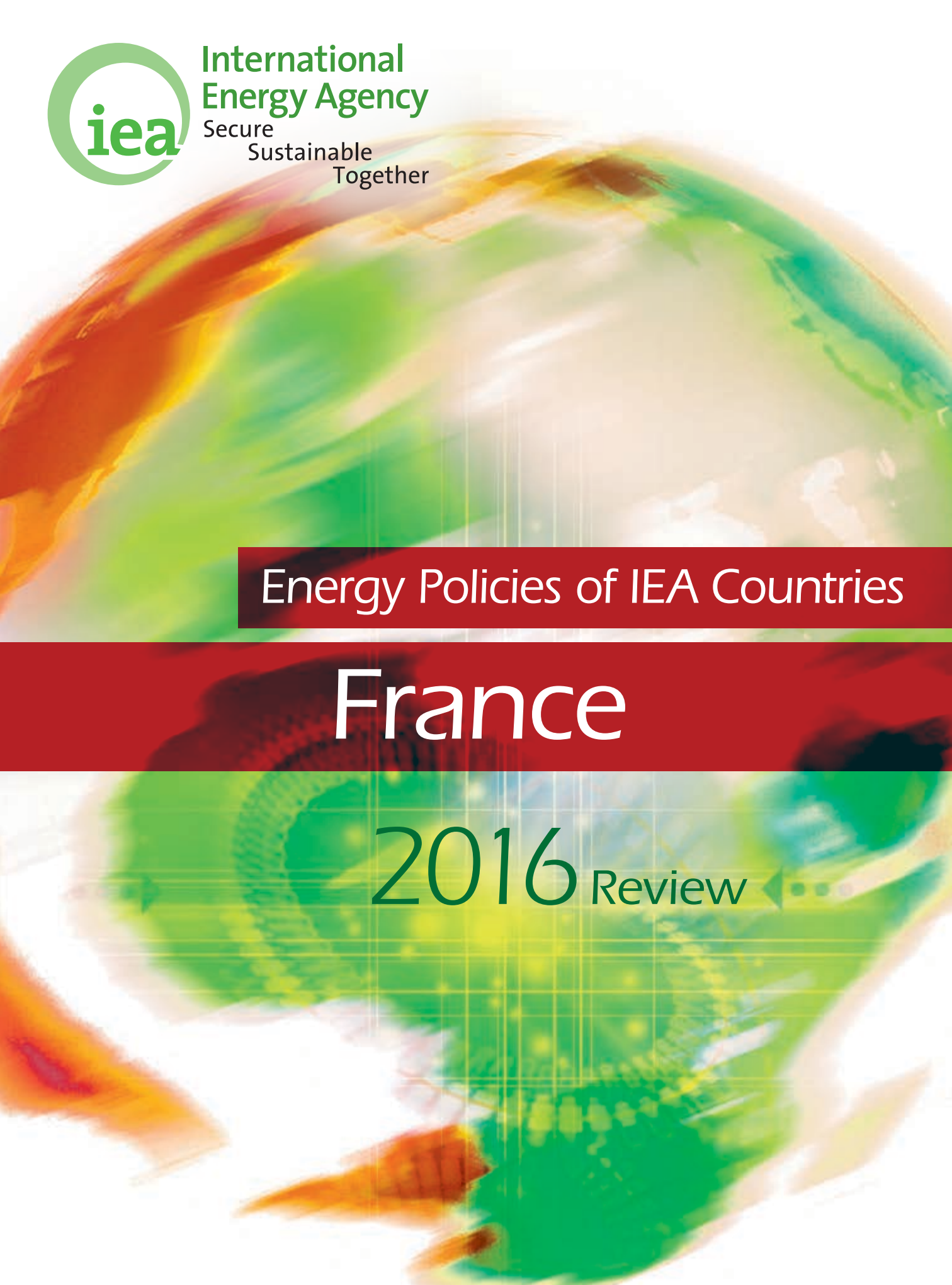

International
Energy Agency
Secure
Sustainable
Together
Energy Policies of IEA Countries
France
2016 Review

International Energy Agency

Secure Sustainable Together

Energy Policies of IEA Countries

France

2016 Review

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

International Energy Agency
Secure
Sustainable
Together

International Energy Agency
Website: ***www.iea.org***

TABLE OF CONTENTS

LIST OF FIGURES, TABLES and BOXES

FIGURES

TABLES

BOXES

1. EXECUTIVE SUMMARY AND KEY RECOMMENDATIONS

PROGRESS AND CHALLENGES

During the seven years since the last International Energy Agency (IEA) in-depth review, the French government has set in motion significant reforms towards more secure, affordable and sustainable energy supplies and the green growth of its economy. France has witnessed the full decoupling of its energy consumption and carbon dioxide (CO_2) emissions from economic and population growth. Total energy supply and consumption as well as CO_2 emissions from fuel combustion have declined sharply over the past decade. The carbon intensity of the French economy is half the IEA average and has decreased by almost 30% below its level in 2004 (versus an IEA average decline of -20% during the same period). Outside transport, CO_2 emissions from fuel combustion have been falling fast. Since 2012, 3.3 gigawatts (GW) of coal-fired capacity was closed, and the remaining oil-fired power plants are planned to be phased out. Energy savings in residential and industrial demand and reduced fossil fuel combustion have contributed to reduced energy supply and consumption in France.

A top priority for France has been to address climate change concerns. As host of the United Nations' 21st Conference of the Parties (COP21) in December 2015, France demonstrated its domestic and international leadership in guiding societal dialogue towards climate change mitigation. At home, France has developed an ambitious and integrated energy and climate policy framework for the energy transition towards 2030 and has adopted significant new policies, including carbon budget/pricing instruments, tax incentives and considerable public funding towards implementing it. The energy system transformation that France is undertaking entails significant structural changes for the energy sector through greater energy efficiency, larger contributions from renewable energies while ensuring the continuous low-carbon nature and security of its electricity supply and the safe operation of France's ageing nuclear fleet.

The state, energy markets, industry and consumers will need to finance the investments required for the energy transition. *Électricité de France (EDF)*'s so-called *Grand Carénage* is a refurbishment and safety upgrades programme required for the long-term operation of its fleet. Its cost (capital expenditures [CAPEX]) was updated in 2015 by EDF to EUR 47.5 billion over the period 2014-25 (in constant euros of 2015). The electricity industry is undergoing considerable financial challenges, but the restructuring and recapitalisation by the state should ensure that resources and capabilities are available to also finance the energy transition. While the energy system transformation will strengthen energy security, green growth and affordability in the longer term, this transformation has implications for maintaining energy security in the short to medium term given the ageing of the nuclear fleet. It is therefore welcome that France is encouraging demand response and will be starting a capacity market in 2017 with a view to ensuring power system adequacy at peak demand and integrating larger shares of

variable renewables. Progress in phasing out regulated tariffs for non-residential gas and electricity users as of 1 January 2016 is another welcome step towards market pricing in gas and electricity markets.

ENERGY SYSTEM TRANSFORMATION

France is one of the leading IEA countries when it comes to a low-carbon energy mix: only 47% of energy came from fossil fuels in 2015, thanks to the large share of nuclear energy, which made up 46% in the energy mix and 78% of electricity generation, the highest share worldwide.

In August 2015, France adopted a long-term framework for the energy transition up to 2030 and 2050. The Energy Transition for Green Growth Act *(Loi relative à la transition énergétique pour la croissance verte, LTECV*) is the result of the National Debate on the Energy Transition (DNTE), an intensive stakeholder consultation that ran from January to July 2013. The IEA welcomes the legal framework, which has binding targets and a carbon price trajectory up to 2030, and has put in place a governance framework based on the National Low-carbon Development Strategy (*Stratégie nationale bas carbone, SNBC*), five-year carbon budgets and a pluriannual energy programming (*Programmation pluriannuelle de l'énergie, PPE*) which covers energy production, energy efficiency, security of supply, and the supply/demand balance for all energy sources. These pillars can ensure periodical review and flexibility over time to adjust the trajectory and align policies to the targets of the Act. This framework is an excellent achievement, and other IEA member and partner countries can learn from France's experience.

