a transparent manner.

Recommendations

The government of France should:

- Clarify and review conditions of the legislative requirement to limit the contribution of nuclear energy to 50% of electricity generation up to 2035, in light of the objectives of climate urgency, climate neutrality, affordability and renewable energy deployment.
- Take a timely decision on the role of nuclear beyond 2035, based on the completion of ongoing studies and necessary socio-economic analysis and consultations to decide on the combination of long-term operations and nuclear new build required, with a view of decarbonising electricity supply and to achieve net zero by 2050.
- Ensure the sustainable long-term funding of nuclear energy generation, while preserving a competitive electricity market, including the refurbishment and safety upgrades of existing reactors and the financing of new builds from 2023 onwards.
- Strengthen the nuclear energy research most relevant to the energy transition, including the provision of flexible electricity by small modular reactors, co-generation[2] of electricity and heat, integration with hydrogen production, and materials' testing under conditions of long-term operations.

[2] Co-generation refers to the combined production of heat and power.

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9. Natural gas

Key data (2020 estimated)

Domestic natural gas production: 0.01 bcm (compared to 0.76 bcm in 2009)

Net imports (2019): 44.2 bcm (52.4 bcm imports, 8.2 bcm exports)

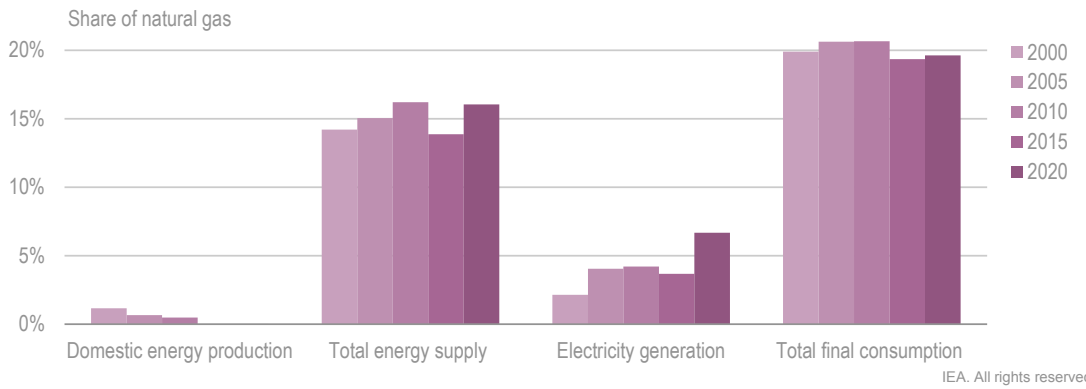
Share of gas: 0% of domestic energy production, 16% of total energy supply (TES), 7% of electricity generation, 20% of total final consumption (TFC) (2019)

Gas consumption by sector (2019): 42.4 bcm in 2019, -6% since 2009
Industry 31%, residential 30%, electricity and heat generation 19%, services and others 17%, other energy 1.5%, transport 0.4%

Overview

France's National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone, SNBC) and the multiannual energy plan (PPE) have very ambitious targets to reduce the country's use of fossil fuels by 40% in 2030 compared to 2012 levels. To achieve those targets, natural gas consumption is set to decline by 25% from current levels by 2030.

Figure 9.1 Share of natural gas in France's energy system, 2000-20



Natural gas accounts for a stable share of 20% of France's consumption, but almost no natural gas is produced in France.

Note: The latest available data for total final consumption are from 2019.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

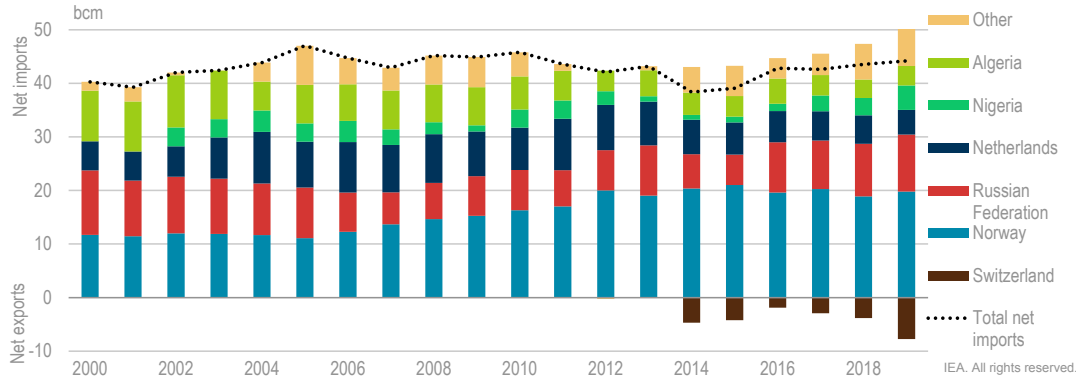
Natural gas accounted for 20% of total energy supply (TES) in 2019 (Figure 9.1) and its role has remained stable in total final consumption (TFC) over two decades. While natural gas contributed 4% of electricity generation in 2010, today it is 7%. With 0.1 billion cubic metres (bcm) of biogas produced in France in 2019, renewable gases represent a growing market (see Chapter 5).

Supply

In 2019, France net imports of natural gas totalled 44.2 bcm (Figure 9.2), which were supplied mostly from Norway (19.8 bcm), the Russian Federation (10.6 bcm), the Netherlands (4.6 bcm) and Nigeria (4.5 bcm). During the past decade, net gas imports have remained stable, with only a marginal decrease in 2014 to 38.4 bcm. Liquefied natural gas (LNG) imports doubled between 2018 and 2019, reaching 19.7 bcm, and met 45% of national gas demand. At the same time, the share of pipeline imports decreased to 55%. By comparison, in 2014, 85% of imports came via pipelines and 15% by LNG. In 2019, France exported 0.4 bcm to Italy and 7.8 bcm to Switzerland.

In 2019, 10% of France's natural gas market was supplied by low-calorific gas (L-gas) originating from the Netherlands. However, the Dutch government has decided to end production from the Groningen field in 2022, three years ahead of schedule. It will respect its existing contracts with France that will expire at the latest by 2029. The French network operator GRTgaz is implementing an ambitious transition plan for the conversion of all affected customers in the northern part of the country to H-gas by end of 2028.

Figure 9.2 France's natural gas net imports by country, 2000-19



France has diversified sources of natural gas imports and has increased its exports in recent years, mainly to Switzerland.

Notes: bcm = billion cubic metres. Natural gas exports to Italy are not visible at this scale.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Domestic gas production

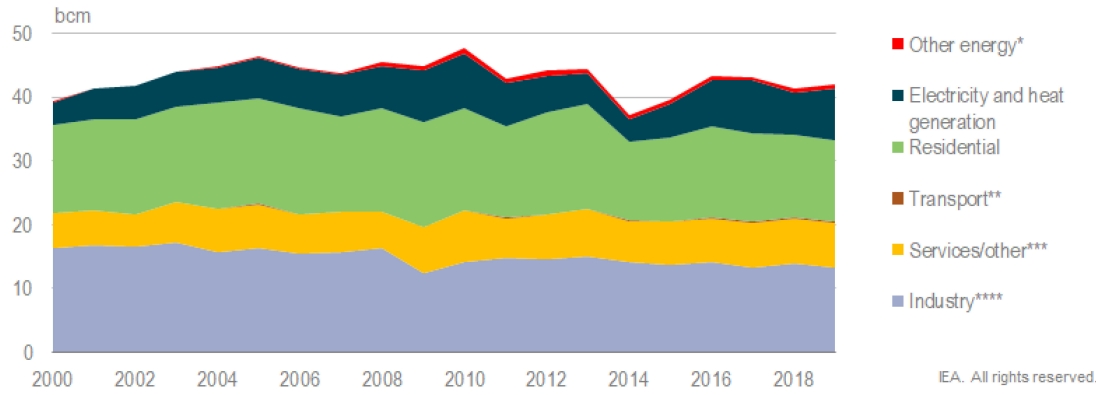
The only remaining natural gas production in France is a coal-bed methane extraction in the northern part of France, with 77 million cubic metres (mcm) of production per year. The production of 34 mcm is injected into the network; the rest is used to produce electricity locally. Under the Hydrocarbons Law of 2017, no exploration and production will be permitted beyond 2040 and no new production permits have been issued since the law entered into force. With this, France has become one of the first countries to completely

ban gas and oil exploration on the national territory, although it is mainly a symbolic measure, as proven and recoverable deposits in mainland France are almost inexistent.

Demand

Natural gas consumption in France has decreased by 6% over the last decade, from 45.3 bcm in 2009 to 42.4 bcm in 2019 (Figure 9.3). In 2019, consumption in the industry sector represented 31% (13.2 bcm), followed by the residential sector at 30% (12.8 bcm), electricity and heat generation at 19% (8 bcm), services and others at 17% (7.0 bcm), other energy at 1.5% (0.6 bcm), and transport at 0.4% (0.2 bcm). Consumption of natural gas in the residential sector has decreased by 22% over the last decade, but remains highly sensitive to temperature variations.

Figure 9.3 France's natural gas demand by sector, 2000-19



Overall, France's share of natural gas consumption in industry, services, and electricity and heat generation has remained constant since the IEA's last review.

* *Other energy* includes oil and gas extraction and other energy sector use.

** *Services/other* includes commercial and public services, agriculture/forestry, and fishing.

*** *Transport* gas demand is barely visible at this scale, which increased from 0.1 bcm in 2011 to 0.2 bcm in 2018.

**** *Industry* includes non-energy use, and energy demand from petroleum refineries.

Note: bcm = billion cubic metres.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

An increase of gas demand was observed from 2015 to 2017, notably in power generation. However, since 2017, this trend has reversed, and gas consumption has decreased due to mild temperatures and stronger reliance on nuclear and hydropower. In total, 11.4 million customers are using natural gas in France (94% are households, which consume 25% of gas volumes in the country, while the remaining 75% is consumed by non-households ([industry, the tertiary sector, power stations], representing 6% of customers).

The French gas sector remains the third-largest gas market in the EU, after Germany and Italy. However, natural gas represents a slightly smaller share of total primary energy consumption in France than the EU average (22%). The country's population density is lower than the EU average and development of the gas network more costly. The large nuclear fleet provides for the easy-to-use alternative of electric heating, which is dominant in France. As a result, natural gas networks are only available in 30% of French cities (although 80% of the French population lives in a district with access to natural gas

and all but one of France's mainland's departments are connected to the gas grid). There are no plans to expand the gas network.

During the first half of 2020, natural gas consumption in France declined due to the fall in economic activity and lockdowns in response to the COVID-19 pandemic. Domestic gas demand decreased by 11% in March and by 35% in April 2020 (compared to the same months in 2019). Industrial gas demand fell by 68% in March 2020 alone.

Biogas

The government's plan to move away from fossil fuels includes a multi-fold increase in biogas production, while decreasing overall gas consumption. France has a strong potential for biogas production, notably based on agricultural waste. For several years, the government has actively supported the growth of biogas and biomethane in France. The market mechanisms and the various subsidies offered made it possible to reduce the high costs of production. With a new PPE adopted in 2020, the government revised downwards certain assumptions for the biogas market, which certain market players were disappointed to see: some were expecting a 30% biogas target, whereas the government's 2030 target was set at 7% (up to 10% if further production cost reductions are possible).

This would mean a volume of up to 3.1 bcm of biomethane in the system in 2030, a 30-fold increase from the 108 mcm produced in 2019. The interim plan included in the PPE calls for biogas production to rise to 1.2 bcm as early as in 2023 (of which almost half would be injected into the network), and further strong growth to the target of 2030 (2 bcm injected of the 3.1 bcm produced). Currently, there are around 1 000 of small-scale biogas plants at different stages of development across France (in comparison to around 900 already in operation), with a total maximum potential production capacity of 2.1 bcm per year.

The government supports biogas production through various instruments, with fixed purchase tariffs being the pillar of support for the industry. This mechanism gives producers the certainty of selling biogas and biomethane to selected suppliers at a previously fixed price and for a fixed term. These purchase tariffs, determined by the government, depend on several factors, such as the form of valorisation used, the size of the production unit and the nature of the feedstocks. There are two types of fixed purchase tariffs:

- For biomethane injected into natural gas networks, with a duration of the purchase obligation of 15 years. At the end of 2019, the purchase tariff stood between EUR 45 per megawatt hour (MWh) and EUR 139/MWh, depending on the size of the plant. A bonus can be added depending on the type of feedstock used. However, the new PPE plans for a gradual reduction of these tariffs by 2% per year. The target prices of EUR 75/MWh in 2023 and EUR 60/MWh in 2028 are forecasted for the new tender scheme for medium and large biomethane plants.
- For electricity produced from biogas, with a duration of the purchase obligation of 20 years. However, when the biogas plants exceed a capacity of 500 kilowatts (kW), they must participate in a formal bidding process. The purchase price mechanism has caused a strong growth in co-generation in agricultural areas, resulting in 80% of the produced biogas directly burnt for power generation and the remaining share injected into the grid.

A new tender scheme for medium and large biomethane plants will have two calls for tenders each year, for an annual production objective of 350 gigawatt hours (GWh) per

year each. This is a good step forward; however, policy and support instruments should be constantly monitored to allow for timely adjustments to achieve the ambitious biogas production goals in France.

The government has not yet presented concrete plans for future use of the existing natural gas infrastructure, some of which may turn into stranded assets if demand declines as projected. Concerns about regulated stranded assets are mitigated by companies with the introduction of accelerated depreciation process. This, however, cannot address the problem in full. A significant part of the existing natural gas infrastructure will be used for biogas transportation and storage. Since 2018, the cost of gas network adaptation for biogas injection has no longer been solely borne by biogas producers, but is instead shared between all gas network users. The challenges are nevertheless complex: biomethane plants inject their volumes into the closest low-pressure gas network, which makes long-distance transmission impossible. Network meshing and reverse flow compressors may be necessary to achieve the ambitious goals for biogas production in France.

Hydrogen

As part of France's Recovery Plan from the COVID-19 pandemic, the government presented a national hydrogen strategy in September 2020. It provides for an investment of EUR 7.2 billion by 2030 and a hydrogen production capacity of 6.5 GW, with the creation of up to 150 000 jobs. The strategy plans to bring savings of 6 million tonnes of CO_2 per year by 2030, the equivalent of the annual emissions of the city of Paris. A national Hydrogen Council presented initial plans for 3.2 GW of large-scale electrolysis capacity to key ministers in late February 2021. The projects, which require some EUR 8 billion of investment, could begin to benefit from funding under the EU's Important Projects of Common European Interest programme by the end of 2021. Based on efficiency considerations, the plan mainly focuses on the direct use of low-carbon hydrogen, including from electrolysers using nuclear power and renewables.

The government does not foresee linking up local clusters by dedicated hydrogen transmission pipelines, although this option is clearly preferred by the relevant private stakeholders that will build and operate the hydrogen pipelines. As the plans for developing a pan-European hydrogen network are rapidly materialising, France risks missing out on these opportunities, as other countries are quickly moving forward. The government should enable these industrial opportunities with a cost-effective transition of the EU gas infrastructure, to decarbonise existing hydrogen production in industry. However, a clear vision on the future regulatory framework for hydrogen to accompany these investments, (i.e. determining objectives on decarbonisation, roles and responsibilities) is not yet in place. The recent announcement of Total and Engie to design and build the Masshylia project, France's largest renewable hydrogen production site at Total's La Mède facility (operating as a biorefinery), is a promising step forward. The installation of a 40 MW electrolyser, powered by solar PV of over 100 MW, will produce 5 tonnes of green hydrogen per day to meet the needs of the biorefinery processing, and will avoid 15 000 tonnes of CO_2 emissions per year. Air Liquide and Siemens Energy have also announced a funding application for a 200 MW electrolyser at the Port-Jérôme-sur-Seine chemical facility.

Gas market structure

Wholesale and retail supply

More than 180 natural gas suppliers are authorised to deliver gas in France, and among them around 30 are registered as foreign companies. Around 100 traders have received similar authorisation from the Ministry of the Ecological Transition (MTE) to operate on the gas market in France. The list of all suppliers is available on the MTE's website.[1] Major players in the gas wholesale market include Mercuria Energy Trading SA, Eni, EDF, Shell Energy Europe Limited, and Total E&P.

In 2020, the major players in the gas retail market were Engie (23.6% public ownership), EDF (83.7% public ownership), Eni Spa and Total. Since the reform of regulated tariffs commenced in 2014, alternative suppliers have more than doubled the number of their residential consumers (a 16.7% market share at the end of 2014 versus a 35% market share in June 2020). The market share of alternative suppliers for non-residential customers has risen by more than 50% (from 30.6% in 2015 to 46.6% in June 2020). The market share in volume is higher; alternative suppliers accounted for almost 66% of non-residential and 33% of residential supplies. The switching rate has increased significantly (about 5% by the end of 2019, against 2% in 2014). However, this rate dropped below 3% in 2020, in the context of the COVID-19 pandemic.

Networks and tariffs

The natural gas transmission network is operated by two transmission system operators (TSOs): GRTgaz and Teréga.

GRTgaz (a 75% subsidiary of Engie, and 25% of the Société d'Infrastructures Gazières), operates 8 110 km of the main network and 24 043 km of the regional networks (together around 87% of the gas transmission network in France). In 2021, Engie agreed to sell an 11.5% stake in GRTgaz.

Teréga, TotalEnergies's former subsidiary TIGF (sold in 2013 to the SNAM-CIG-EDF consortium) operates 650 km of the main network and 4 450 km of the regional networks in the south-west of France. Teréga, with about 13% of the network, is the second gas TSO. Teréga also operates gas storage facilities.

The networks of the two operators are interconnected in Castillon-la-Bataille (Dordogne) and Cruzy (Herault). The length of the networks in France totals 195 000 km, the second-longest gas distribution network in Europe after Germany.

Distribution networks are owned by local authorities and are managed through a concession-based system whereby concession agreements govern the relationship between local authorities and GRDF (Gaz réseau distribution France, a subsidiary of Engie

[1] www.ecologie.gouv.fr/sites/default/files/Liste%20des%20founitsseurs%20autoris%C3%A9s%20-%20mai%202018.pdf.

which operates 95% of the distribution grids in France), or 22 local distribution companies, which cover the remaining 5% of the market and offer their own regulated tariffs.

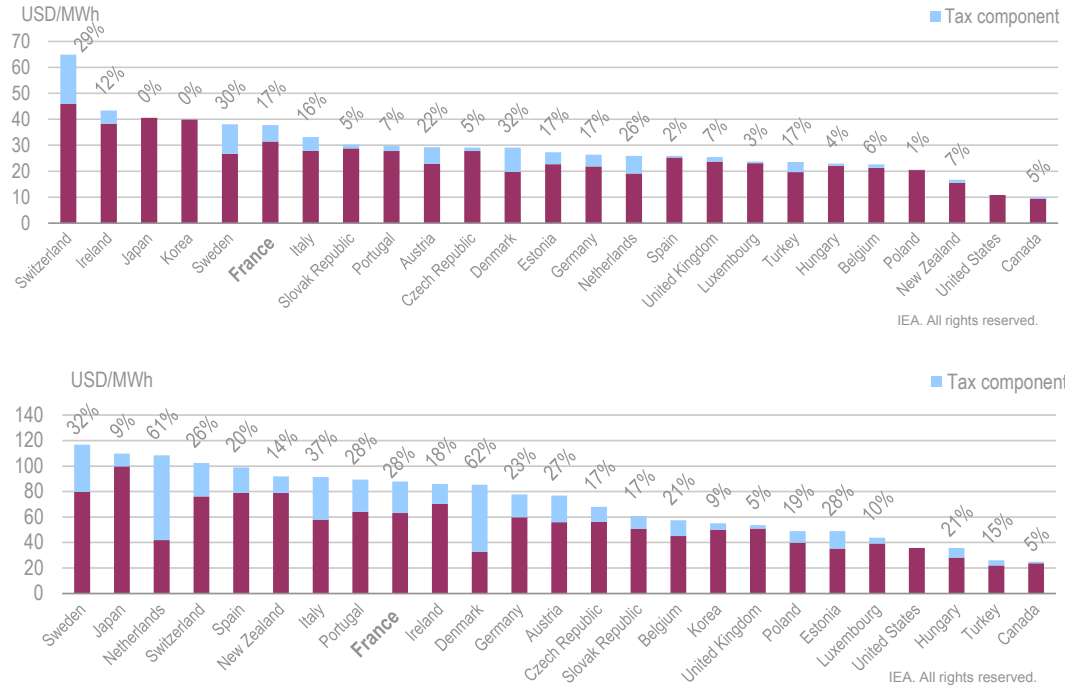
Transmission tariffs

The latest tariffs for use of the networks entered into force on 1 April 2020 for the period 2020-24. According to Article L452-1 of the Energy Code, the tariffs for using the transmission networks, commercial terms of use and rates for additional services performed by TSOs are established in a transparent and non-discriminatory manner by the Energy Regulatory Commission (CRE). Upon a proposal by the operators, the CRE sets tariffs, taking into account the energy policy guidelines set by the Ministry for the Economy, Finance and the Recovery and the MTE.

Retail gas prices and taxes

The natural gas price for industry in France ranked sixth-highest among IEA member countries in 2020 at USD 37.8/MWh, with a tax rate of 17% (Figure 9.4), while the price for households ranked ninth-highest at USD 87.9/MWh, with a tax rate of 28%.

Figure 9.4 Industry and household natural gas prices in IEA countries, 2020



France's industry and household natural gas prices are above IEA average: they are the sixth-highest for industry and the ninth-highest for households

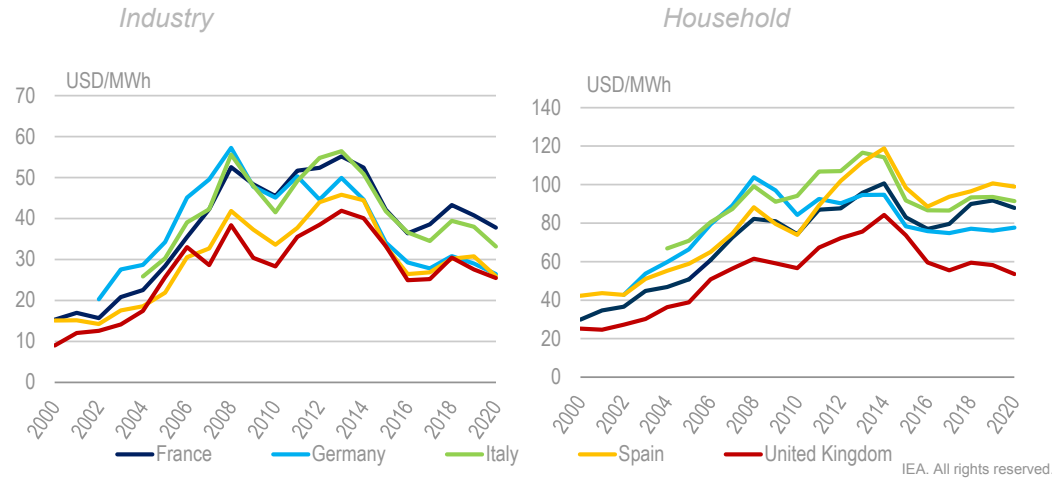
* Tax information for industry and household prices are not available for the United States exclusively

Notes: MWh = megawatt hour. Industry price data are not available for Australia, Finland, Greece, Mexico or Norway. Household price data are not available for Australia, Finland, Greece, Mexico or Norway.

Source: IEA (2021b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Natural gas prices in France followed similar trends as its neighbouring countries of Germany, Italy, Spain and the United Kingdom over the period 2000-20. Since 2014, France has had the highest natural gas industry price, surpassing that of Italy (Figure 9.5).

Figure 9.5 Natural gas prices in France and selected IEA countries, 2000-20



France's natural gas prices follow similar trends as its neighbouring countries, with France seeing some of the highest gas prices for industry in Europe.

Notes: MWh = megawatt hour. Industry data are unavailable for Germany (2001) and Italy (2000-2003). Household data are unavailable for Germany (2001) and Italy (2000-03).

Source: IEA (2021b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Gas policy and market regulations

The Energy and Climate Law of 2019 targets a 40% reduction of fossil fuel consumption by 2030 (from 2012 levels). Under the PPE, France targets a reduction of natural gas consumption to 31 bcm by 2030 (down by 19% from 2012 levels, but a 25% reduction from 2019 levels). France expects to see a sharp decline in natural gas demand as it pursues stronger energy efficiency measures, mostly in the residential sector (less gas-based heating, in particular),[2] as well as in the tertiary sector. The economic situation and the competitiveness of natural gas compared to other fuels will, however, determine the use of gas in non-household sectors, which consume 75% of natural gas in the country.

Major changes in natural gas policy have been introduced since the IEA's last in-depth review in 2016, including

- a phase-out of regulated tariffs for industrial customers was completed by the end of 2020
- a single gas-trading zone, TRF Trading Region France, was introduced on 1 November 2018

[2] In 2017, fossil fuels provided 43% of the energy distributed by France's 761 heating and cooling networks, with 37% natural gas, 5% coal and 1% fuel oil. According to the Environmental Regulations 2020, as of July 2021, newly built homes will not be allowed to use natural gas as a heating source in favour of greener options.

- the Law on Hydrocarbons of 2017 bans oil/gas production in France (amending also the Energy Code and introducing important changes to the natural gas market).[3]

Retail market reforms – the end of regulated gas tariffs

The phase-out of regulated tariffs brought major changes to the retail market. Since 1 December 2020, commercial customers are no longer eligible for regulated tariffs. For residential consumers, the regulated tariffs will end on 30 June 2023. In June 2020, 3.7 million out of 11.4 million customers still purchased gas under regulated tariffs. Incumbent suppliers control over 50% of the residential market, although alternative suppliers have doubled their market share since 2015. The Law on Energy and Climate of 2019 ensured that customers benefiting from regulated tariffs have full access to information on possible market options and obliges incumbent suppliers to remain neutral with respect to customer queries about possible contract changes. Alternative suppliers have also been given access to contact data of customers under regulated tariffs to be able to present them market offers, in compliance with the EU General Data Protection Regulation. Customers can contract "market offers" and can switch suppliers to get other prices; some of these offers are up to 10% cheaper than regulated tariffs. France has set up an independent and free gas and electricity price comparison tool (www.energie-info.fr), which is handled and updated regularly by the energy ombudsman.[4]

Regulated gas tariffs in France are set by the MTE and the Ministry for the Economy, Finance and the Recovery, following the opinion of the CRE. Each year by the beginning of July, a ministerial tariff order together with calculation formula is published. This order reflects both changes in supply and non-supply costs. The application of this formula to variations in gas prices on European markets leads to monthly changes in regulated natural gas tariffs. It also reflects variations in Engie's natural gas supply conditions. An increase in the purchase price from international producers has a direct impact on the regulated price of gas in France. Regulated prices also depend on the tariff zone in which the household is located, and the purposes of gas use of the household (cooking, heating).

After rising by +0.2% in January 2021, the gas tariff for households increased again in February by 3.5%. The latest yearly ministerial tariff order was approved by the CRE on 25 June 2021 and stipulated a 10% tariff increase as of 1 July.[5] In the context of the gas price hike in September 2021 in Europe and across the world, on 30 September, the government announced a "tariff shield" and decided to freeze natural gas tariffs until April 2022, following the increase on 1 October 2021 announced by Engie (12.6%).

A single gas-trading zone

Since the IEA's last review, two gas network reinforcements, one in Val-de-Saône and one in Gascogne-Midi, have been completed to allow for the merger of the previously separate two French trading zones into one single trading area, the so-called TRF, or Trading Region France. The objective of the market merger was set by the CRE in 2012, largely to ease north-south gas network congestions. The project necessitated a cumulative

[3] www.legifrance.gouv.fr/jorf/id/JORFTEXT000036339396.
[4] www.energie-mediateur.fr.
[5] www.cre.fr/Actualites/evolution-des-tarifs-reglementes-de-vente-de-gaz-d-engie-et-des-eld.

investment of EUR 823 million from both TSOs, GRTgaz and TIGF (today's Teréga). It included doubling the length of the Val-de-Saône pipeline (188 km) and reinforcing the Gascogne-Midi pipeline, as well as adapting numerous pump stations and compression stations across the system. After two years of operations, the benefits of the merger are quite visible, both in terms of infrastructure operations (no congestion, liquid flows and continuity of network nominations) and customer service. Access of all French companies and consumers to a single market price reduced the isolation of southern France and related lower dependency of that region on LNG supplies.

Natural gas infrastructure

Figure 9.6 Gas infrastructure in France

France has seven interconnection points, with a total of 2 380 GWh/d import capacity (Table 9.1). Taisnières B is dedicated to importing low-calorific gas (L-gas) from the Netherlands through Belgium and is expected to deliver less and less volumes due to the closure of the Groningen gas field in the Netherlands. Oltingue, Pirineos and Virtualys have reversible capacity flows.

In the past France considered the construction of a new gas pipeline within France and between France and Spain (MidCat and South Transit East Pyrenees projects), but has abandoned these plans in view of planned reductions of gas consumption in France and overcapacity of the grid. Neither project was included on the European Commission's list of projects of common interest.

Table 9.1 Entry interconnection capacities of the French gas network (GWh/d)

Interconnection	2019	Planned 2028	Utilisation rates 2019
Taisnières B	230	115	43%
Dunkerque	577	570	85%
Virtualys	630	630	55%
Obergailbach	618	618	24%
Pirineos	225	225	56%
Oltingue	100	100	75%
All interconnections	**2 380**	**2 265**	

Note: GWh/d = gigawatt hour per day.
Source: Ministry of the Ecological Transition.

Table 9.2 Exit interconnection capacities of the French gas network (GWh/d)

Interconnection	2019	Planned 2028	Utilisation rates 2019
Virtualys	270	270	5%
Oltingue	254	254	44%
Pireneos	170	170	58%
All interconnections	**694**	**694**	

Note: GWh/d = gigawatt hour per day.
Source: Ministry of the Ecological Transition.