To drive long-term decarbonisation of the economy and reduce greenhouse gas (GHG) emissions by 40% to 2030, the Energy Transition for Green Growth Act acknowledges the need to accelerate actions in transport, industry and buildings, while maintaining a clean electricity mix. Sectoral strategies have been adopted: a low-carbon mobility strategy was presented in July 2016, with measures that build on France's lead in the deployment of electric vehicles (EV) with 7 million EV charging points planned for 2030. In the buildings sector, the government aims to renovate 500 000 dwellings per year and targets the renovation of low-income households under the Better Living Programme. Building codes have been strengthened with the new thermal renovation regulations of 2012.

As the cornerstone of the transition, the role of renewable energy in the power mix is to be increased to 40% by 2030 (from its current share of 16.5%), and France aims to accelerate energy savings while preparing for the future, given its ageing nuclear fleet. The government set the ambitious target of reducing the share of nuclear from 78% in 2015 to 50% by 2025.

France has witnessed growing shares of renewables, reaching 15% in total final consumption (TFC) in 2014. However, it is not yet on track towards achieving its target of 23% by 2020. The required growth in the next six years (2015-20) will need to be twice that of the rates achieved over the last nine years (2005-14). Targets have been reached for solar photovoltaics and biomass, which alone account for more than 36% of the growth of the renewable energy share since 2005, but there is a gap to be filled for hydro, wind power and heat. Onshore wind has reached about 10 GW, but offshore wind deployment has not started despite ambitious plans. Delays in the development of wind energy are the result of non-economic barriers rather than economic ones, including the

overlapping administrative and judiciary procedures for clearing a permit of any claim (seven years on average for wind mills), coupled with a lack of social acceptance for wind and biomass. The Energy Transition for Green Growth Act introduced the single permit, which should improve permitting for onshore/offshore wind parks and reform the tax base for the funding of the new feed-in premium/feed-in tariff regime. However, further work is needed with regard to the siting and grid connection of offshore wind and, in the long term, grid integration of variable renewable energy.

The Act requires the reduction of total final energy consumption by 20% in 2030 and 50% in 2050, and the reduction of fossil fuel consumption of 30% by 2030, all compared to 2012 levels. France has improved the energy intensity of its economy by 16.5% for the last decade since 2005. TFC, which has been declining since 2004, was down by 13% from the record-high of 169.8 million tonnes of oil equivalent (Mtoe) in 2004. However, the current rate of decline is not yet enough to meet France's energy savings target for 2020, which requires 131 Mtoe versus 147.7 Mtoe (2014). The success of France's energy transition will depend on the mobilisation of significant investment for the increase of renewable energy and energy efficiency and the closure or long-term operation of the nuclear fleet. The long-term visibility of financing remains a challenge. Therefore, the stability of the carbon signal in the annual Finance Laws, the efficient remuneration in the electricity market and the predictability of the state guarantees for technologies that are not yet competitive and sectors where high externalities are involved are critical.

Commendably, the carbon trajectory can provide visibility to actors outside of the European Union's Emissions Trading Scheme and encourages improvements in energy efficiency and low-carbon technology solutions. The first pluriannual energy programming was presented in 2016; however, it only covers the period up to 2023 and does not address the question of the long-term operation or closure of the French nuclear fleet, pending safety reviews by the French Nuclear Safety Authority in 2018/19. The government has yet to evaluate the cost-effectiveness of all measures for the energy transition, comparing the levelised cost of electricity of different technologies and changes in energy market fundamentals over the PPE horizon.

France will need to track progress towards its ambitious targets. This requires robust energy data, indicators and resources to be allocated to this important exercise. The IEA encourages the government to continue the work on integrated energy–climate–air quality scenarios, building on those of the SNBC and the PPE, and to establish a tracking framework to assess progress towards the targets annually, including with regard to public/private sector investment compared to the SNBC. This can guide future carbon budgets, sectoral strategies and energy–climate–air quality plans developed at the various levels of administration. It will help evaluate the cost implications of the energy transition and provide an outlook for investment in low-carbon energy sources.

The success of the energy transition and its implementation will also rest on the capacity of local and regional authorities to put into practice the objectives set out by the government. Regions are charged to carry out local climate, air and energy plans (*plans climat–air–énergie territoriaux*, and *schémas régionaux climat–air–énergie*), which are co-ordinated by local authorities, next to regional energy efficiency plans, and to monitor compliance and achieve legal objectives. Such a decentralised approach is welcome because it can support a shift from a supply-side and centralised energy system to a more demand-oriented and decentralised one, and to the organisation of the energy transition. The IEA recommends that the government ensure that not only the

authorities charged with the implementation of the energy transition at local and regional levels, but also regulatory and consumer authorities, have the requisite autonomy and resources to support and carry out their activities.

ENERGY SECURITY

France's energy sector is shaped by the role of nuclear energy, which in 2015 accounted for 46% of total energy supply and 78% of the power mix. France holds the second-highest installed capacity for nuclear (63 GW) and level of nuclear generation among IEA member countries after the United States and has the world's highest share of nuclear in its electricity mix (78%). The French nuclear power programme was developed in the 1980s, largely a result of the oil price shocks in the 1970s, but the fleet is reaching 30 years and no decision has been taken with regard to long-term operation, pending safety reviews. The Nuclear Safety Authority (ASN) is expected to present the generic studies in 2018 that will inform the decisions of the operator EDF and shareholders with regard to the possible long-term operation (LTO) of the fleet and subsequent safety assessments at a plant-by-plant level.

France is preparing for the transition of its nuclear fleet. The nuclear industry is constructing one new reactor at Flamanville (a European pressurised water reactor), which is expected to come online when the oldest plant in Fessenheim is closed as anticipated in 2018. However, delays and technical challenges abound. The implementation of the 50% target remains challenging given the large role that nuclear electricity plays in the French mix and the average age of the fleet.

The 50% target would imply the closure of a large number of plants. Depending on the evolution of electricity demand, progress in energy efficiency, and renewables deployment, the 50% target may affect the economics of electricity and final electricity prices, GHG emissions and the reliability of supply in France as well as exports to neighbouring countries. The government needs to ensure the security of the electricity supply at a time of increasing outages or suspension of ageing plants for increased maintenance, and to deal with decommissioning and long-term waste management. When implementing the target, through the PPE among others, the government should assess the safety and economic aspects of LTOs, the impact on electricity prices, GHG emissions, and the future of the French nuclear industry, and ensure that the industry has the long-term planning horizon to implement safety upgrades in a timely manner.

Since 2009, the French government has also taken steps towards opening its historically monopolised gas and electricity markets. In response to the European Commission's intervention, the government put in place regulated access to 25% of EDF's nuclear electricity fleet for alternative suppliers under the so-called ARENH (*accès régulé à l'électricité nucléaire historique*) mechanism in 2011, following the Act for the New Organisation of the Electricity Market (*Nouvelle organisation du marché de l'électricité, NOME*). France has developed demand response in all energy, capacity and balancing markets, a valuable experience for other IEA member counties. Regulated tariffs were abolished on 1 January 2016 for medium-sized and large industry electricity and gas consumers. The government has increased transparency on the calculation of regulated tariffs and aims to reinforce social support programmes, like energy vouchers, while phasing out social tariffs offered by the incumbent supplier in support of the energy-poor.