France has four LNG terminals: two in Fos-sur-Mer, one in Montoir de Bretagne and one in Dunkerque. Fos Tonkin and Montoir are owned by Elengy, a 100% subsidiary of Engie created in early 2009. The Fos Cavaou terminal is owned by Fosmax LNG, a subsidiary of Elengy (over 70%) and Total, and is operated by Elengy. The Dunkerque terminal is majority owned by Fluxys with a minority share of Korean investors. The average utilisation rate of the French LNG terminals was 41% in 2019. The Dunkerque and Montoir terminals do not have plans for expansion over the next decade, while the terminals in Fos-sur-Mer are studying an expansion to reach 500 GWh/d of capacity (from 410 GWh/d today). Three out of four LNG terminals are functioning on the basis of full third-party access. The Dunkerque LNG was granted a total exemption from regulated third-party access and tariff regulation for a period of 20 years, hence the rules and the terminal access prices are set by the terminal operator (Fluxys).

Table 9.3 Liquefied natural gas terminals in France, 2020

LNG terminal	Year of construction	Storage capacity (m^3)	Ships allowed (m^3)
Fos Tonkin	1972	80 000	75 000
Fos Cavaou	2010	330 000	266 000
Montoir	1980	360 000	266 000
Dunkerque	2016	570 000	266 000
TOTAL		**1 340 000**	

Source: Ministry of the Ecological Transition.

Gas storage

Total gas storage capacity in France amounts to 12.2 bcm. There are two underground gas storage operators:

- Storengy, a 100% subsidiary of Engie created in 2009, operates 13 sites in France (plus 6 in Germany and 1 in the United Kingdom), including 10 aquifers and 3 salt caverns, representing a total volume of 9.3 bcm (76% of country's capacity). Storengy also operates salt caverns in Manosque owned by Geomethane.
- Teréga, one of the country's two TSOs, operates two sites in aquifers in the south-west part of the country (in Izaute and Lussagnet), representing a total volume of 2.9 bcm (24% of total capacity).

Third-party access to gas storage capacities is ensured under the Energy Code. The Law on Hydrocarbons (2017) introduced some modification to the gas storage system. Prior to its entry into force, gas suppliers had the legal obligation to build up gas stocks to a predetermined volume. Yet, this rule was contested because the price for storage, freely set by gas storage operators, was considered too high. France launched a reform of the gas storage legal framework and issued a decree (on 31 July 2017) to specify the conditions when and how the legal obligation to build up gas stocks applies.

The amended gas storage regulation entered into force in 2018. The first major change in this gas storage reform is the end of a government-imposed storage obligation system for suppliers. Now, suppliers themselves determine the level of stocks to be acquired to cover their customers' needs for the year. The other major change in this reform concerns the sale of storage capacity from essential storage facilities. This is now conducted through annual auctions organised by operators, Storengy and Teréga, in which all suppliers can participate, whether established in France or in another country. The conditions for holding these auctions (marketing schedule, reserve price, etc.) are set by the CRE. Storage operators are granted a minimum revenue. If the auctions do not create enough revenues to meet this minimum, the difference is levied on consumers through the transmission tariff. If the auction revenues are higher than the set minimum, the surplus is handed back to transport network users by lowering the transmission tariff.

Each year, the government determines the minimum level of gas reserves necessary to ensure the security of national supply. If, at the end of the auctions, the capacities acquired by all suppliers prove to be insufficient to cover this minimum stock level, the government can oblige gas suppliers to subscribe additional storage capacities. This mechanism, called the "safety net", encourages suppliers to participate in the auctions. However,

in 2020, tariffs covered 26-66% of the allowed revenues of the storage operators, which seems to indicate a lack of incentives or regulatory flexibility to fully grasp market value of this mechanism. In February 2020, the European Commission launched an investigation as to whether there was sufficient justification for the method used to value the regulated storage assets, and whether the new mechanism would have a negative impact on competition and trade between member states. On 28 June 2021, the Commission concluded that the mechanism strengthens the security and diversification of the energy supply without unduly distorting competition.[6]

Security of gas supply

French policies to enhance natural gas security of supply are based on two pillars:

- risk mitigation: planning of gas supply to meet expected demand and market regulation in the form of public services obligations on all gas sector players
- emergency response policies: an emergency action plan divided into three levels: early warning, alert level and emergency level.

Risk mitigation

The PPE aims at forecasting the possible evolution of the energy system and at identifying investments needed to ensure security of supply during the energy transition. The PPE provides a list of the essential gas storage facilities (facilities whose operations have to be maintained under all circumstances), which are needed for the efficient functioning of the network and security of gas supply, mostly to deal with sudden cold spells and to help manage flows in the gas network.

Public service obligations

To ensure the availability of sufficient gas supply and reduce the vulnerability of the gas system in case of a crisis, public service obligations are assigned to the TSOs and DSOs, operators of LNG terminals, underground storage operators, and gas suppliers. In accordance with those provisions, the French gas system is designed to adequately respond to a 3 consecutive days of cold spell that occurs with a probability of once every 50 years.

Suppliers must guarantee supply to their clients (except to industrial customers with interruptible contract) in case of:

- a cold winter as it occurs every 50 years
- 3 consecutive days of cold spell that may occur every 50 years
- failure of its major supply source during 6 months.

Due to the important role of gas for heating, French gas demand is highly weather correlated. The average daily consumption can fluctuate almost fivefold between August (530 GWh/d) and February (2 370 GWh/d). The historic peak demand of 3 675 GWh/d was observed on 8 February 2012. Considering a cold spell with an occurrence of once

[6] https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3281.

every 50 years, daily peak demand is estimated at 4 300 GWh/d. To meet demand on a peak day, the French system relies on 3 715 GWh/d of entry capacities (2 385 GWh/d by import pipelines and 1 330 GWh/d by LNG), as well as a maximum of 2 750 GWh/d of technical storage withdrawals and 50 GWh/d of demand reduction measures. France may also decide to stop interruptible export capacities in case of a crisis, but the IEA notes that such a measure undermines international emergency co-operation if taken unilaterally and not as part of cross-border solidarity agreements.

The value of French security of supply criterion (N-1) is higher than 100% (at around 144%), ensuring the theoretical possibility to cover peak demand if the largest piece of infrastructure fails. The single largest infrastructure of the French gas system is the entry interconnection point at Taisnières H that imports gas from the Netherlands and Norway, with a capacity of 640 GWh/d.

France has fewer flexibility tools on the demand side than other countries; in particular, there is little gas-fired power generation that could be substituted by other fuels in case of a gas emergency. However, a new regulatory framework was introduced in 2020 to increase demand-side flexibility. Industrial consumers using more than 5 GWh of gas per year can enter into an interruptible contract with the operator of their gas network (DSO or TSO), for which they are rewarded a lower tariff. In case of gas shortages, the system operators can activate the interruptible contacts provisions and reduce gas supplies to these customers on very short notice.

The Energy and Climate Law of 2019 introduced an additional regulatory measure to assure security of gas supply to customers in case of an emergency: the emergency supplier mechanism. The idea is to appoint an emergency supplier on the basis of geographical distribution and candidate capacity. These companies take over the responsibilities of the gas supplier when the incumbent is unable to satisfy its customers' demand. In such a situation, the appointed emergency supplier contacts the customer, informing him that he is taking over as emergency supplier and quoting an additional service fee. The customer can refuse this service if he is able to find another supplier.

Also, since the 2018 reform and introduction of a single trading zone (TRF), when the TSO is conducting a tender to balance the system, all gas providers must provide their unused and technically available gas stocks from essential gas storage facilities and LNG terminals. It allows the TSO to find balancing volumes quickly, although the prices at which gas stocks are offered are determined by their owners.

Emergency response policies

In case of an emergency and when preventive actions (increase of supply, by-passing of certain infrastructure, etc.), are not sufficient to satisfy French customers' demand, specific measures are foreseen in the emergency plan. The main mechanism to manage a gas crisis is targeted gas curtailment – a new framework for gas curtailment has been introduced and should be completed in 2021.

The emergency plan foresees three crisis levels:

- Early warning level: when there is concrete, serious and reliable information that an event may occur which is likely to result in significant deterioration of the supply situation and is likely to lead to the alert or the emergency level being triggered.

- Alert level: when a supply disruption or exceptionally high gas demand occurs which results in significant deterioration of the supply situation, but the market is still able to manage that disruption or increased demand without the need to resort to non-market measures.
- Emergency level: in the event of exceptionally high gas demand, a significant supply disruption or other significant deterioration of the supply situation, and in the event that all relevant market measures have been implemented but the supply of gas is still insufficient to meet the remaining gas demand, so that non-market measures have to be additionally introduced.

When an emergency is declared by a decision of the minister in charge of energy, non-market-based measures could be taken, notably to ensure supply to protected customers in France (although according to the government, the EU definition of "protected customers" is impossible to apply in practice, as these customers are connected to the same distribution grid as non-protected customers), or as a solidarity act to another member state of the European Union. Such non-market based measures are:

- Recommendation of energy demand reduction, issued by the MTE.
- Use of interruptible contracts with financial compensation, conducted by the TSO.
- As a last resort, gas demand curtailments can be decided by grid operators, beginning by industrial consumption, without compensation. The MTE and the Ministry of the Interior will intervene in case grid operator orders are not pursued by customers.

With the change in the storage regime in 2018, the government expects suppliers at the beginning of the winter to hold a certain level of gas in storage depending on their customers' consumption; the volumes are decided by the suppliers themselves. TSOs hold storage to fulfil their obligation as a last resort gas supplier, which is to supply the essential social services for five days in the event of the failure of their suppliers. Demand-side response by means of interruptible contracts offers a flexibility which represents only 2% of once-in-50-years peak demand. Supply curtailment for industrial customers represents 5% of the peak demand.

France does not co-operate significantly on emergency policies with its neighbouring countries. The centralised odorisation of natural gas in France makes it technically impossible to physically accept gas from neighbouring countries in the event of a crisis. The government has also not taken significant steps to conclude solidarity agreements according to the provisions of Regulation (EU) 2017/1938 on measures to safeguard the security of gas supply, although it has started adapting its regulation on gas curtailment to allow it to conclude such solidarity agreements.

National Emergency Strategy Organisation structure

For the gas sector, as for the oil sector, the General Directorate for Energy and Climate Change in the MTE, and more precisely its Directorate for Energy, is responsible for the management of supply emergencies.

During a crisis, suppliers and infrastructure operators are required to regularly transmit their analysis of the situation to the National Emergency Strategy Organisation (NESO). Suppliers could also be asked to transmit information to their consumers.

Gas emergency response exercises are regularly organised with stakeholders on a range of gas disruption scenarios. The main objectives are to test the implementation of the emergency plan and its communication with the national crisis organisation described above.

Assessment

In 2019, natural gas demand in France stood at 42.4 bcm, accounting for 20% of final energy demand. This share has remained constant in the past decade, as residential and industrial demand decreased, while demand from power generation increased. In total, 11.4 million customers are using natural gas in France (94% are households, representing 25% of gas demand, while the remaining 75% is consumed by non-household sectors, including industry). The natural gas transmission network is operated by two operators: GRTgaz and Teréga.

France's domestic natural gas production is negligible, accounting for a mere 1%. Furthermore, the Hydrocarbons Law of 2017 specifies that no exploration and production will be permitted beyond 2040 and no more new production permits will be issued. For its imports, the country relies on a diversified portfolio by origin and route. In 2019, gas supply mainly originated from Norway (19.8 bcm), Russia (10.6 bcm), the Netherlands (4.6 bcm) and Nigeria (4.5 bcm). LNG plays an increasing role in supplying the French market, with 45% of imports in 2020. France also exported 7.4 bcm of natural gas to Italy, Spain and Switzerland in 2019.

Since the IEA's last review, the French government has completed a demanding market integration process by merging the remaining two market zones into a single gas-trading zone, TRF, as of 1 November 2018. The observed benefits are the creation of a single market price for the whole country, increased liquidity in the market and improved security of supply.

Since the reform of regulated tariffs commenced in 2014, alternative suppliers have more than doubled the number of their residential consumers (a 16.7% market share at the end of 2014 versus a 35% market share in June 2020). The market share of alternative suppliers for non-residential customers has risen by more than 50% (from 30.6% in 2015 to 46.6% in June 2020). The market share in volume is higher; alternative suppliers accounted for almost 66% of non-residential and 33% of residential supplies. The switching rate has increased significantly (about 5% by the end of 2019, against 2% in 2014). In the retail sector, the phasing out of regulated tariffs was completed on 1 December 2020 for professional consumers, while regulated tariffs will remain available for household consumers until 30 June 2023.

The regulated tariff is set by the government each year in the form of a price formula allowing then for monthly adjustments, following the opinion of the CRE. Since the start of the deregulation of gas prices, the share of the incumbent, Engie, has dropped considerably. Commercial offers are often more attractive than the regulated tariff (they can be up to 10% cheaper). Gas prices in France rank among the highest in the IEA. France has set up an independent and free gas and electricity price comparison tool (www.energie-info.fr), which is handled and updated regularly by the energy ombudsman.

The gas sector is expected to fundamentally contribute to the decarbonisation target as set in the SNBC and the PPE. Gas demand is projected to decline by 25% by 2030 in comparison to 2019 levels (from 42.4 bcm to 31 bcm as projected by the PPE).

The government has been supporting indigenous production of biogas and biomethane to promote both gas supply security and the low-carbon energy transition. In 2019, domestic production still had a marginal share of total gas supply (0.3%). The PPE sets a target for 7% of biogas in gas consumption in 2030, and 10% if costs targeted in the baseline trajectory decline further. According to these projections, biogas production will sharply increase to up to 3.1 bcm per year by 2030. This will require enhanced policy efforts and investments, for which the current support scheme in the form of feed-in tariffs and a planned tendering scheme may not be sufficient. With growing shares of biomethane in the network, grid adaptation, like network meshing and reverse flows on low-pressure pipelines, will also be needed.

France presented a very ambitious national hydrogen strategy in September 2020. It envisages an investment of EUR 7.2 billion over the next few years to help create 6.5 GW of hydrogen production capacity by 2030. However, beyond the strategy and announcements of massive financial support, the government does not yet have a concrete action plan to realise these ambitions, even though the calls for tenders were launched. In addition, France may miss the chance to participate in a pan-European hydrogen network, as many countries are more advanced in this regard. France should act quickly to catch up with its European partners, especially as production of hydrogen by electrolysis has considerable potential in France, given its highly decarbonised electricity.

Although the government has ambitious plans for the gas sector, the gas consumption reduction target of 25% by 2030 is not adequately supported by focused policy measures, notably given that 75% of gas was used by the non-household sector in 2019. Achieving the target will greatly depend on the choices concerning the future electricity mix, in particular when the option of new gas-fired power plants would be explored, in combination with carbon capture, utilisation and storage. The development of an energy system strategy which makes the best use of the comparative advantages of each energy vector and carrier, as is being done in many countries, can address the concerns about stranded assets.

Questions arise on how existing infrastructure and high security of supply standards will be maintained during the energy transition, given the expected significant drop in gas demand. This will likely put an upward pressure on tariffs and prices, as there will be less consumption to pay for the upkeep of the system. Additionally, important parts of gas infrastructure may become stranded assets over a relatively short period of time, including distribution networks which belong to local municipalities.

Gas emergency response

Due to the important role of gas for heating, French gas demand is highly weather correlated. Average consumption can fluctuate almost fivefold between the summer and winter months. Although efforts were made to make demand more flexible with the introduction of interruptible contracts, the effectiveness of this measure still needs to be assessed. Until then, the main mechanism to manage a gas crisis, albeit as a measure of last resort, is targeted gas curtailment. A new framework for gas curtailment has been introduced and should be completed in 2021.