In the gas wholesale market, the increasing level of competition and traded volumes at the French hubs and the market integration between north and south are encouraging news. However, electricity market opening is still lagging behind and the market remains highly concentrated, notably as the majority of the generation assets, hydro and nuclear, remain with the incumbent EDF, and attempts to reform hydropower concessions are not yet successful. The ARENH mechanism is conceived as a temporary measure until 2025 with a price of EUR 42 per megawatt-hour (MWh), but it has not achieved its objectives. Power purchases from the market are more attractive given that electricity wholesale prices have fallen below EUR 40/MWh. The government should promote competition by opening up concessions for hydropower facilities. When implementing the new capacity market in 2017, the government must remain vigilant to ensure that there is fair competition in the capacity mechanism for alternative and foreign suppliers.

The government has not set a date for the phase-out of regulated tariffs for households, which are calculated on the basis of ARENH. Despite the emergence of competition and market offers, many households and small business consumers still choose to remain with regulated tariffs. Switching procedures, consumer empowerment, the roll-out of smart meters, and price comparison tools are just emerging. Despite having a large number of distribution system operators, EDF's Enedis holds 95% of all the distribution network concessions, many of which will soon expire. Given that the European Union is embarking on a new electricity market design, and the current network concessions are drawing near the end, the government has an opportunity to review distribution and retail sector regulations. Commendably, the energy regulatory authority, the Commission for Energy Regulation (CRE), and the Energy Ombudsman support the process of market opening with a combination of competition, enforcement, regulation, and consumer education. The resources and competences of the competition authority, the energy regulator, and the consumer authorities have to reflect those priorities.

Since 2009, the French government and operators have continued to develop interconnection capacity, notably in gas but also in electricity, where new sub-sea cable projects are planned. France is very engaged in the Pentalateral regional forum discussions. In 2015, the high-level group between France and Spain put forward a roadmap of actions. A new French–Spanish electricity interconnection was inaugurated and has been operational since 2015. France has already reached a level of interconnection with its neighbours that is above the 10% EU target as threshold. In fact, interconnections are not only good for exports but crucial to enhance France's security of supply, particularly since the country can be heavily dependent on electricity imports on cold winter days.

KEY RECOMMENDATIONS

The government of France should:

- *Ensure the long-term visibility for the financing of the energy transition through pluriannual energy programming and carbon pricing mechanisms, and assess progress through adopting annual reviews and roadmaps based on robust scenarios.*
- *When implementing the targeted share of 50% nuclear in the power mix, guarantee continuous security of electricity supply and maintain the low-carbon footprint, building on an analysis of supply/demand patterns. Take into account safety and economic aspects when deciding on the long-term operation of France's Generation II plants and new Generation III plants.*

- *Continue to broaden the tax base for the financing of renewable energy support by sharing the cost across all energy consumer groups; further shorten the lead times for obtaining the necessary permits, prepare the siting of onshore and offshore wind parks as well as their connection to the electricity grid.*
- *In the pluriannual energy programming and National Energy Efficiency Action Plan, clarify the actions required to achieve the ambitious goals for the heat sector and building renovation, and to reduce energy poverty as set out in the Energy Transition for Green Growth Act; place policy emphasis on energy efficiency in small and medium-sized enterprises, and give recognition to the role that industry can play in the energy transition to green growth.*
- *Continue work towards market opening, competition, and consumer empowerment in gas and electricity retail markets, provide sound resourcing of regulatory and consumer authorities, and consider the phase-out of regulated tariffs for residential users.*

PART I
POLICY ANALYSIS

Figure 2.1 Map of France

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

2. GENERAL ENERGY POLICY

Key data (2015 estimated)

Energy production: 137.3 Mtoe (nuclear 83%, biofuels and waste 10.8%, hydro 3.4%, wind 1.3%, oil 0.7%, solar 0.6%, geothermal 0.2%), +0.2% since 2005

TPES: 245.7 Mtoe (nuclear 46.4%, oil 28.8%, natural gas 14.3%, biofuels and waste 6.1%, coal 3.6%, hydro 1.9%, wind 0.7%, solar 0.3%, geothermal 0.1%, electricity net exports -2.2%), -9.3% since 2005

TPES per capita: 3.7 toe (IEA average: 4.5 toe), -13.8% since 2005

TPES per GDP: 0.1 toe/USD 1 000 PPP (IEA average: 0.11 toe/USD 1 000 PPP), -16.5% since 2005

Electricity generation: 563.2 TWh (nuclear 77.7%, hydro 9.7%, wind 3.8%, natural gas 3.5%, coal 2.2%, biofuels and waste 1.3%, solar 1.5%, oil 0.3%), -1.4% since 2005

Power generation per capita: 9.1 MWh (IEA average: 9.9MWh), -8.6% since 2005

TFC (2014): 147.7 Mtoe (oil 45.6%, electricity 24.2%, natural gas 19.1%, biofuels and waste 7.4%, coal 2.1%, heat 1.5%, solar 0.1%), -13% since 2004

COUNTRY OVERVIEW

In 2015, metropolitan France had a population of 64.7 million inhabitants (66.7 including its overseas territories). With a land area of 549 087 km^2, France is the largest country in the European Union (EU). Its population density of 118 inhabitants/km^2 is above the OECD average of 35, but in line with the EU average of 112. France's population is growing at a rate of 0.4% per year. The country benefits from a large geographical diversity as 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, 11 million km^2 of exclusive economic zone, behind the United States, and has around 500 ports, including seven commercial state ports. About 70% of France's trade volume is made by sea route.

President François Hollande is the head of state under the Fifth Republic (Constitution of 4 October 1958) following the presidential elections of 2012, with Prime Minister Bernard Cazeneuve as head of government. Ms. Ségolène Royal has been Minister of Environment, Energy and the Sea since 2014. The next presidential elections are scheduled for April and May 2017.

In the 2012 election campaign, François Hollande made a commitment to the energy transition, which is the key domestic priority of Minister Royal together with France's international leadership on climate change. In December 2015, France hosted the 21st Conference of the Parties (COP21) under the United Nations Framework Convention on Climate Change (UNFCCC) which successfully concluded the Paris Agreement. In July

2016, France presented its sustainable development goals to the United Nations as one of 22 first-mover countries to implement the UN Agenda 2030, adopted in September 2015.

In 2015, France reformed its regional governance and reduced the number of administrative regions from 27 to 18 (as of 1 January 2016, see Figure 2.6). There are 13 regions with 101 départements in metropolitan France (including the territorial collectivity of Corsica) and five located overseas (French Guiana, Guadeloupe, Martinique, Mayotte, and La Réunion), the so-called *départements d'outre-mer (DOM)*. All territorial collectivities have their own local assemblies and executives. This in-depth review covers only metropolitan France and not the DOM.

The fifth largest economy in the OECD, France shows high standards of living thanks to a well-educated workforce, work-life balance, environmental quality and low average income inequality that, unlike many other OECD countries, have not worsened over time (OECD, 2016).

France has a diversified industrial structure, a sound banking system and in general terms, high educational attainment. GDP per capita, USD 39 813, is at the OECD average (USD 39 976). However, France's fundamental economic problem is a lack of economic growth. Unemployment is at a high level and still rising (10% in total, but 23% of population under the age of 25). Over the past decades, France has had a structurally weak real economic growth with the second highest level of public spending among OECD countries (58% of GDP in 2014) and a rising government debt (119% of GDP in 2014). The competitiveness of the French industry has been decreasing. The OECD projects an economic growth rate of 1.6% in the coming years.

France is a founding member of the European Union (EU), the Organisation for Economic Co-operation and Development (OECD), the Group of Seven and the United Nations (UN), and holds a permanent seat in the UN Security Council.