In 2018, the French government amended the existing gas storage regulation, which provides a list of essential gas storage facilities that must continue to operate under all circumstances. Capacities are auctioned, while a minimum level of revenue is being determined by the regulator. The potential gap between minimal revenue and actual costs is being socialised by tariffs. Although this approach has allowed for a solid availability of storage capacity in France, auctions in 2020 accounted for a rather low level of revenue streams, indicating a lack of incentive from the new regulation.

The TSOs and DSOs are ultimately responsible in France for gas supply and crisis management. There is little engagement from the government in managing potential crises and emergency exercises are mostly run by the TSOs and DSOs, with occasional participation of the administration. In order to ensure the availability of sufficient gas supply and reduce the vulnerability of the gas system in case of a crisis, public service obligations are assigned to all market players, with the key role of the TSOs and DSOs in managing the crisis. France has very little crisis co-operation with its neighbouring countries and is not active in gas crisis co-operation at the European level.

Recommendations

The government of France should:

- Match demand reduction ambitions for natural gas with concrete policy initiatives, e.g. blending of biogas and hydrogen, energy efficiency measures, financial incentives, and advanced electrification of industrial processes. Develop an energy system integration strategy, building on the comparative advantages of each energy vector and carrier, and ensuring consistency between policy objectives, to enable an efficient and cost-effective decarbonisation of the gas sector.
- Ensure concrete policy frameworks to facilitate the envisaged substantial growth of biogas and biomethane production, with matching infrastructure developments, allowing for up to 10% of biogases to be accepted in the grid by 2030, including by reviewing the effectiveness of support mechanisms for biogas production.
- Broaden, in close consultation with relevant stakeholders, the hydrogen strategy, looking at production, demand and required infrastructure developments, including the potential need for imports/exports and the repurposing of existing gas networks.
- Assess the security of supply situation, strategy and response measures in neighbouring countries when assessing France's own security of supply standards (i.e. infrastructure standard) and when developing initiatives (e.g. storage policy) to ensure consistency and cost-effectiveness as well as promote regional solidarity.

References

IEA (International Energy Agency) (2021a), World energy statistics, *IEA World Energy Statistics and Balances* (database), accessed on 10 September 2021 www.iea.org/statistics.

IEA (2021b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

10. Oil

Key data (2019/20 estimated)

Domestic crude oil production (2020): 16.4 kb/d, -31% since 2010

Net imports of crude oil (2019):* 981 kb/d, -32% since 2009

Domestic oil products production (2019): 1 077 kb/d, +53% since 2009

Net imports of oil products (2019): 589 kb/d, +120% since 2009

Share of oil (2020): 31% total supply (total energy supply [TES] and international bunker fuels),** 44% TFC, 1% in electricity generation and 1% in domestic energy production

Oil consumption by sector (2019): 1 678 kb/d (domestic transport 56%, international bunkering 10%, industry including non-energy consumption 20%, services and agriculture 8%, residential 6%, energy sector including power generation 1%)

* Imports of crude oil include crude oil, natural gas liquids and feedstock.

** Total energy supply does not include oil used for international bunkering.

Overview

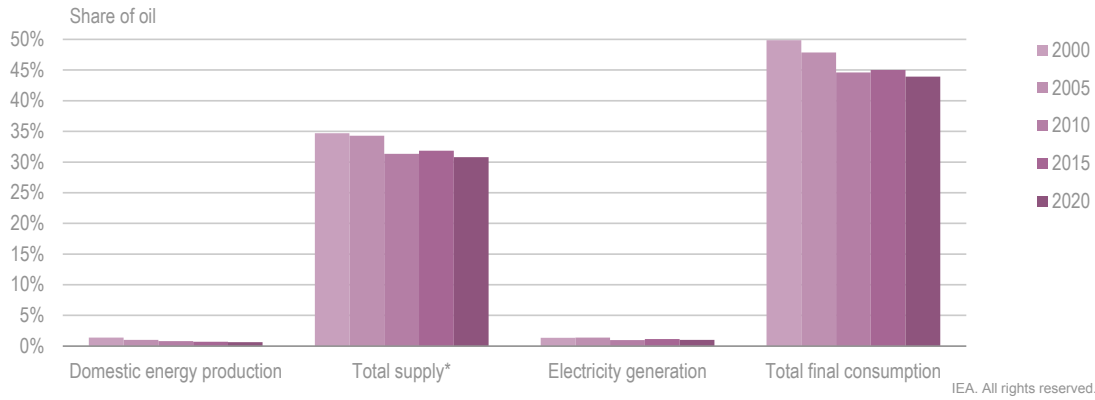
The oil sector in France, as in many other countries, will remain important for transport and specific industries, but the sector will be confronted with large transformation efforts in the coming years. The National Low-Carbon Strategy (Stratégie Nationale Bac-Carbone, SNBC) and the multiannual energy plan (PPE) target a decrease in France's oil consumption of 19% by 2023 and of 34% by 2028 compared to 2012 levels, through a range of policy measures, including promoting electric vehicles, increasing the use of railroads (also for heavy-goods transport) and phasing out oil in residential heating in favour of green sources. France has also set mandatory blending targets of biofuels supported by a dedicated financial support scheme and tax incentives. The country is developing a biofuels manufacturing sector, which will support increased demand for biofuels from transport, aviation and marine bunkers, to respond to a surge across the European Union of the demand for advanced sustainable biofuels.

As oil made up 44% of France's total energy consumption in 2019, the implementation of government targets under the SNBC and PPE will require very robust action, as well as attention to the economic challenges for oil operators. A consolidation of assets and declining levels of investments are likely and may have an impact on maintaining security of supply. The government will need to ensure, together with key stakeholders in the oil industry, that security of oil supply is maintained during the energy transition.

Supply and demand

In 2020, oil represented 31% of France's total energy supply (TES), the same as in 2010 (Figure 10.1). Oil made up 44% of total final consumption (TFC), compared to 45% in 2010. Domestic oil production or oil use in electricity generation have no importance.

Figure 10.1 The role of oil in supply, electricity and consumption in France, 2000-20



The role of oil in TFC decreased from 2000 to 2010 but has largely remained stable since.

* *Total supply*: share of oil in total energy supply plus international bunker fuels.

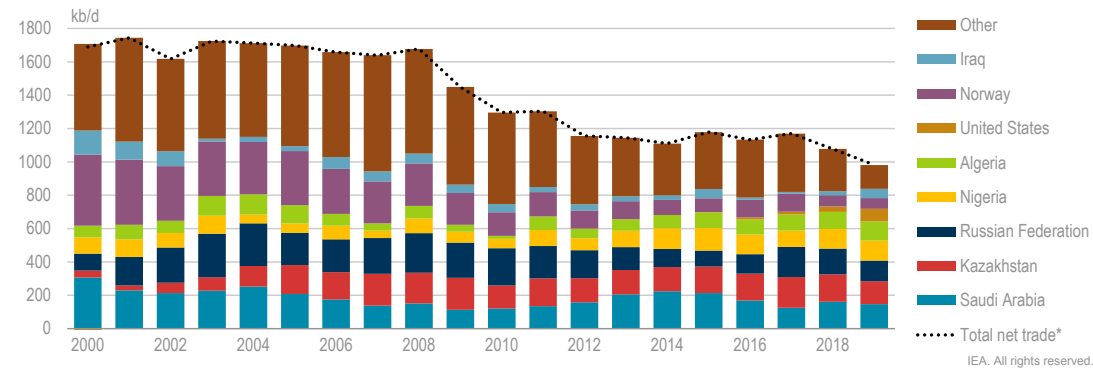
Note: The latest available data for total final consumption are for 2019.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Crude oil trade

Net imports of crude oil decreased to 981 thousand barrels per day (kb/d) in 2019, a 17% drop since 2015 (Figure 10.2). France has several crude oil suppliers, including Saudi Arabia (147 kb/d), Kazakhstan (137 kb/d), the Russian Federation (125 kb/d), Nigeria (120 kb/d), Algeria (115 kb/d), the United States (76 kb/d) and Norway (64 kb/d), among others.

Figure 10.2 France's crude oil net imports by country, 2000-19



France's crude oil imports are well-diversified and have decreased steadily.

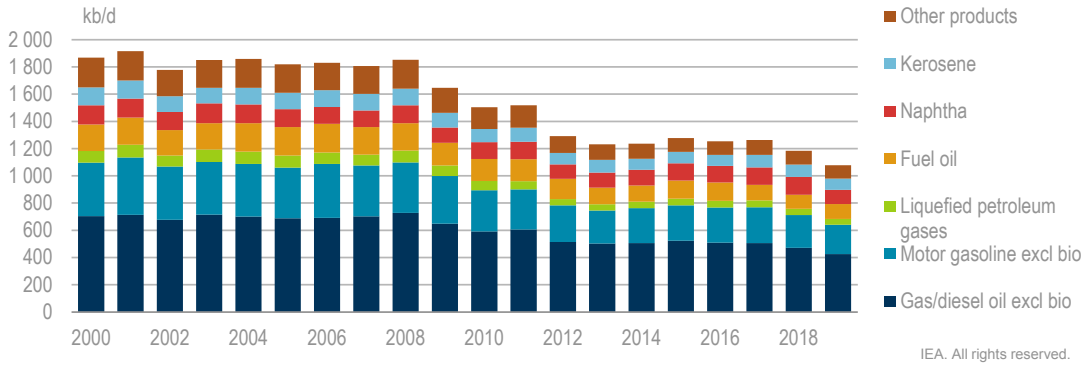
Notes: kb/d = thousand barrels per day. Crude oil data include crude oil, natural gas liquids and feedstock.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics

Oil products supply and trade

Due to the closure of a number of refineries, production of oil products in France has decreased over the last two decades, totalling 1 077 kb/d in 2019 and included: gas/diesel (excluding biofuels) at 425 kb/d in 2019, motor gasoline at 215 kb/d, fuel oil at 109 kb/d, naphtha at 104 kb/d, kerosene (including jet fuel) at 84 kb/d and liquefied petroleum gases at 43 kb/d, as well as other products at 97 kb/d (Figure 10.3).

Figure 10.3 France's oil products production, 2000-19



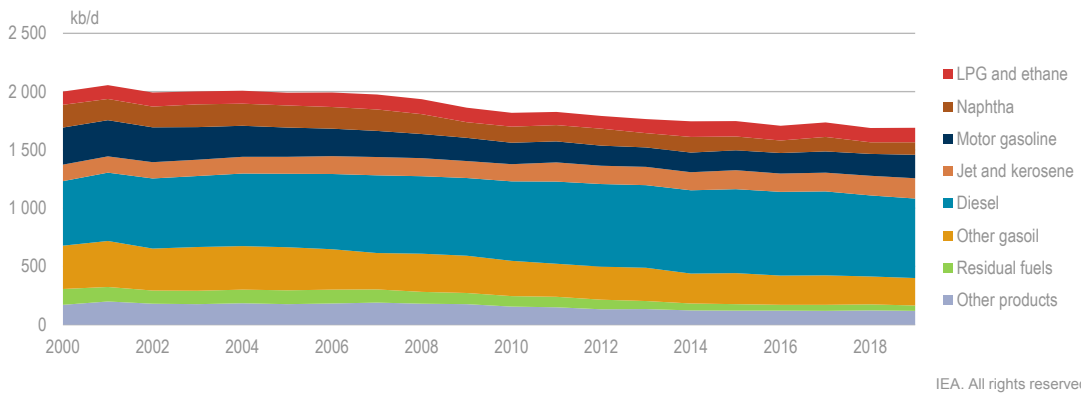
Diesel oil and gasoline are the main oil products from France's refineries.

* *Kerosene-type jet fuel* is at a negligible amount on this scale.

Note: kb/d = thousand barrels per day.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 10.4 France's oil products consumption, 2000-19



France's oil products consumption has steadily decreased over the period, with diesel being the most consumed product.

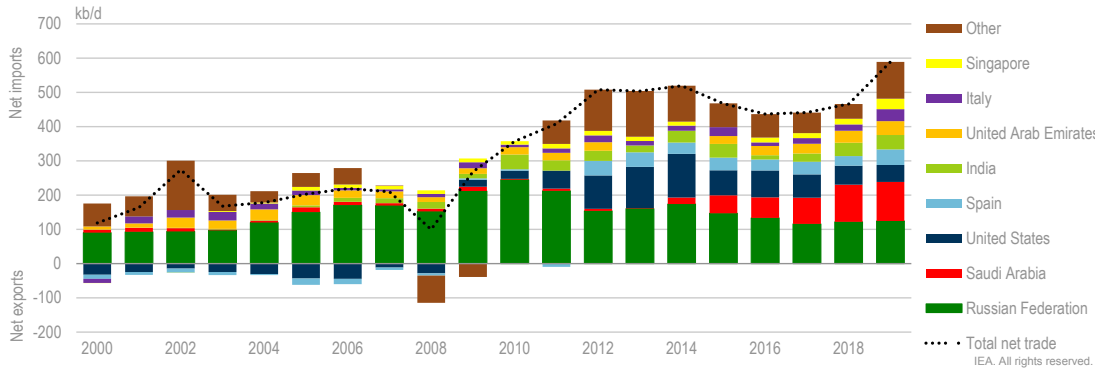
Note: kb/d = thousand barrels per day. LPG = liquefied petroleum gas.

Source: IEA (2021b), *Monthly Oil Data Service*, www.iea.org/statistics.

In 2019, total consumption of oil products in France was 1 444 kb/d, with gas/diesel oil at 843 kb/d, motor gasoline at 181 kb/d, liquefied petroleum gas and ethane at 141 kb/d, naphtha at 84 kb/d, jet and kerosene at 79 kb/d, residual fuels at 24 kb/d, and other products at 93 kb/d (Figure 10.4).

In 2019, France was a net importer of oil products, totalling 589 kb/d from a diverse range of countries, including Russia (125 kb/d), Saudi Arabia (114 kb/d), the United States (50 kb/d), Spain (45 kb/d) and the United Arab Emirates (41 kb/d) (Figure 10.5).

Figure 10.5 France's oil products net trade by country, 2000-19



France imports oil products from a diverse set of countries, with a major role for Russia and Saudi Arabia.

Note: kb/d = thousand barrels per day.

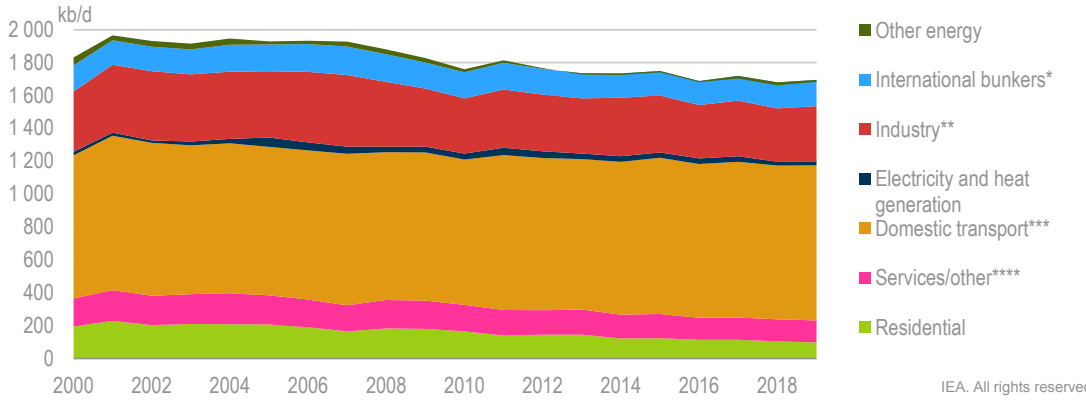
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil demand

In 2019, total oil demand was 1 678 kb/d. Domestic transport consumed 946 kb/d (56%, down from 59% in 2015), industry 337 kb/d, international bunkers 160 kb/d, services and others 134 kb/d, and residential 97 kb/d (Figure 10.6).

Total oil demand has decreased by 8% over the last decade, mainly driven by falling oil consumption in the residential sector (-46%), electricity and heat generation (-31%), and services and others (-22%). Oil consumption in the domestic transport sector has only decreased by 5% over the past decade.

Figure 10.6 France's oil demand by sector, 2000-19



Transport, followed by industry, account for the largest share of oil consumption in France.

* *International bunkers* includes bunker fuels for international aviation and navigation.

** *Industry* includes demand from oil refineries.

*** *Domestic transport* includes non-energy use in transport.

**** *Services/other* includes commercial and public services, agriculture, forestry, and fishing.

Note: kb/d = thousand barrels per day.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil policy

The Energy Transition for Green Growth Act of 2015 set ambitious national climate and energy targets, including the accelerated reduction of fossil fuels consumption. The Hydrocarbons Act of 2017 banned all new oil and gas explorations. From 2021 on, no new authorisation can be granted to extract hydrocarbons and no existing licences will be renewed, as the government targets to phase out production by 2040. As of 2021, France also stopped providing state export guarantees to projects involving unconventional forms of oil such as shale, to be expanded to all types of oil from 2025. The SNBC and the PPE target a decrease in France's oil consumption of 19% by 2023 and 34% by 2028 (compared to 2012 levels), with a range of rigorous policy measures, including:

- Prohibition of new installations of heating oil equipment in residential and tertiary sectors.
- Adoption of incentives to increase the share of electric mobility (purchase bonuses for electric cars and incentives for building charging stations).
- Ambitious targets in terms of the energy performance of vehicles, both for passenger cars (targets of 4L/100 km average consumption in 2030 for internal combustion vehicles and 12.5 kilowatt hours (kWh)/100 km by 2050 for electric vehicles, compared to around 17.5 kWh/100 km today).
- Strong acceleration in the pace and quality of housing renovations, reducing oil use in the existing building stock.
- Radical improvement of the energy efficiency of residential buildings (allowing a decrease of around 40% in the sector's energy consumption by 2050).
- No new authorisations for power stations producing electricity exclusively from oil.

- Continuation of the Energy Saving Certificate for ending the use of fuel oil boilers in favour of heat from heat pumps, biomass stoves, solar combined systems or connection to a renewable district heating network. Extending the existing Energy Saving Certificate "boost" for the disposal of oil tanks for low-income households.

Biofuels

France is the fourth-largest biofuels producer globally, with a share of 5% in global production, and has a well-developed and robust biofuels infrastructure, including production plants (also former refineries), logistics and feedstock supply chains.

According to the SNBC's assumptions, biofuel consumption will increase to 132 terawatt hours (TWh) in 2050, up from 40 TWh in 2019. By comparison, in 2019, total consumption of all oil products in France was 800 TWh. Out of the 40 TWh of biofuels used, two-thirds was fatty acid methyl esters (FAME), followed by hydrotreated vegetable oils (HVO) (16%), ethanol (11%) and ethyl tertiary butyl ether (ETBE) (6%).

Bio-component targets for transport fuels have gradually been increasing since 2015 – from 7% for petrol and 7.7% for diesel to 9.2% and 8.4% respectively, in 2022. As of 2022, kerosene will also be subject to a mandatory share of 1%, to reach a level of 5% in 2030. The PPE also stresses the role of advanced biofuels and targets a 1.2% share for petrol and a 0.4% share for diesel as of 2023, with a plan to reach 3.8% and 2.8% respectively in 2028.

Support for bio-content in fuels is largely tax-based in France. Distributors are obliged to comply with the requirement to add bio-components to the fuels they sell for consumption. If they fail to comply with this requirement, they are subject to an additional tax of 8% for gasoline and 8.2% for diesel in the form of the incentive tax on the incorporation of biofuels (TIRIB). But the tax rate gradually declines as the share of bio-components increases and becomes zero for fuels that meet the blending target. To avoid the TIRIB, fuel distributors that fall short of the blending mandate may buy certificates from distributors that incorporated more than the required amount.

In 2020, 85% of biofuels and 62% of feedstock used in the country originated from the European Union, while 48% of biofuels consumed were produced domestically. However, a target of tripling the biofuels production by 2050 will be very challenging in terms of feedstock supply. It will require stronger policies for developing production and logistical infrastructure and securing feedstock that meets high sustainability criteria, for which competition will grow globally. To commence on this path, France stopped supporting the use of palm oil as a feedstock in January 2020.

Vehicle fleet

The transport sector is responsible for 38% of energy-related CO_2 emissions in France. As of 1 January 2020, France had a total of 38.2 million cars, a very modest decrease from 38.3 million a year earlier. This is the first time that the number of cars has decreased since 2012. More than 97% of the fleet is made up of gasoline and diesel propelled engines. Diesel remains the majority (58.7% of the fleet), even if its share has been decreasing since 2015 (-5.1%). Since 2017, the number of new gasoline vehicles sold has exceeded the number of new diesel vehicles sold.

According to the Ministry of the Ecological Transition, throughout 2019, average CO_2 emissions from new passenger cars sold in France were 112 g CO_2/km. Although emissions have fallen sharply over the last 20 years (175 g CO_2/km in 1997), they have been stagnating since 2015. This can be explained in particular by the lower share of diesel vehicles sold, in favour of gasoline vehicles, and the increase in sport utility vehicles.

A rapid growth of electric and hybrid cars, together with biofuels, is fundamental to reduce transport emissions in France. The government is supporting the development of clean cars in two areas. The first is support for the development of charging infrastructure and the second is an introduction of emissions free zones in cities and accelerating clean mobility solutions.

The Energy Transition for Green Growth Act of 2015 assumed an increase in the number of public and private charging stations to 7 million by 2030 (an increase from 452 000 at the end of 2020), which is supported by numerous financial schemes. For electric cars, the government plans to have 4.8 million electric vehicles and plug-in-hybrids on the roads by 2028 and 15 million by 2035, an exponential spike up from around 650 000 in 2021. France also has in place a system of financial support for the purchase of clean cars by private owners (a bonus of up to EUR 6 000), linked to a system designed to accelerate the removal of the most emitting cars from the market (financial support and administrative restrictions for the circulation of the oldest vehicles). The system includes support of up to EUR 50 000 for the purchase of an electric or hydrogen powered truck or bus, aiming at reducing emissions from the most polluting vehicles, especially in cities.

Market structure

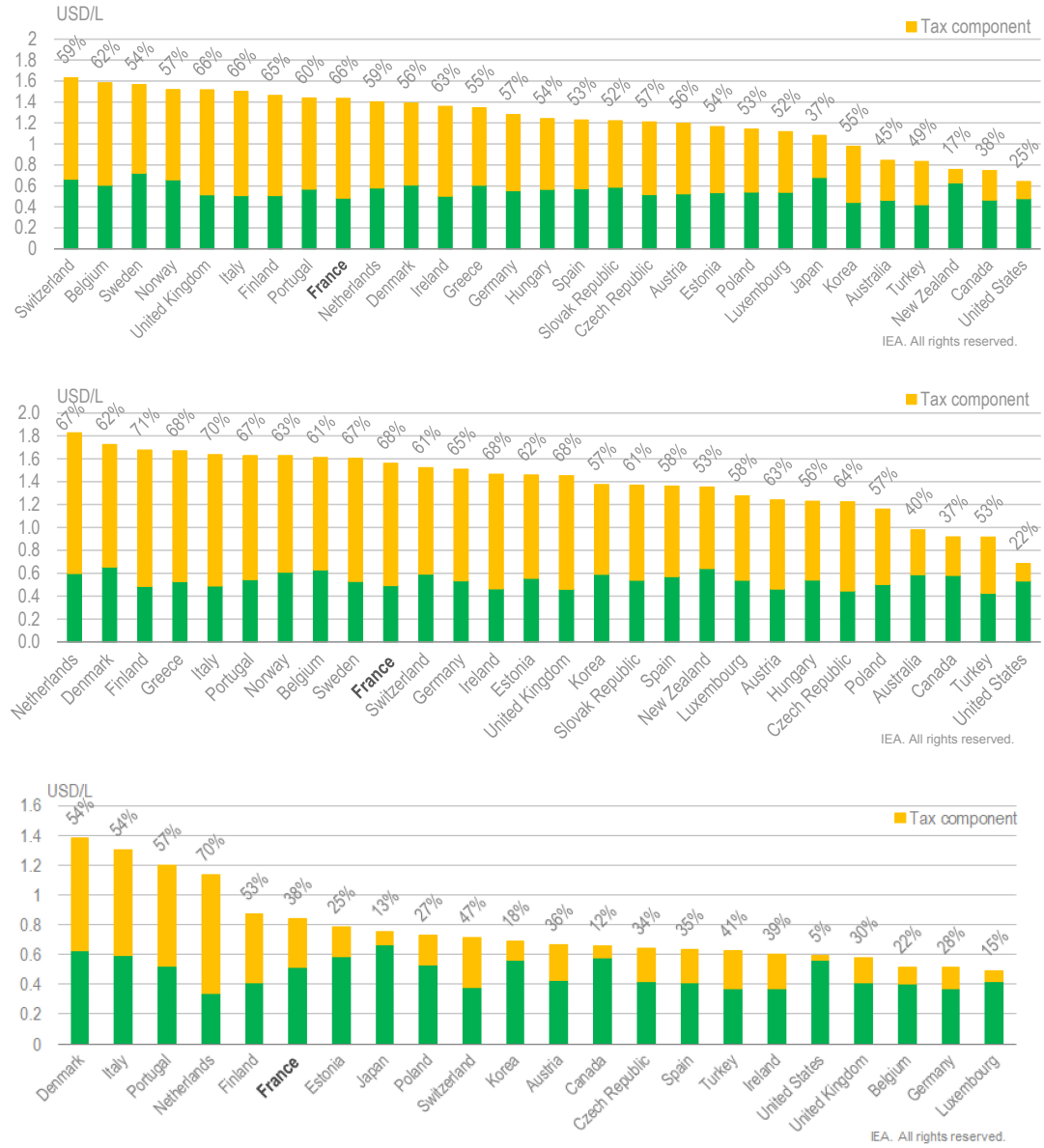
Exploration and production

The production of crude oil on French territory was 723 500 tonnes in 2019. It has diminished by more than 75% since the end of the 1980s. This production satisfies less than 1% of domestic oil consumption. The reserves of crude oil (18 million tonnes [Mt]) and hydrocarbons extracted from natural gas production would represent almost 25 years of operation at the current rate. However, according to the provisions of the Law on Hydrocarbons, no production activities will go beyond 2040 in France.

Oil prices and taxes

Oil product prices are set freely except, in the overseas territories. The price for automotive diesel in the third quarter of 2020 was USD 1.4/L, with a 66% tax share, ranking France ninth-highest among IEA countries. The price of premium unleaded gasoline was the tenth-highest amongst IEA countries, at USD 1.6/L, with a 68% tax share. Light fuel oil had the sixth-highest price among IEA countries, at USD 0.8/L, with a tax share of 38%.

Figure 10.7 Price comparisons for automotive diesel, unleaded gasoline (95 RON) and light fuel oil in the IEA, 3Q 2020



Automotive diesel, unleaded gasoline and light fuel oil prices in France are above the IEA average.

Notes: Automotive diesel data do not include Mexico. Premium unleaded gasoline data are not available for Japan or Mexico. Light fuel data are not available for Australia, Hungary, Mexico, New Zealand, Norway, the Slovak Republic or Sweden.

Source: IEA (2020c), *Energy Prices and Taxes Third Quarter 2020*, www.iea.org/statistics.

Oil infrastructure

Refining

France has 7 operating refineries (down from 12 a decade ago). France's refining capacity amounted to 62 Mt in 2019, compared to 98 Mt in 2009, a decrease of around 40%.

Refineries are mainly concentrated in two zones: the Marseille-Fos area with two refineries (Fos, Lavéra), and the Basse-Seine area with another two facilities (Gonfreville, Gravenchon). Isolated refineries are those of Donges (Grand Ouest region) and Feyzin (Lyon). Total, Esso and Petroineos are the operators of refineries in the country.

In Martinique, the SARA refinery contributes to the supply of the West Indies.

The La Mède refinery, operated by Total, was closed in 2016 and has been transformed into a biorefinery. This biorefinery, unique in France, started operations in early July 2019 and is one of the largest in Europe.

Figure 10.8 Oil infrastructure in France

The shutdown of the Grandpuits refinery was announced in September 2020, motivated primarily by repeated failures in the Île-de-France pipeline that supplies it with crude oil. Refining at all units of the refinery ceased in 2021 and the storage of oil products will end at the end of 2023. The site will be converted into a "zero oil platform for biofuels and bioplastics" – the second biorefinery in the country with activities to support an advanced circular economy, which is expected to start operations in 2024.

All three refinery operators in France invested in upgrading the efficiency of their plants. However, the structural decline in European demand for oil products and the growth of more competitive refineries abroad (including in the United States, Asia and the Middle East), are weakening prospects for French refining.

Ports and pipelines

France imports almost all of its oil through sea ports; crude oil (116.4 Mt in 2019) comes through the ports of Le Havre (30.1%), Marseilles (34.8%) and Nantes-Saint-Nazaire (12.1%). Refined products are imported by sea, but come also from neighbouring countries, by road, by pipeline or by river (Belgium and Germany).

Crude oil pipelines in France connect import depots and refineries. The main ones are:

- the southern European pipeline (PSE), which supplies the refineries of Feyzin and Cressier (Switzerland) from Marseille
- the Antifer-Le Havre pipeline, which transports crude oil from the port of Antifer to the CIM (Compagnie Industrielle Maritime) depot, located in Le Havre; the oil is then transported to the refineries in the Basse-Seine region.

Product pipelines supply the distribution depots. France has four pipeline systems dedicated to refined products:

- The Le Havre-Paris (LHP) pipeline supplies the Île-de-France (Paris) region and the Paris airports and also serves the areas of Caen and Orléans-Tours.
- The Méditerranée Rhône pipeline (PMR) supplies the Lyon region, the Côte-d'Azur and Switzerland (Geneva) from Fos-sur-Mer.
- The common defence pipeline (ODC) represents the French part of the Central Europe Pipeline System (CEPS) of the North Atlantic Treaty Organization and extends over 2 260 km in France.
- The Donges-Melun-Metz (DMM) pipeline crosses France from west to east, from the port of Saint-Nazaire to Saint-Baussant. It supplies the region of Le Mans and eastern France. It is connected to the LHP and the ODC.

Some pipelines supply both distribution depots and refineries with crude oil and products:

- The Île-de-France pipeline (PLIF) supplies the Grandpuits refinery (south-east of Paris) from the port of Le Havre and can be used as a back-up to supply the Normandy refinery. It also transports finished products from the Grandpuits refinery to the Gargenville depot or to those in Le Havre. The PLIF also provides the Grandpuits refinery with crude oil extracted from Paris area oil fields.
- The pipelines between Fos and Manosque (PSM and GSM) transport crude oil and refined products between the port of Marseille and the caverns of Manosque, as well as the brine, which is involved in emptying and filling these caverns.