SUPPLY AND DEMAND

SUPPLY

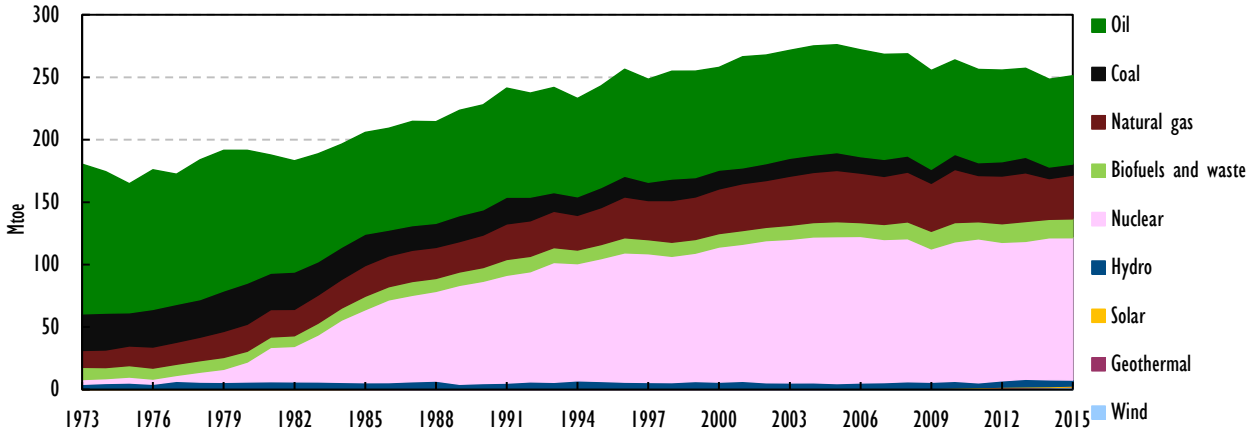
France's total primary energy supply (TPES)[1] was 245.7 million tonnes of oil-equivalent (Mtoe) in 2015. Since the peak of 270.9 Mtoe in 2005, TPES contracted by 9.3% (Figure 2.2). Nuclear accounted for 46.4% of TPES in 2015, the largest share of nuclear in TPES among IEA members (Figure 2.3), though 3% lower than in 2005.

Fossil fuels accounted for 46.6% of TPES, made up of oil (28.8%), natural gas (14.3%) and coal (3.6%). Renewable energy sources accounted for 9.2% of TPES, made up of biomass and waste (6.1%), hydro (1.9%), wind (0.7%), solar (0.3%) and a marginal portion of geothermal (0.1%).

TPES from renewable energy grew by 35.4% over the past decade to 2015. As such, the total share of renewables in TPES has increased by only 3 percentage points from 6.2% in 2005 to 9.2% in 2015.

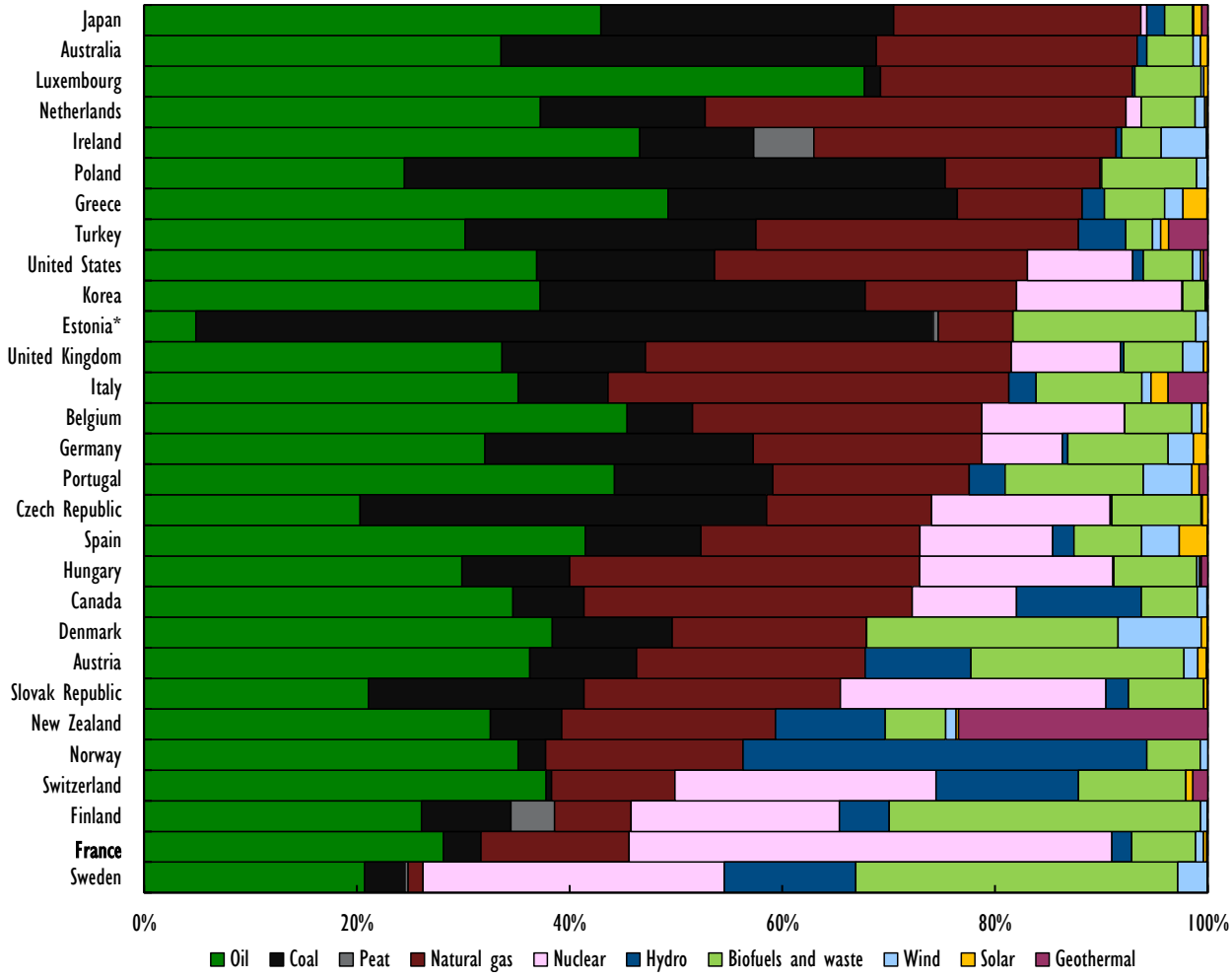
1. TPES is made up of production *plus* imports *minus* exports *minus* international marine bunkers minus international aviation bunkers *plus/minus* stock changes. This equals the total supply of energy that is consumed domestically, either in transformation (for example refining) or in final use.

Figure 2.2 TPES, 1973-2015



Source: IEA (2016), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Figure 2.3 Breakdown of TPES in IEA member countries, 2015



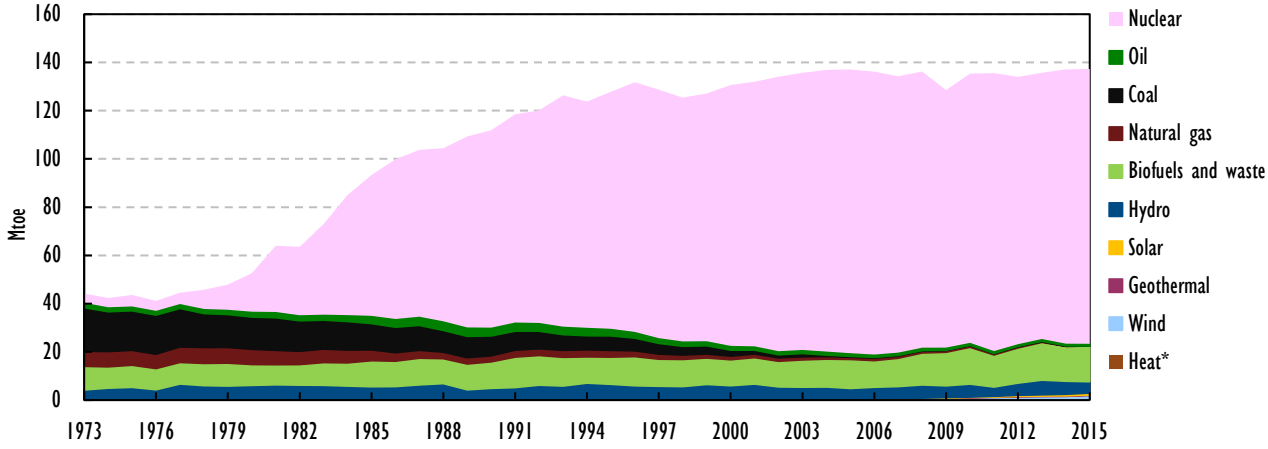
* Estonia's coal represents oil shale.