Distribution of petroleum products

The retail fuel market in France was deregulated in 1987. There are around 11 000 retail service stations divided between different categories of networks:

- 47% of mass distribution stations (hypermarkets) account for 62% of the fuel market
- 53% of stations in the "traditional" network account for 38% of the market with:

- 30% of stations managed under a contract with an oil company, mostly located in urban areas with significant sales volumes
- 70% of independent stations, under an oil brand or without (so-called “white pumps”), mainly active in rural areas and delivering lower volumes of fuel.

The fuel distribution market in France is characterised by large differences in final prices between sites and operators. To make it easier for consumers to get information to choose the cheapest refuelling sites, the government has set up a website (www.prix-carburants.gouv.fr), on which price data are published daily.

Storage

France’s overall storage capacity of petroleum products has remained at a stable 46 million m^3 (290 mb). More than 60% of the capacity is for the storage of refined products (182 mb).

Out of the total, 21.5 million m^3 are storage depots, 15.1 million m^3 are located in refineries and adjacent storage depots of refineries, 9.2 million m^3 are in underground caverns and some 300 000 m^3 are located at main airports. The number of smaller depots has decreased in favour of large capacity depots due to strong competition. Among the 203 depots, 90 are solely for distribution. These are small depots, generally with a capacity of less than 1 000 m^3.

The distribution of storage capacities in France is not homogeneous. The proximity of refiners, import sites, but also massive transport infrastructure for products influences the distribution. The Normandy and Provence regions alone represent 48% of national storage capacities. To a lesser extent, the Nouvelle Aquitaine and Hauts de France regions stand out, with 18% of capacity due to the presence of large import depots. Île-de-France and the Auvergne-Rhône-Alpes region, with 8.6% and 6.4% respectively, also represent a significant share, which can be explained by the major economic activity in these areas. Finally, all other regions represent only 18.4% of the country’s storage capacity.

Oil emergency policies

France has a comprehensive legislative and regulatory framework in place to provide for the country’s response to an oil emergency. The framework is based on a stockholding obligation on industry, active market entities, high-quality and accuracy of data reporting, and both public and private institutions. Within the Ministry of the Ecological Transition, the General Directorate for Energy and Climate Change (DGEC), and more precisely its Directorate for Energy, is responsible for the management of oil supply emergencies.

Legislation and the National Emergency Strategy Organisation

The French Energy Code and Order of 25 March 2016 relating to the constitution of strategic oil stocks, provide the French government with powers to guarantee that oil stocks in the country are sufficient to meet the IEA’s and EU’s requirements, and that it can draw stocks in case of a domestic or international emergency.

Public authorities perform general supervision over the strategic stocks system by participating on the boards of directors of the Comité Professionnel des Stocks Stratégiques Pétroliers (CPSSP) and Société Anonyme de Gestion des Stocks de Sécurité (SAGESS).

The CPSSP is a legal body with a board of directors representing various oil organisations and representatives of relevant ministries. Under the Law of 31 December 1992 reforming the petroleum regime, the sole mission of the CPSSP is to constitute and safeguard stocks of crude oil and oil products to cover the part of the stockholding obligation of oil operators as attributed by law to the CPSSP. In practice, the CPSSP is an intermediary between market operators obliged to maintain stocks and the SAGESS, which actually stores oil on behalf of these market operators (84.5% of the CPSSP's obligations is delegated to SAGESS). The CPSSP does not have a particular role in case of an oil crisis. Although the agency is a private entity and is not a part of the administration, 2 of its 13 administrators' seats are held by the Ministry of the Economy and the Ministry of Budget. The DGEC attends board meetings in an advisory capacity. Decisions of the board are submitted to this government commissioner for his agreement, and he has a right of veto.

SAGESS is an association established in 1988 by the oil operators where shareholding is allocated to obligated operators, in proportion to their market shares. SAGESS's role is to build up and maintain strategic stocks of oil to contribute to the fulfilment of obligations defined by national and international standards and to enable its shareholders to delegate their stockholding obligation.

SAGESS is directly responsible for managing stocks in the case of a crisis, upon the DGEC's decisions. The Ministries of Energy, Budget and Economy attend the SAGESS boards in an advisory capacity. Any board decision can be redeliberated on one of these three ministers' request.

Although France has not officially defined its National Emergency Strategy Organisation (NESO) structure, during emergencies, the DGEC/Directorate for Energy acts as the NESO and as such falls into the country's general emergency structure, ultimately led by the prime minister. Depending on the level and type of the crisis, the prime minister can activate the "Interministerial Crisis Cell" and decide to give the lead to the ministry in charge of energy. In such a case, the Roquelaure Crisis Centre in the ministry would operate as a communication cell by using the means of the Ministerial Operational Centre of Monitoring and Warning (CMOVA) to manage the crisis and co-ordinate between the administration and the market. In case of a decision to release oil stocks, SAGESS would be a primary contact of the DGEC/Directorate for Energy, while CPSSP is not part of the emergency system. Oil operators are always closely engaged in the management of an oil crisis. They provide information but also advise due to their knowledge of the logistics of the oil industry.

France elaborated a Hydrocarbons Resources Plan, which serves as an emergency handbook to manage all types of oil emergencies, including a description of step-by-step procedures and the responsibilities of different state and market actors during an emergency. In addition, the National Localisation Plan of Stockholding sets the rules for deploying oil stocks throughout the country, to assure for their immediate availability close to consumption centres, should the need arise. It also reflects the decentralised nature of the French administration, where certain roles during emergencies are delegated to prefects of regions and departments.

Emergency exercises and training are conducted on a regular basis, due to the frequency of responses to various kinds of emergencies in the country (industrial accidents, strikes, local shortages of products).

Stockholding

In order to fulfil its international stockholding obligation, France puts an obligation on companies that sell oil products on the domestic market. The level of this obligation (for the accounting year of July to June), is set at 29.5% of quantities sold during the previous year for each of the following categories:

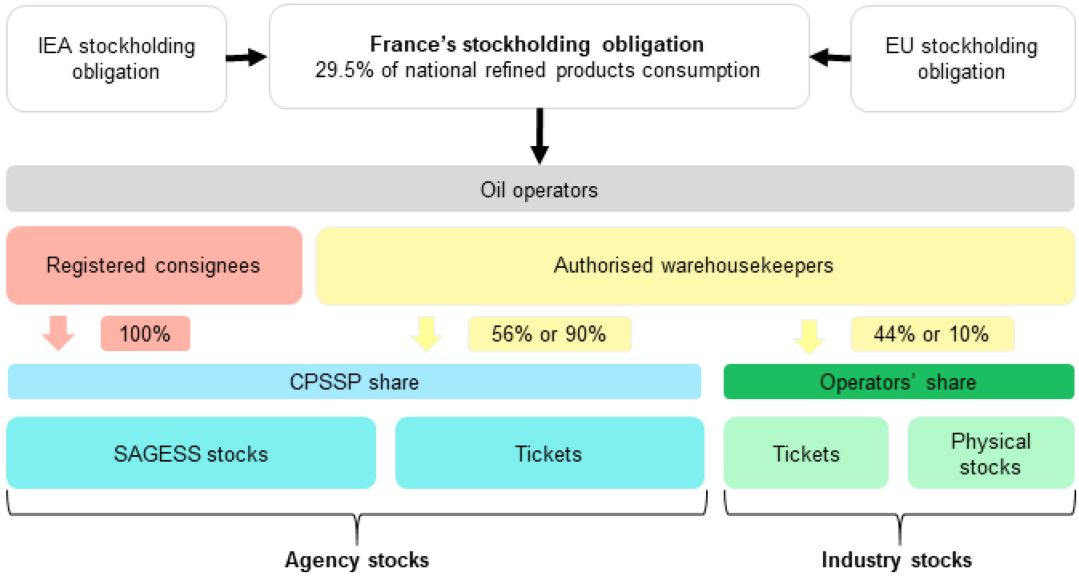
- Category 1: motor and aviation gasoline
- Category 2: gas oil and distillate fuel oil
- Category 3: kerosene-type jet fuel
- Category 4: fuel oil.

Oil operators are divided into two groups according to their customs status: authorised warehouse keepers or registered consignees. In meeting their stockholding requirements, warehouse keepers may choose to delegate either 56% or 90% of their stockholding obligation to the CPSSP, for which they must pay the remuneration. Registered consignees (around 30 in the country) are obliged to delegate their entire obligation to the CPSSP (see Figure 10.9). Almost all companies choose to delegate 90% of their obligation to the CPSSP, instead of 56% (only a few refineries choose this option). Thus, 85% of the industry's obligation was delegated to the agency in 2020 (up from 78% in 2016). Operators themselves stored 15% of stocks in the country (either in the form of physical stocks or domestic tickets). The CPSSP then utilises SAGESS to hold and manage physical stocks. In 2020, 90% of the total delegation vested in the CPSSP by operators was commissioned to SAGESS. The CPSSP may also purchase domestic or international tickets.

SAGESS does not own storage facilities, but is the owner of large quantities of physical oil stocks (65% of all oil volumes in the country). As of February 2021, SAGESS managed 13.6 Mt of stocks, the majority of which is dispersed across a large number of storage locations in France, including refineries and storage depots, much of it comingled with commercial stocks. Segregated stocks are mostly held in caverns near Manosque in south-east France. SAGESS holds diesel, gasoline, kerosene, heating oil and crude oil, with the stock profile of the refined products held balanced to market consumption.

Specific to the French system, industry operators very often request that the government (DGEC) releases stocks from the strategic reserves – almost on a daily basis and much more frequently than in any other IEA country. The comingling of SAGESS stocks with commercial stocks, along with highly optimised industry distribution systems with very low volume margins, has decreased the industry's ability to respond to local supply constraints with their commercial stocks, leading to an overreliance on strategic stocks. Thus, in practice, the CPSSP's stocks act as a "joint operational stockpile" of industry, rather than as strategic stocks for severe emergencies. Given the frequency of stock releases, to increase the resilience of the distribution system, consideration should be given to introducing a balanced payment by oil operators for making use of the CPSSP's exchange and loan facility. Notwithstanding the overreliance by industry on strategic stocks, the stockholding system as such is well established and understood by all the relevant entities and provides the administration with the flexibility to quickly respond to frequent local crises or an IEA collective action.

Figure 10.9 Stockholding system in France

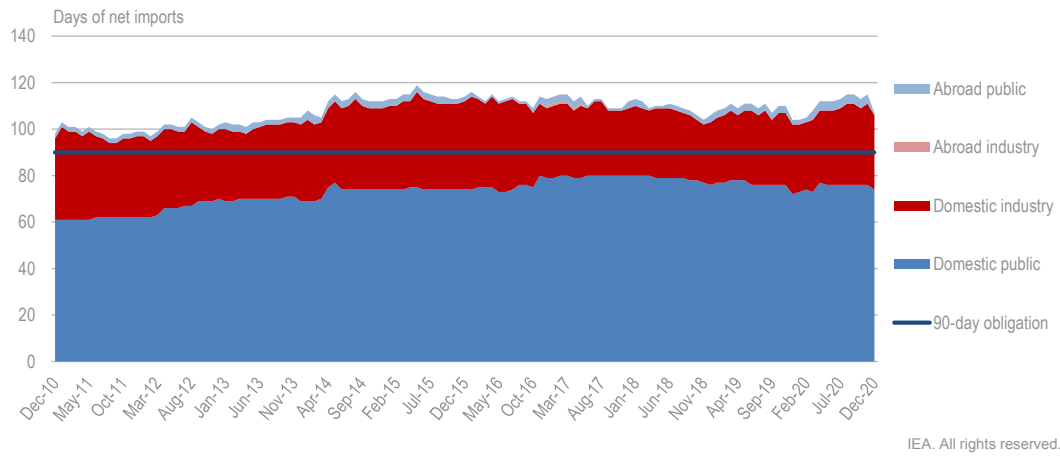


Note: CPSSP = Comité Professionnel des Stocks Stratégiques Pétroliers. SAGESS = Société Anonyme de Gestion des Stocks de Sécurité.

Oil stocks

Oil stocks in France have consistently been above the 90-day requirement, necessary for compliance with the IEA's rules (Figure 10.10). At the end of 2020, total stocks were at 107 days, with 32 days for industry-owned stocks and 75 days for agency (CPSSP) stocks.

Figure 10.10 Emergency oil stocks in France by type, 2010-20



France's emergency stocks have consistently been above the IEA requirements.

Source: IEA (2021b), *Monthly Oil Data Service*, www.iea.org/statistics.

Assessment

Government policies enshrined in the SNBC and the PPE target a 19% decrease in France's oil consumption by 2023 and 34% by 2028 (compared to 2012 levels). The main policies focus on the transport sector and include support for the purchase of electric and hybrid vehicles, incentives for building charging stations, enhanced biofuel blending obligations, and prioritising rail and modal shifts in urban transport. France is also aiming to phase out oil from the heating sector, by prohibiting new oil installations in the residential and tertiary sectors and replacing all oil boilers by 2028. And no new authorisations for power stations producing electricity exclusively from oil will be issued.

During 2019, total oil demand in France was 1 659 kb/d, having decreased by 11% over the previous decade. Oil accounted for 44% of France's TFC in 2019, primarily due to its dominant role in transport (where 90% of TFC was derived from oil) and its still significant use in industry (where oil represented 35% of TFC). Domestic transport consumed 937 kb/d in 2019 (56% of total country's oil use), with industry consuming 319 kb/d (19.2% of total consumption) and international bunkers 156 kb/d (10% of the total).

Diesel consumption has decreased by 5.8% since 2015, while gasoline has increased by 18.8%, reflecting a halt to the further dieselisation of the French vehicle fleet. Since 2017, the number of new gasoline vehicles sold has exceeded the number of new diesel vehicles sold, while the total number of cars has stabilised. More than 97% of the fleet is made up of internal combustion engines. With a government plan to have 15 million electric and hybrid vehicles on the road in 2035, this ratio will have to change quickly. Already in the first half of 2021, electric vehicles and plug-in hybrids have reached 15.7% of new car sales, against 2.8% in 2019.

Oil production in France is negligible, covering 1% of domestic demand. According to the provisions of the Law on Hydrocarbons adopted in 2017, no production activities will go beyond 2040 in France and no new exploration permits authorised after 2018, with an exception only for the extension of a valid exclusive exploration permits.

Crude imports are sourced from a wide variety of countries, including Algeria, Kazakhstan, Libya, Nigeria, Norway, Saudi Arabia and the Russian Federation. Refined products are also imported from a variety of countries. France's diverse supply chains, avoiding an overreliance on supply from one particular region, enhances its security of supply. Most crude and refined products are imported through ports, notably Marseilles, Le Havre and Saint-Nazaire, with some refined products also being imported by pipeline, road and river. A network of pipelines efficiently transports crude from the ports to refineries and refined products to distribution depots throughout the country.

French refining capacity has decreased by a third since 2009, to 62 Mt (following closures of 6 out of 12 refineries). Production of oil products in France has consequently decreased. Refining operations do not completely match domestic demand, with a surplus in gasoline but a deficit in diesel production.