Source: IEA (2016), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

In 2015, energy imports amounted to 147.8 Mtoe with 32.9 Mtoe of exports. Oil imports totalled 98.2 Mtoe (66.4% of total imports), with 39.4 Mtoe of natural gas (26.7%) and 8.8 Mtoe of coal (5.9%). Exports were made up of oil products (21.3 Mtoe, 64.8%), electricity (6.4 Mtoe, 19.4%), and natural gas (4.9 Mtoe, 14.8%). Imports have declined by 16.9% since 2005 while exports decreased by 6.2% during the same period. The strongest decrease in imports came from coal, which declined by 37.7% over the past decade to 2015.

France produced 137.3 Mtoe of energy in 2015, 83% of which stems from nuclear with the remainder from biofuels and waste (10.8%), hydro (3.4%), wind (1.3%), oil (0.7%), solar (0.6%) and a negligible portion of geothermal. Energy production in 2015 was 0.2% higher than in 2005. Production has remained relatively stable over the past decade to 2015, with the exception of the 5.7% decrease in 2009, during the global financial and economic crisis, followed by a 5.3% recovery in 2010.

Figure 2.4 Energy production by source, 1973-2015



* Negligible.

Source: IEA (2016), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

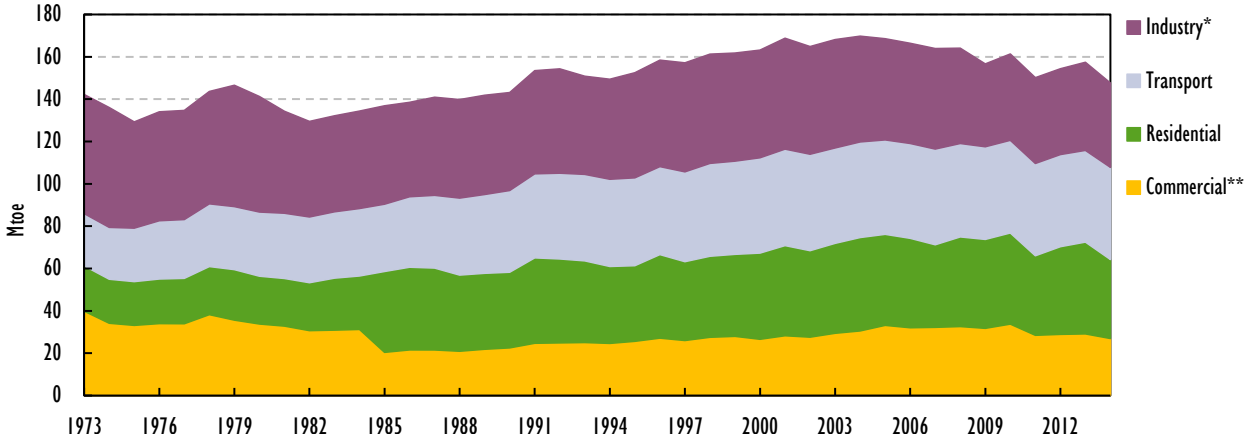
DEMAND

France's total final consumption (TFC)[2] amounted to 147.7 Mtoe in 2014. TFC represents around 60.9% of TPES, with the remainder used in power generation and other energy industries. TFC reached a record high in 2004 at 169.8 Mtoe. TFC has declined by 13% over the past decade to 2014 (Figure 2.5). The strongest decline was by 6.9% during 2011.

Transport is the largest consuming sector and accounted for 29.5% of TFC in 2014, or 43.5 Mtoe. The industrial and residential sectors represented 27% and 25.3%, respectively, while the commercial sector consumed 18.2%. Since the peak in 2004, transport and industry have reduced demand by 3.6% and 20.3%, respectively, while residential and commercial demand fell by 15.4% and 11.7%. The sharp decline of TFC reflects the structurally weak economic growth and energy efficiency progress in residential and commercial and services sectors (see Chapter 3 on Energy Efficiency).

2. TFC is the final consumption by end-users, i.e. in the form of electricity, heat, gas, oil products, etc. TFC excludes fuels used in electricity and heat generation, and in other energy industries (transformations) such as refining.

Figure 2.5 TFC by sector, 1973-2014



* Industry includes non-energy use.

** Commercial includes commercial and public services, agriculture, fishing and forestry.

Source: IEA (2016), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

INSTITUTIONS

The **Ministry of Environment, Energy and the Sea** (*Ministère de l'environnement, de l'énergie et de la mer, MEEM*) covers a large portfolio along seven pillars: sustainable development, energy, air quality and climate, infrastructure and transport, water and biodiversity, buildings and sustainable cities, risk prevention, and the sea and the coast. Within MEEM, the **Directorate-General for Energy and Climate (DGEC)** plans and implements policies in energy markets and energy supply (including nuclear), air quality, international climate change negotiations, mitigation and adaptation. Energy taxation is shared between MEEM and the Ministry of Economy and Finance.

Compliance with safety and radiation protection rules is carried out by the independent **Nuclear Safety Authority** (*Autorité de sûreté nucléaire, ASN*).

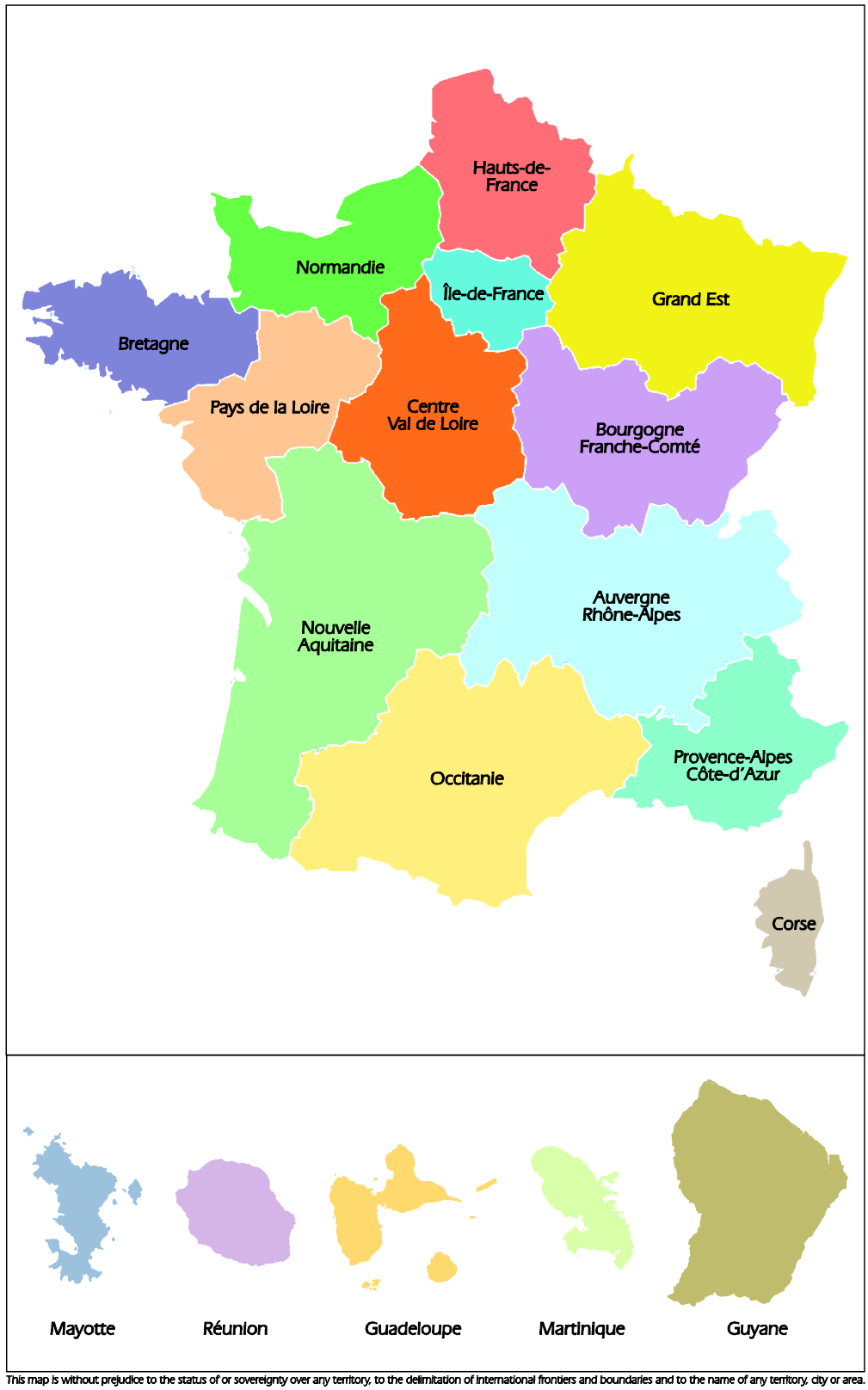
Under the authority of MEEM and the regional authorities (*préfets*), the regional directorates **DREAL** (*directions régionales de l'environnement, de l'aménagement et du logement*, **DRIEE** for Ile-de-France and **DEAL** for DOMs and Corsica) work closely with the public to implement energy policy objectives, in particular through regional climate-air-energy schemes (SRCAE) and territorial climate-air-energy plans (PCAET).