France has extensive storage capacity, totalling around 46 million m^3 (290 mb). Despite the ongoing decrease in refining capacity, storage levels have remained largely stable since 2014. More than 60% of storage capacity is for refined products. The distribution of

storage capacities in France is not homogeneous. The proximity of refiners and import sites as well as massive transport infrastructure for petroleum products influences the locations.

There are over 11 000 service stations in France, with 62% of volumes served by mass distribution stations belonging to hypermarkets, and 38% by smaller urban and rural based stations. The government has created a free online fuel price comparison tool (www.prix-carburants.gouv.fr), which is updated daily and well known to consumers.

France has set a mandatory blending of biofuels for fuel distributors, with certain tax incentives envisaged for meeting the blending targets (TIRIB). The bio-component targets for transport fuels have been gradually increasing since 2015, and will be 9.2% and 8.4% for petrol and diesel respectively in 2022. Penetration of advanced biofuels is targeted, with obligatory blending objectives in 2023 of 1.2% for gasoline and 0.4% for diesel oil, rising further to 3.8% and 2.8% in 2028, respectively.

France has a well-developed biofuels manufacturing sector, being the fourth-largest producer globally. While some refining capacity has already been converted to biorefining, production capacity is likely to increase over the next decade in response to rising demand. Challenges will arise in the sourcing of sufficient quantities of finished biofuels and sustainable feedstock. Notwithstanding the expected increase in domestic production, it seems likely that considerable quantities of biofuels and feedstock will need to be imported. To meet high sustainability standards of feedstock, France stopped supporting the use of palm oil in January 2020.

The implementation of government targets outlined in the SNBC and the PPE to reduce oil consumption will pose economic challenges for oil operators. This is likely to lead to a consolidation of assets and declining levels of investment and may have an impact on maintaining security of supply. Already, the optimisation of the tight supply chain is done through an overreliance on the strategic stocks surplus by oil operators to maintain supplies to the market.

The government, in dialogue with industry partners and other stakeholders, should consider infrastructure requirements needed to ensure the availability of products during the transition to electrification and alternative liquid fuels. At the same time, measures should be considered to encourage the continued repurposing of existing infrastructure for biofuels production and distribution, and to encourage the roll-out of electric vehicle charging points and alternative fuel delivery systems via the existing service station network.

Emergency policy

France has a comprehensive legislative and regulatory framework in place to provide for the country's response to an oil emergency. The framework is based on a stockholding obligation on industry, facilitated by a stockholding agency (CPSSP) and an association of oil operators (SAGESS), active market entities, high-quality and accuracy of data reporting, and both public and private institutions. Within the Ministry of the Ecological Transition, the Directorate for Energy is responsible for the management of oil supply emergencies. The Energy Code and Order of 25 March 2016 relating to the constitution of strategic oil stocks provide the French government with powers to guarantee that oil stocks in the country are sufficient to meet the IEA's and EU's requirements, and that it can draw stocks in case of a domestic or international emergency.

France has an elaborate Hydrocarbons Resources Plan, which serves as an emergency handbook to manage all types of oil emergencies, including the description of step-by-step procedures and the responsibilities of different state and market actors during an emergency. In addition, the National Localisation Plan of Stockholding sets the rules for deploying oil stocks throughout the country, to assure for their immediate availability close to consumption centres, should the need arise. It also reflects the decentralised nature of the French administration, where certain roles during emergencies are delegated to prefects of regions and departments.

The oil security system in France is based on a stockholding obligation imposed on industry equal to 29.5% of the volume of oil sold by them for domestic consumption during the previous year (from July to June). In meeting their stockholding requirements, warehouse keepers may choose to delegate either 56% or 90% of their stockholding obligation to the CPSSP, for which they must pay the remuneration. Registered consignees are obliged to delegate their entire obligation to the CPSSP. The CPSSP then utilises SAGESS's services to hold and manage physical stocks.

Particular to the French system is that industry operators very often ask the government to loan stocks from the strategic reserves, much more frequently than in any other IEA country. Notwithstanding the overreliance by industry on strategic stocks, the stockholding system as such is well established and provides the administration with the flexibility to quickly respond to local crises or an IEA collective action.

To prepare for the energy transition, and as part of the sector's coupling strategy, the government should provide clarity on the future role of petroleum products. The use of mineral oils will decrease, putting pressure on the viability of current distribution chains and oil stockholding, while at the same time the use of biofuels will increase, posing storage and distribution challenges.

These changes will have a marked effect on the utilisation of existing infrastructure, including refineries, and may trigger a fundamental market realignment. It is important that the government continues to engage with key stakeholders to ensure security of supply is maintained during the energy transition.

Recommendations

The government of France should:

- Together with market operators and other key stakeholders, examine the implications of policies to decrease petroleum product demand and the expected rationalisation of infrastructure for national supply, and explore opportunities for accelerated repurposing of particular existing assets to meet biofuels production and distribution requirements.
- Assess, in conjunction with all relevant stakeholders, options for meeting increased domestic biofuels demand and the longer term need to ensure the availability of sufficient quantities of sustainable feedstock.

- Review the capacity and adequacy of the transport and storage infrastructure that provides products to the Paris region and determine its level of resilience, in light of recent difficulties with the PLIF pipeline and the closure of the Grandpuits refinery.
- Consider the establishment of a minimum stock level, below which stock levels will not be permitted to fall by way of exchanges and loans, so as to ensure the availability of adequate stocks in the event of a significant or prolonged market disruption.

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ANNEX A: Organisations visited

Agency for the Ecological Transition (ADEME)
Association Française de Gaz (AFG)
Air Liquide
Alternative Energies and Atomic Energy Commission (CEA)
AMORCE
Association Nationale des Opérateurs Détaillants en Énergie (ANODE)
Association of Energy Economists (FAEE)
CIM/PISTO
Comité Professionnel des Stocks Stratégiques Pétroliers (CPSSP)
CSF NSE
Électricité de France (EDF)
Energy Regulatory Commission (CRE)
ENEDIS
ENERPLAN
ENGIE
Eni
Fédération des Services Énergie Environnement (FEDENE)
Fédération nationale des collectivités concédantes et régies (FNCRR)
France Énergie Éolienne (FEE)
France Gaz Renouvelables
France Nature Environnement (FNE)
French Union of Petroleum Industries (UFIP)
GRDF
Greenpeace France
GRTgaz
Hynamics
IFP Energies Nouvelles (IFPEN)
Institute for Climate Economics (IC4E)
Institute for Sustainable Development and International Relations (IDDRI)
Ministry for the Economy, Finance and the Recovery (MEF)
Ministry of the Ecological Transition (MTE)
Ministry of Higher Education, Research and Innovation (MESRI)
National Agency for the Management of Radioactive Waste (ANDRA)
National Alliance for the Coordination of Energy Research (ANCRE)
National Centre for Scientific Research (CNRS)
National Research Agency (ANR)
Network of Regional Energy and Environment Agencies (RARE)
Nuclear Safety Authority (ASN)
ORANO
Photovoltaic Institute of Île-de-France (IPVF)
Regional and Interdepartmental Directorate for the Environment, Planning and Transport (DRIEE)

Regions of France
Renewable Energies Union (SER)
Réseau Action Climat (RAC)
RTE
Safra
Société anonyme de gestion de stocks de sécurité (SAGESS)
Teréga
Total Direct Energie
TOTAL Energies
UEF
UPRIGAZ

ANNEX B: Review team and preparation of the report

The in-depth review team visited virtually France from 1 to 11 March 2021. The review team met with government officials, energy suppliers, market participants, interest groups in the public and private sectors, consumer representative associations, research institutions, and other organisations and stakeholders. This report was drafted based on the information obtained during these meetings, the team's preliminary assessment of France's energy policy, the government's response to the IEA's energy policy questionnaire, and information on subsequent policy developments from the government and private sector sources. The members of the team were:

IEA member countries

Dr Noé van Hulst, Netherlands (team leader)

Dr Lesley Dowling, Australia

Mr Maarten Noeninckx, Belgium

Mr John Twamley, Ireland

Dr Alessandro Lanza, Italy

Mr Kyle Nicholas, United States

Dr Christopher Kukla, United Kingdom

Mr Pierre Loaec, European Commission

Dr Jan Horst Keppler, OECD Nuclear Energy Agency

International Energy Agency

Mr Aad van Bohemen, Head of Energy Policy and Security Division

Ms Sylvia Beyer, Senior Energy Policy Analyst (review co-ordinator)

Mr Milosz Karpinski, Energy Analyst

The review team is grateful for the co-operation and assistance of the many people who supported the review. Thanks to their hospitality, openness and willingness to share information, the visit was highly informative, productive and enjoyable. The review team expresses its gratitude to the Director General for Energy and Climate, Mr Laurent Michel, the Director for Energy, Ms Sophie Mourlon and Mr Aurelien Gay, senior advisor to the Director for Energy, whose overview comments helped frame all the discussions during the review. The team also extends a special thanks to Ms Carole Lancereau, Mr Brice Leroy and Mr Gustave Richard from the Ministry of the Ecological Transition for their tireless efforts in co-ordinating the in-depth review and the emergency response review parts of the review visit, prompt responses to the team's many requests, and patience throughout the weeks leading up to and during the review.

This review was prepared under the guidance of Aad van Bohemen, Head of the Energy Policy and Security Division, IEA. Sylvia Beyer managed the review and is the main author and co-ordinator of the report. Milosz Karpinski wrote the chapters on oil and natural gas. Alessio Scanziani and Clémence Lizé drafted the sections relating to energy data contained in each chapter, supported by Myriam Badri, Eunjin Choe and Anders Caratozzolo, who together ensured the preparation of the report with figures, tables and maps.

Helpful comments, chapter reviews and updates were provided by the following IEA staff: Carlos Fernández Alvarez, Blandine Barreau, Francois Briens, Paolo Frankl, Peter Fraser, Paulina Henriot, César Aljeandro Hernandez, Simone Landolina, Jean-Baptiste le Marois, Sara Moarif, Grergely Molnar, Jaques Warichet. Thanks also go to Michel Berthelemy from the OECD Nuclear Energy Agency.

Special thanks to the IEA Secretariat with regard to the data, publication and editing. Erica Robin, Roberta Quadrelli and Domenico Lattanzio provided support on statistics. Therese Walsh managed the editing process and Astrid Dumond managed the production process. Isabelle Nonain-Semelin finalised the layout. Ms Tanya Dyhin and Grace Gordon managed the design process. Jad Mouawad and Jethro Mullen supported the press launch. The report was edited by Jennifer Allain.

The Shared Goals, which were adopted by the International Energy Agency (IEA) ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The Shared Goals are presented in Annex D.

ANNEX C: Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2018	2019	2020E
TOTAL PRODUCTION		**44.2**	**111.9**	**130.6**	**135.7**	**135.0**	**131.2**	**119.5**
Coal		18.0	8.3	2.5	0.2	-	-	-
Peat		-	-	-	-	-	-	-
Oil		2.1	3.5	1.8	1.1	0.9	0.9	0.8
Natural gas		6.3	2.5	1.5	0.6	0.0	0.0	0.0
Biofuels and waste[1]		9.8	11.0	10.8	15.5	16.8	16.7	15.8
Nuclear		3.8	81.8	108.2	111.7	107.6	104.0	92.2
Hydro		4.1	4.6	5.7	5.4	5.6	4.9	5.3
Wind		-	-	0.0	0.9	2.5	3.0	3.5
Geothermal		0.0	0.1	0.1	0.2	0.4	0.5	0.5
Solar/other[2]		0.0	0.1	0.1	0.2	1.2	1.3	1.4
TOTAL NET IMPORTS[3]		**138.3**	**113.6**	**124.6**	**124.5**	**112.3**	**112.7**	**96.1**
Coal	Exports	1.3	0.6	0.5	0.2	0.0	0.0	0.0
	Imports	10.8	13.5	13.4	12.3	9.3	7.3	5.1
	Net imports	9.5	12.8	12.8	12.1	9.2	7.3	5.1
Oil	Exports	13.6	14.6	22.7	23.1	20.3	17.5	13.2
	Imports	142.2	100.5	112.5	106.3	97.2	95.2	78.0
	Int'l marine and aviation bunkers	-7.2	-5.6	-7.9	-7.8	-7.7	-7.8	-3.9
	Net imports	121.5	80.3	82.0	75.4	69.2	69.9	60.9
Natural gas	Exports	0.1	0.3	0.7	2.6	5.3	9.7	8.2
	Imports	7.6	24.7	36.5	42.1	43.9	48.9	41.3
	Net imports	7.6	24.4	35.8	39.6	38.6	39.2	33.1
Electricity	Exports	0.6	4.5	6.3	4.3	6.6	6.3	5.5
	Imports	0.4	0.6	0.3	1.7	1.2	1.3	1.7
	Net imports	-0.2	-3.9	-6.0	-2.6	-5.4	-5.0	-3.9
TOTAL STOCK CHANGES		**-2.3**	**-1.7**	**-3.5**	**2.7**	**-1.0**	**-1.4**	**2.2**
TOTAL SUPPLY (TES)[4]		**180.1**	**223.8**	**251.7**	**262.9**	**246.3**	**242.5**	**217.8**
Coal		29.3	20.1	14.9	12.0	9.1	7.3	5.4
Peat		-	-	-	-	-	-	-
Oil		119.8	84.0	82.2	77.0	70.9	71.1	61.7
Natural gas		13.5	26.0	35.8	42.6	36.8	37.5	35.0
Biofuels and waste[1]		9.8	11.0	10.8	15.7	17.6	17.9	16.7
Nuclear		3.8	81.8	108.2	111.7	107.6	104.0	92.2
Hydro		4.1	4.6	5.7	5.4	5.6	4.9	5.3
Wind		-	-	0.0	0.9	2.5	3.0	3.5
Geothermal		0.0	0.1	0.1	0.2	0.4	0.5	0.5
Solar/other[2]		0.0	0.1	0.1	0.2	1.2	1.3	1.4
Electricity trade[5]		-0.2	-3.9	-6.0	-2.6	-5.4	-5.0	-3.9
Shares in TES (%)								
Coal		*16.3*	*9.0*	*5.9*	*4.6*	*3.7*	*3.0*	*2.5*
Peat		-	-	-	-	-	-	-
Oil		*66.5*	*37.5*	*32.7*	*29.3*	*28.8*	*29.3*	*28.3*
Natural gas		*7.5*	*11.6*	*14.2*	*16.2*	*15.0*	*15.5*	*16.1*
Biofuels and waste[1]		*5.4*	*4.9*	*4.3*	*6.0*	*7.1*	*7.4*	*7.7*
Nuclear		*2.1*	*36.6*	*43.0*	*42.5*	*43.7*	*42.9*	*42.3*
Hydro		*2.3*	*2.1*	*2.3*	*2.1*	*2.3*	*2.0*	*2.5*
Wind		-	-	-	*0.3*	*1.0*	*1.2*	*1.6*
Geothermal		*0.0*	*0.0*	*0.1*	*0.1*	*0.2*	*0.2*	*0.2*
Solar/other[2]		*0.0*	*0.0*	*0.0*	*0.1*	*0.5*	*0.5*	*0.7*
Electricity trade[5]		*-0.1*	*-1.7*	*-2.4*	*-1.0*	*-2.2*	*-2.0*	*-1.8*

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2018**	**2019**	**2020E**
TFC	**142.2**	**141.6**	**161.5**	**159.8**	**151.4**	**150.1**	**..**
Coal	14.0	6.3	3.4	2.7	1.5	1.2	..
Peat	-	-	-	-	-	-	..
Oil	96.0	75.1	80.5	71.3	66.2	65.9	..
Natural gas	10.3	23.9	32.1	33.0	30.2	29.5	..
Biofuels and waste[1]	8.9	9.7	9.0	11.7	12.2	12.4	..
Geothermal	0.0	0.1	0.1	0.0	0.0	0.0	..
Solar/other[2]	-	0.0	0.0	0.1	0.2	0.2	..
Electricity	12.8	26.0	33.1	38.2	37.6	37.1	..
Heat	0.3	0.5	3.2	2.9	3.6	3.7	..
Shares in TFC (%)							
Coal	*9.8*	*4.4*	*2.1*	*1.7*	*1.0*	*0.8*	..
Peat	-	-	-	-	-	-	..
Oil	*67.5*	*53.1*	*49.9*	*44.6*	*43.7*	*43.9*	..
Natural gas	*7.2*	*16.9*	*19.9*	*20.7*	*19.9*	*19.6*	..
Biofuels and waste[1]	*6.3*	*6.8*	*5.6*	*7.3*	*8.1*	*8.2*	..
Geothermal	*0.0*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	..
Solar/other[2]	-	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*	..
Electricity	*9.0*	*18.4*	*20.5*	*23.9*	*24.8*	*24.7*	..
Heat	*0.2*	*0.3*	*2.0*	*1.8*	*2.4*	*2.5*	..
TOTAL INDUSTRY[6]	**56.3**	**44.8**	**49.2**	**42.6**	**41.5**	**40.9**	**..**
Coal	7.3	4.6	2.7	2.3	1.4	1.2	..
Peat	-	-	-	-	-	-	..
Oil	35.0	17.8	18.6	15.8	14.5	14.7	..
Natural gas	5.7	11.1	14.7	12.1	12.2	11.7	..
Biofuels and waste[1]	1.2	1.5	1.6	1.5	1.8	1.8	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	-	0.0	0.0	..
Electricity	7.2	9.9	11.6	10.1	10.1	9.9	..
Heat	-	-	-	0.8	1.5	1.6	..
Shares in total industry (%)							
Coal	*12.9*	*10.3*	*5.6*	*5.4*	*3.4*	*2.8*	..
Peat	-	-	-	-	-	-	..
Oil	*62.1*	*39.6*	*37.9*	*37.0*	*34.9*	*35.9*	..
Natural gas	*10.0*	*24.8*	*29.8*	*28.5*	*29.4*	*28.6*	..
Biofuels and waste[1]	*2.1*	*3.3*	*3.2*	*3.4*	*4.5*	*4.4*	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	-	-	-	..
Electricity	*12.8*	*22.0*	*23.5*	*23.7*	*24.2*	*24.3*	..
Heat	-	-	-	*1.9*	*3.6*	*4.0*	..
TRANSPORT[4]	**24.7**	**38.4**	**44.8**	**43.6**	**45.2**	**45.2**	**..**
OTHER[7]	**61.2**	**58.4**	**67.5**	**73.6**	**64.7**	**63.9**	**..**
Coal	6.6	1.7	0.6	0.4	0.1	0.1	..
Peat	-	-	-	-	-	-	..
Oil	37.0	19.6	18.2	15.3	10.6	10.3	..
Natural gas	4.6	12.8	17.5	20.8	17.8	17.6	..
Biofuels and waste[1]	7.7	8.2	7.1	7.8	7.3	7.3	..
Geothermal	0.0	0.1	0.1	0.0	0.0	0.0	..
Solar/other[2]	-	0.0	0.0	0.1	0.2	0.2	..
Electricity	5.0	15.5	20.7	27.2	26.7	26.3	..
Heat	0.3	0.5	3.2	2.1	2.1	2.1	..
Shares in other (%)							
Coal	*10.8*	*2.8*	*0.9*	*0.5*	*0.1*	*0.1*	..
Peat	-	-	-	-	-	-	..
Oil	*60.4*	*33.6*	*26.9*	*20.7*	*16.4*	*16.0*	..
Natural gas	*7.5*	*22.0*	*25.9*	*28.3*	*27.5*	*27.5*	..
Biofuels and waste[1]	*12.6*	*14.0*	*10.5*	*10.6*	*11.2*	*11.5*	..
Geothermal	*0.0*	*0.2*	*0.2*	*0.0*	*0.1*	*0.1*	..
Solar/other[2]	-	*0.0*	*0.0*	*0.1*	*0.3*	*0.3*	..
Electricity	*8.2*	*26.5*	*30.7*	*37.0*	*41.2*	*41.2*	..
Heat	*0.4*	*0.8*	*4.8*	*2.8*	*3.2*	*3.3*	..

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2018**	**2019**	**2020E**
ELECTRICITY GENERATION[8]							
Input (Mtoe)	36.7	98.3	127.5	137.1	131.1	127.8	..
Output (Mtoe)	15.7	35.9	46.0	48.5	49.6	48.7	45.4
Output (TWh)	182.5	417.2	535.2	564.5	576.4	566.2	527.9
Output shares (%)							
Coal	*19.7*	*8.5*	*5.8*	*4.7*	*1.8*	*1.0*	*1.0*
Peat	-	-	-	-	-	-	-
Oil	*40.2*	*2.1*	*1.3*	*1.0*	*1.0*	*1.0*	*1.0*
Natural gas	*5.5*	*0.7*	*2.2*	*4.2*	*5.3*	*6.9*	*6.7*
Biofuels and waste[1]	*0.1*	*0.4*	*0.7*	*1.1*	*1.9*	*2.0*	*2.1*
Nuclear	*8.1*	*75.3*	*77.6*	*75.9*	*71.6*	*70.5*	*67.0*
Hydro	*26.1*	*12.9*	*12.4*	*11.1*	*11.3*	*10.1*	*11.8*
Wind	-	-	-	*1.8*	*5.0*	*6.1*	*7.7*
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	*0.3*	*0.1*	*0.1*	*0.2*	*2.1*	*2.3*	*2.8*
TOTAL LOSSES	**38.1**	**77.6**	**94.9**	**102.0**	**92.6**	**89.5**	**-0.1**
of which:							
Electricity and heat generation[9]	20.8	62.0	78.3	85.1	78.6	76.2	..
Other transformation	5.3	2.2	1.8	2.6	3.4	3.1	-0.1
Own use and transmission/distribution losses	12.1	13.4	14.8	14.4	10.6	10.2	..
Statistical differences	**-0.2**	**4.7**	**-4.6**	**1.1**	**2.3**	**2.9**	**..**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2018**	**2019**	**2020E**
GDP (billion 2015 USD)	1065.91	1661.09	2046.50	2317.57	2569.46	2616.81	2411.26
Population (millions)	53.33	58.26	60.90	65.01	67.27	67.46	67.65
TES/GDP (toe/1000 USD)[10]	0.17	0.13	0.12	0.11	0.10	0.09	0.09
Energy production/TES	0.25	0.50	0.52	0.52	0.55	0.54	0.55
Per capita TES (toe/capita)	3.38	3.84	4.13	4.04	3.66	3.59	3.22
Oil supply/GDP (toe/1000 USD)[10]	0.11	0.05	0.04	0.03	0.03	0.03	0.03
TFC/GDP (toe/1000 USD)[10]	0.13	0.09	0.08	0.07	0.06	0.06	..
Per capita TFC (toe/capita)	2.67	2.43	2.65	2.46	2.25	2.22	..
CO_2 emissions from fuel combustion ($MtCO_2$)[11]	474.4	345.4	364.7	340.1	300.6	293.9	..
CO_2 emissions from bunkers ($MtCO_2$)[11]	22.7	17.3	24.2	23.9	23.6	23.7	..
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-17**	**17-18**	**18-19**	**19-20**
TES	1.3	1.2	0.4	-0.9	-0.5	-1.6	-10.2
Coal	-2.2	-2.9	-2.2	-2.6	-8.0	-19.8	-25.7
Peat	-	-	-	-	-	-	-
Oil	-2.1	-0.2	-0.7	-0.7	-3.4	0.3	-13.3
Natural gas	3.9	3.2	1.8	-1.4	-4.3	1.9	-6.9
Biofuels and waste[1]	0.7	-0.2	3.8	1.6	0.6	1.4	-6.5
Nuclear	19.7	2.8	0.3	-1.0	3.7	-3.4	-11.3
Hydro	0.7	2.1	-0.6	-3.2	30.2	-12.6	9.3
Wind	-	-	71.0	13.8	16.2	21.4	17.2
Geothermal	26.6	1.4	3.3	13.4	2.8	5.7	-
Solar/other[2]	2.0	-0.3	9.4	30.8	12.1	10.6	9.3
TFC	-0.0	1.3	-0.1	-0.4	-2.3	-0.9	..
Electricity consumption	4.3	2.4	1.4	-0.2	-0.5	-1.2	..
Energy production	5.6	1.6	0.4	-0.7	4.6	-2.8	-8.9
Net oil imports	-2.4	0.2	-0.8	-0.5	-5.0	1.1	-12.9
GDP	2.6	2.1	1.3	1.2	1.9	1.8	-7.9
TES/GDP	-1.3	-0.9	-0.8	-2.0	-2.2	-3.3	-2.6
TFC/GDP	-2.6	-0.8	-1.3	-1.6	-4.1	-2.7	..

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Footnotes to energy balances and key statistical data

1 Biofuels and waste comprise solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.

2 Other includes tide, wave and ambient heat used in heat pumps.

3 In addition to coal, oil, natural gas and electricity, total net imports also include biofuels.

4 Excludes international marine bunkers and international aviation bunkers.

5 Total supply of electricity represents net trade. A negative number in the share of TES indicates that exports are greater than imports.

6 Industry includes non-energy use.

7 Other includes residential, commercial and public services, agriculture/forestry, fishing, and other non-specified.

8 Inputs to electricity generation include inputs to electricity, co-generation and heat plants. Output refers only to electricity generation.

9 Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear; 10% for geothermal; and 100% for hydro, wind and solar photovoltaic.

10 Tonnes of oil equivalent per thousand US dollars at 2015 prices and exchange rates.

11 "CO_2 emissions from fuel combustion" have been estimated using the IPCC Tier I Sectoral Approach methodology from the 2006 IPCC Guidelines. Emissions from international marine and aviation bunkers are not included in national totals.

ANNEX D: International Energy Agency "Shared Goals"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases, this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these Shared Goals. Decision makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the polluter-pays principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle, from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA ministers at the meeting of 4 June 1993 in Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

ANNEX E: Glossary and list of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

ADEME	Agency for Ecological Transition
ARENH	regulated access to historical nuclear electricity tariff *accès régulé à l'électricité nucléaire historique*
CCE	climate energy contribution
CEA	Alternative Energies and Atomic Energy Commission
CEE	energy-saving certificate *certificat d'économies d'énergie*
CIR	research tax credit
CITE	energy transition tax credit *crédit d'impôt pour la transition énergétique*
CNRS	National Centre for Scientific Research
CO_2	carbon dioxide
CPSSP	Comité Professionnel des Stocks Stratégiques Pétroliers
CRE	Energy Regulatory Commission
DGEC	Directorate for Energy and Climate Change
DNSH	do no significant harm
DPE	energy performance diagnostic *diagnostic de performance énergétique*
DSO	distribution system operator
EC	European Commission
EDF	Électricité de France
EED	Energy Efficiency Directive
ELD	local distribution company *entreprise locale de distribution*
EPR	European power reactor
ETS	Emissions Trading System
EU	European Union
EUR	euro
EV	electric vehicles
FEC	final energy consumption
GDP	gross domestic product
GHG	greenhouse gas
HCC	High Council on Climate
IEA	International Energy Agency
ITC	tax on domestic consumption of energy

LCOE	levelised cost of electricity
LNG	liquefied natural gas
LOLE	loss of load expectation
LULUCF	land use, land-use change and forestry
MI	Mission Innovation
MTE	Ministry of the Ecological Transition
NEA	Nuclear Energy Agency
NECP	National Energy and Climate Plan
NESO	National Emergency Strategy Organisation
NO_X	nitrogen oxide
OECD	Organisation for Economic Co-operation and Development
PCAET	territorial climate-air-energy plans *plans climat-air-énergie territoriaux*
PEC	primary energy consumption
PIA	Investments for the Future Programmes
PNACC	National Climate Change Adaptation Plan
PPE	multiannual energy plan *programmation pluriannuelle de l'énergie*
PPP	purchasing power parity
PV	photovoltaic
PWR	pressurised water reactor
R&D	research and development
RD&D	research, development and demonstration
SAGESS	Société Anonyme de Gestion des Stocks de Sécurité
SME	small and medium-sized enterprise
SNBC	National Low-Carbon Strategy Stratégie Nationale Bas-Carbone
SNRE	National Strategy for Energy Research Stratégie nationale de recherche énergétique
SRADDET	regional plans for spatial planning, sustainable development and equality *schémas régionaux d'aménagement, de développement durable et d'égalité des territoires*
TES	total energy supply
TFC	total final consumption
TFEC	total final energy consumption
TICFE	final consumption of electricity
TIRIB	tax on the incorporation of biofuels
TPES	total primary energy supply
TRF	Trading Region France
TSO	transmission system operator
USD	United States dollar

Units of measure

bcm	billion cubic metres
bln	billion
CO_2-eq	carbon dioxide equivalent
g CO_2	gramme of carbon dioxide
GW	gigawatt
GWh	gigawatt hour
Hz	Hertz
kb/d	thousand barrels per day
kg	kilogramme
km	kilometre
km^2	square kilometre
kV	kilovolt
kW	kilowatt
kW_e	kilowatt electrical
kWh	kilowatt hour
kWp	kilowatt peak
L	litre
mcm	million cubic metres
Mt	million tonnes
Mt CO_2	million tonnes carbon dioxide
Mt CO_2-eq	million tonnes carbon dioxide equivalent
Mtoe	million tonnes of oil equivalent
MW	megawatt
MWh	megawatt hour
MWp	megawatt peak
MW_{th}	megawatt thermal
PJ	petajoule
t	tonne
toe	tonne of oil equivalent
TWh	terawatt hour

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Energy Policy Review

The International Energy Agency (IEA) regularly conducts in-depth peer reviews of the energy policies of its member countries. This process supports energy policy development and encourages the exchange of international best practices and experiences.

In 2019, France put its target to reach net zero emissions by 2050 into law and updated its energy transition framework the following year with a new National Low-Carbon Strategy and 10-year energy plan. However, France's energy transition has experienced significant delays, and implementation remains challenging despite the many reforms underway. Moreover, new European Union climate goals will compel the French government to upgrade its 2030 targets and track progress more stringently.

For decades, French power generation has produced a relatively low level of carbon dioxide emissions compared with similar economies, owing to the significant share of nuclear energy. However, the country's nuclear fleet is ageing, and overall emissions are rising because energy consumption across the economy as a whole remains dominated by fossil fuels, notably in transport. Maintaining low-carbon power generation as a base for further decarbonisation and electrification requires timely decisions on the future electricity mix and accelerated investments.

France's economic recovery plan from the Covid-19 crisis and its 2030 investment plan will help accelerate its energy transition by driving progress in sustainable mobility, building retrofits and hydrogen.

This report includes a series of recommendations to support France's efforts to tackle these challenges and to meet its energy and climate goals.