The **Environment and Energy Management Agency** (*Agence de l'environnement et de la maîtrise de l'énergie*, *ADEME*) is a public agency under the joint supervision of MEEM and the **Ministry of Higher Education and Research (MESR)**, dedicated to energy efficiency and sustainable development, including broader remits, such as climate change and energy research and development. At the regional level, it is represented by regional delegations.

The **Commission for Energy Regulation** (*Commission Régulation de l'Énergie, CRE*) regulates the French gas and electricity markets and ensures the right of access to all transmission and distribution networks. It monitors electricity, gas, CO_2 markets and partly administers the support scheme for renewable energies.

Consumer interests are currently represented by the **Energy Ombudsman** and consumer associations (notably *UFC Que Choisir* and CLCV).

Figure 2.6 The administrative regions of France as of 1 January 2016



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

KEY POLICIES FOR THE ENERGY TRANSITION

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 (*Grenelle de l'Environnement*), France has put in place an energy policy framework for the energy transition to green economic growth towards 2030. The new framework reflects 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, LTECV*) entered into force on 17 August 2015 and is being implemented through more than 150 regulations. The Act is the result of the National Debate on the Energy Transition (DNTE), 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% of CO_2 reductions by 2050):

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 towards the core objectives 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 ACT

The Energy Transition for Green Growth Act of 17 August 2015 is a comprehensive legal framework with the aim of tackling climate change and reinforcing energy independence and energy security. The main five action principles of the French energy transition are *i)* to promote demand-side management and consumer engagement, energy efficiency and lower energy use, notably in buildings, *ii)* to collaborate jointly with citizens, companies and territories and local authorities, *iii)* to ensure transparency and information about the energy cost and prices, *iv)* to develop energy research and innovation (low-carbon mobility, marine energies and energy storage), and *v)* to diversify the energy mix, further limiting the use of fossil fuels, diversifying electricity generation and increasing the share of renewable energies. As part of the Act, several energy and climate targets are made legally binding, notably the:

- reduction of greenhouse gas (GHG) emissions by 40% in 2030 and by a factor of 4 towards 2050 (compared to 1990)
- reduction of final energy consumption by 20% in 2030 and 50% in 2050 (compared to 2012)
- renewables share of 32% in gross final energy consumption and 40% of total electricity generation by 2030;
- reduction of fossil fuel consumption of 30% by 2030 (in comparison to 2012)

- reduction of nuclear share in the electricity mix down to 50% by 2025 (from 78% today) and capping the installed capacity of nuclear power at the current level of 63.2 GW (to build one new reactor, France needs to close an old one)
- reduction of municipal waste production per capita of 10% over 2010-20, including building and public work sectors (circular economy) with 50% less landfill by 2025
- a long-term carbon trajectory from EUR 14.5 per tonne of CO_2 equivalent in 2015, to EUR 56/tCO_2 in 2020 and EUR 100/tCO_2 in 2030, which is implemented through the annually confirmed carbon component in energy taxation and the EU-ETS.

Besides the headline goals, the Energy Transition for Green Growth Act includes policy proposals and strategies for key sectors, including buildings, transport, waste, the circular economy, renewable energy and nuclear safety, and endorses a collaborative approach of government, industry, citizens and regional/territorial/local authorities. The government financially supports activities in the best performing energy-transition territories, positive-energy territories, and zero-waste territories.

In the buildings sector, the government aims to increase the renovation rate (500 000 dwellings per year by 2017) and to oblige house owners to carry out energy refurbishment when restoring façades, re-roofing or converting a loft. The zero-interest eco-loans to finance energy refurbishment have been simplified and the scope of the energy transition tax credit (*crédit d'impôt pour la transition énergétique, CITE*) increased to cover 30% of the cost of any thermal refurbishment work up to a limit of EUR 8 000 for a single person and EUR 16 000 for a couple.

In the context of the energy transition, the government encourages low-carbon mobility and has presented a clean mobility plan. France has incentives to purchase clean vehicles (bonus-malus scheme and car conversion bonus of maximum EUR 10 000) and to finance electric vehicle (EV) domestic charging stations with energy transition tax credits. The government aims to install at least 7 million public and private EV charging points by 2030 and encourages initiatives to create "breathable cities" in five years. It is preparing a national plan to reduce air pollution.

Combating energy poverty should be improved by distributing energy vouchers to 4 million vulnerable households. And 30% of the revenues raised from the energy efficiency certificates should be dedicated to fuel poverty under the "Better Living Programme" of the French Agency for Habitation Improvement (ANAH) as 70 000 low-income households shall be refurbished every year. Consumers will become more active with smart grids, with 35 million smart electricity meters (Linky) and with 11 million smart gas metres (Gazpar).

In the area of renewable energy, the Energy Transition for Green Growth Act also sets out the reform of the support scheme (feed-in tariff system) and its funding (*contribution aux charges de service public de l'électricité*, *CSPE*[3]) towards a market premium and calls for tender for large-scale mature renewable facilities. This aims to ensure the cost-competitiveness of renewable energies. In addition, the Act introduced the facilitation of crowd-funding for citizens and local authorities, and the use of the single permit for the construction of new wind energy, biogas and hydro-power facilities.

3. CSPE is a tax component that is paid by electricity consumers. A new regulation has been set up since early 2016 (see below section on green taxation).

PLANNING AND TRACKING OF THE ENERGY TRANSITION

In November 2015, France adopted its first national low-carbon development strategy (*stratégie nationale bas carbone, SNBC*), supported by the related regulation establishing GHG emission limits (carbon budgets) for the periods 2015-18, 2019-23 and 2024-28. The strategy covers all sectors of the French economy, including those sectors not under the EU-ETS, e.g. transport, buildings and agriculture/waste sectors which are facing the main decarbonisation challenge.

TERRITORIAL PLANNING

Sectoral (transport, urban and rural planning, energy production and agriculture) and local planning exercises will have to take this SNBC strategy and its carbon targets into account, targets that will be updated for every five-year carbon budget.

For the implementation of the energy transition, the government promotes partnerships with the territories and regions and supports their plans. At the regional level, directorates are encouraged to prepare and implement regional climate-air-energy schemes (*schémas régionaux climat–air–énergie*), first adopted in 2012, which now include energy efficiency plans and should serve as framework for the territorial plans. Regional delegations of ADEME support the territories and the various authorities, including for the development of thermal refurbishment platforms and regional energy efficiency plans which would also involve renewable energy. Mandatory since 2010 for areas with more than 50 000 inhabitants, the Energy Transition for Growth Act builds on the territorial climate-air-energy plans (*plans climat–air–énergie territoriaux*), which are co-ordinated by the local authorities in the territories and now also include air quality.

FINANCING THE ENERGY TRANSITION

In order to ensure visibility of investment for the energy industry, public and private alike, the government expanded its current investment planning (*programmation pluriannuelle de l'investissment, PPI*) towards a multi-annual energy investment programme. In October 2016, almost one year after the Energy Transition for Green Growth Act was adopted, the first pluriannual energy programming (*programmation pluriannuelle de l'énergie, PPE*) for the period 2016-23 was adopted. The PPE merges and expands the scope of existing separate programming tools into a single exercise, covering electricity production by each generating source, including renewable energy,[4] the supply/demand balance, energy efficiency and security of supply, in order to align policies to the targets established by the Act.

The PPE must also be compatible with the carbon budgets and sectoral targets of the SNBC. Each PPE has to cover 10 years and be revised every five years, except the first PPE which covers eight years (2016-23) and will be revised at the end of 2018. At the end of each five-year period (for the first time in 2018) the government has to present an evaluation report measuring progress in energy transition. Under Article 174 of the Energy Transition for Green Growth Act the tracking of public and private energy investment is required. The PPE investments may be compared with those of the "reference scenario" of the carbon budgets.

4. In the first period of the PPE, the renewable energy targets were adopted ahead of the PPE, in spring 2016, under the previous planning regime, the *programmation pluriannuelle de l'investissment* (PPI).

Substantial investments are needed for the energy transition, in energy efficiency, in renewable energy and in the nuclear fleet. While the carbon trajectory in the Energy Transition for Green Growth Act will ensure the reduction of fossil fuels use over time in the sectors outside the EU-ETS, the reformed renewable support scheme and EDF as the owner and operator of the French nuclear fleet will need to shoulder the cost of the energy transition.

Amid rising financial deficits of the previous renewable energy support scheme (under contribution to public service electricity, CSPE), the government revised the scheme with a view to broaden the tax base to contributions from all energy users, not only electricity consumers (see section on green taxation below and Chapter 9 on Renewable Energy). Over the past few years, the cost of renewable energy technologies has been coming down globally and in France (where recent solar PV bids included remunerations at EUR 87 to EUR 70/MWh), but not as fast as in other EU countries.

One of the main financing challenge relates to the operation of the French nuclear fleet, notably the cost of the new nuclear reactors (like the European Pressurised Water Reactor EPR in Flamanville), the cost of closure and decommissioning of existing plants by the end of their design life of 40 years and/or the cost of long-term operation (LTO) of the existing fleet beyond the design life to 50 or 60 years (so-called *Grand Carénage*), which is estimated to amount to EUR 100 billion for the period 2014-30 by the French auditor *Cour des Comptes* (CdC, 2016) or at least EUR 47.5 billion up to 2025 (EDF estimate). No decision has been taken with regard to the LTO by EDF pending the fourth periodic safety review of the French Nuclear Safety Authority (ASN) in 2018/19 and plant-by-plant safety assessments for the decennial review. Increasing cost overruns of the EPRs in France and abroad have put pressure on the financing of the French nuclear power sector. The takeover of AREVA by EDF adds to the financing challenges.

Declining wholesale electricity prices (dropping below EUR 40/MWh in 2014 and 2015) have reduced interest in the regulated access to historic nuclear electricity (ARENH, accès regulé à l'électricité nucléaire historique) price of EUR 42/MWh which was supposed to guarantee access to nuclear electricity at cost for alternative energy suppliers. According to the IEA/NEA study on the Projected Cost of Electricity Generation (IEA/NEA, 2015), the levelised costs of electricity were EUR 115/MWh for the Generation III new nuclear and EUR 35/MWh for Generation II nuclear with long-term operation.[5]

Ageing nuclear reactors, safety concerns and maintenance has led to an increased shut down of French nuclear reactors, notably in 2016. With the closure of coal- and oil-fuelled plants, baseload capacity has decreased further. France is launching the capacity market to ensure the security of supply in the energy transition. The European Commission (EC) carried out an inquiry into capacity mechanisms in several EU member states, including in France. On 8 November 2016, the EC approved the revised French revised market-wide capacity mechanism under EU state aid rules. Those revisions will make it possible to include capacities located across the border (as of 2019) and allow new players to enter the market. The capacity market is planned to start on 1 January 2017.

5 The calculation is based on the capital cost of EUR 850 million for the refurbishment of a 1 000 MW_e plant (EDF estimate), a discount rate of 10% (highest value), and integrates operation and maintenance and fuel cycle costs (including waste management and decommissioning provision) of EUR 4/MWh.

TAX INCENTIVES AND LOANS

Several instruments are in place to support the financing of the energy transition, including increased income tax breaks (*crédit d'impôt pour la transition énergétique, CITE*), expanded zero-interest rate loans and increased loan volumes of the Public Investment Bank (*Banque publique d'investissement, BPI*), EUR 800 million/year for investment in renewable energies and a range of new funds are created under the public mission bank *Caisse des Dépôts*.

GREEN TAXATION

Energy taxation in France is set under European directives on excise duties and value-added tax (VAT), which set minimum levels of taxation and allow exemptions or differentiated tax rates subject to certain conditions. In France, there are three main types of excise tax on energy: the two taxes on final electricity consumption (*contribution au service public de l'électricité, CSPE*, and the *taxe sur la consommation finale d'électricité, TCFE*), the domestic tax on natural gas consumption (*taxe intérieure de consommation sur le gaz naturel, TICGN*) and the domestic tax on the consumption of energy products (*taxe intérieure de consommation sur les produits énergétiques, TICPE*).

The sale of electricity, natural gas and petroleum products is also subject to VAT. The 20% normal VAT rate is applied to the consumption of natural gas and petroleum products, while a reduced rate of 5.5% VAT is applied as a standing charge for electricity (depending on the subscribed demand) and for natural gas supply (connection charge).

A major reform of the taxation of energy products in France took place in April 2014, in line with new EU requirements under the Fuel Quality Directive (FQD, Directive 2009/30/EC).

Table 2.1 Domestic taxes on energy products (in eurocents)

		2013	2014	2015	2016	2017
Natural gas	(€/MWh)					
Households		Exemption	1.27	2.64	4.34	5.88
Professionals		1.19	1.27	2.64	4.34	5.88
Coal	(€/MWh)	1.19	2.28	4.75	7.21	9.99
Diesel	(c€/L)	42.84	42.84	46.82	49.81	53.07
Petrol (SP95)	(c€/L)	60.69	60.69	62.41	64.12	65.07
Petrol (E10)	(c€/L)	60.69	60.69	62.41	62.12	63.07
Domestic heating oil	(c€/L)	5.66	5.66	7.64	9.63	11.89
Heavy fuel oil	(c€/kg)	1.85	2.19	4.53	6.88	9.54

Source: MEDDE (2015), *Energy and Climate Panorama 2015*.

Article 31 of the 2014 Finance Law modified the consumer excise tax on the use of fossil fuel products (gasoline, diesel, domestic oil, natural gas, coal, heavy oil) by introducing a carbon component for each fossil fuel, in proportion to the quantity of CO_2 it emits, starting with a CO_2 price equal to EUR 7 per tonne of CO_2 (tCO_2) in 2014.

The carbon component sets a price of carbon for the sectors outside the EU-ETS (the TICPE for energy-intensive users subject to ETS remains unchanged at EUR 7/tCO_2). The carbon component has increased from EUR 7/tCO_2 in 2014, to EUR 14.5/tCO_2 in 2015, to EUR 22/tCO_2 in 2016 and to EUR 30.5/tCO_2 in 2017. In line with the Energy Transition for Green Growth Act, the carbon component will reach EUR 56/tCO_2 in 2020 and EUR 100/tCO_2 in 2030, which needs to be confirmed by annual Finance Acts. In 2016, the government had announced plans to introduce a carbon floor price of EUR 30/tCO_2, which would be imposed on coal use in power generation (natural gas is exempted) and would encourage further retirements of France's remaining coal power plants. However, the plans were not implemented.

According to the Ministry of Energy, Environment and the Sea (MEEM), expected CO_2 emissions reduction amounts to 2 Mt in the building sector and 1 Mt in the road transport sector by 2017, while the expected revenue related to energy taxation on carbon components is estimated at EUR 3.8 billion in 2016. In 2016, around EUR 3 billion shall contribute to a decrease in labour taxation thanks to the tax credit in favour of competitiveness and employment (*crédit d'impôt pour la compétitivité et l'emploi, CICE*).

Measures have been taken to reduce the gap between diesel and gasoline taxes. The 2015 Finance Law raised the taxation on diesel (2 eurocents/litre) which, together with the carbon component, will decrease the tax differential between diesel and gasoline. Consumer excise duty on diesel has increased by almost EUR 4 cents/L in 2015 (EUR 5 cents/L including VAT) for road transport vehicles. Between 2014 and 2017, in total, the tax differential between diesel and gasoline (E10) will have been reduced by EUR 6 cents/L to EUR 12 cents/L. Part of generated revenues has been earmarked to finance transport infrastructure. However, these tax measures will not tackle large diesel users, like freight or industry.

Social protection policies in France resulted in many full or partial tax exemptions or refunds on VAT or excise duties on oil products and in a reduced rate of excise duties on fuels used by taxis, machinery used in agriculture and construction, boats, company cars, etc. Kerosene consumption for domestic flights is not taxed (but aviation is part of the EU-ETS). The government has not been able to cut all existing tax benefits which support high fossil-fuel consumption, but was able to remove or reduce some tax rebates.[6]

In January 2016, the government reformed the electricity public service contribution (CSPE) under the 2015 Finance Law. The CSPE has funded the renewables support scheme; however, its limited revenue base was unable to cover the rising cost of the scheme. Public service expenses are now included in the state budget and thus under parliamentary control. In 2016, the CSPE budget in support of renewable energy is allocated to a dedicated energy transition item, while other general public services are contained in a new public mission budget of the state. The new CSPE committee will monitor the evolution of public service expenses and is consulted on the impact assessment of PPE. As explained in the Chapter 9 on Renewable Energy, the new support scheme will be fed from several taxes on energy, the CSPE, the TICFE and the TICPE.

6. The following tax benefits were abolished: support payment for fuel oil heating (prime à la cuve), exemption from internal consumption tax (ICT) on natural gas, coal, lignite and coking coal consumption). The exemption rates from the ICT were reduced in favour of biofuels and abolished in 2016.

PUBLIC FUNDS

The government launched several calls for proposals for competitive tenders: it promotes about 500 positive-energy territories for green growth, zero-waste territories, 1 500 biogas plants in rural areas and initiatives under the plan for "breathable cities within five years". The loan facility of the *Caisse des dépôts* has been increased to EUR 5 billion to finance initiatives at territorial level on renewable energy, buildings and clean transport. The governmental Energy Transition Financing Fund has been created with EUR 1.5 billion over three years, mainly directed to the Heat Funds and energy refurbishment initiatives for private-sector dwellings, and to support the winners of competitive tenders in the waste prevention and positive energy territories. The ADEME "air" fund will encourage local authorities to create grants for the renewal of inefficient individual wood burners.

ASSESSMENT

Since the last in-depth review in 2009, the government has consolidated its general energy policy towards an integrated energy and climate policy framework for the energy transition. By international comparison, France leads with ambitious energy and climate objectives, set under a legal and governance framework which is based on a national low-carbon strategy, five-year carbon budgets, a pluriannual investment planning and tracking process as well as a carbon price trajectory up to 2030.

Building upon previous objectives set under the POPE Steering Law of 2005 and the Grenelle Environment I and II Acts (*Grenelle de l'Environnement*) in 2007-10, France created a comprehensive and long-term energy transition framework for the period to 2030 and 2050 with the adoption of the Energy Transition for Green Growth Act in 2015 (*Loi relative à la transition énergétique pour la croissance verte, LTECV*). The decision of the French government to design a framework with legally binding targets that is based on a broad national debate of the future transition and a price on carbon with a trajectory up to 2030 is a commendable decision and other IEA member countries can learn from this experience.

The French energy transition builds on the gradually shifting contribution from nuclear power during the transition while phasing in an accelerated deployment of renewable energy technologies over time. The Energy Transition for Green Growth Act endorses ambitious energy and climate targets that are multiple, ambitious and cover several time frames (2020, 2025, 2030, 2050).

To implement this ambitious trajectory, France is currently introducing rules and laws to reach the targets through a new governance, tracking, and planning, including at local levels, so as to provide visibility in the way the energy transition is financed.

First, France has adopted an integrated planning and tracking approach for the co-ordination of all climate and energy targets in the 2030 horizon, which is commendable. There are two main planning instruments in place, namely the national low-carbon strategy and related carbon budgets, and a pluriannual energy programming (PPE), in addition to a number of initiatives and strategies, such as the energy research and development strategy and a clean transport and mobility strategy. Under Article 174 of the Energy Transition for Green Growth Act the tracking of energy investment, public and private, is required, including investments. Investments will be compared with those of the reference scenario in the carbon budgets.

Planning and reviewing carbon budgets and energy investment periodically allows a flexible approach to adjust action over time. Global changes affect technology costs and energy markets. Progress and costs need to be reviewed over time, notably the levelised cost of electricity, the needs implied by robust energy and climate scenarios, data and indicators. Resources will need to be allocated to this important exercise. In addition to the five-year carbon budgets and PPE, an annual roadmap assessing progress and outlining forthcoming policy initiatives can help to ensure timely implementation and visibility of the government's action for all market participants.

Therefore, the IEA encourages the government to continue its work on energy-climate-air quality scenarios; to establish a robust tracking framework to assess progress towards the targets with indicators, to identify the required investment to evaluate the costs and impacts on GDP/employment (green growth); to guide future carbon budgets, including the outlook for investment in low-carbon energy sources; and to inform the strategies developed at the various levels of administration.

Secondly, the success of the energy transition and its implementation will also rest on the capacity of local and regional authorities to put in effect the objectives set out by the government. Regions are charged to carry out local climate, air and energy plans which are co-ordinated by local authorities (*plans climat–air–énergie territoriaux, schémas régionaux climat–air–énergie*), monitoring of compliance, and achieving legal objectives. Such a decentralised approach is welcome, as it supports a shift from a supply-side and centralised energy system to a more demand-oriented and decentralised one and to the organisation of the energy transition. The IEA recommends the government to ensure that authorities charged with the implementation of the energy transition at local and regional levels but also regulatory and consumer authorities, have the necessary autonomy and resources to support and carry out these activities.

Thirdly, France continues green tax incentives, directs increasing public funds to the energy transition and puts a price on carbon. France has made strong progress in taxation. It is leading at international level by setting a carbon trajectory under the Energy Transition Law, by introducing an incremental carbon component in the fossil fuel consumer's excise tax, by setting out a carbon trajectory and by tackling the reform of the CSPE. However, for historic reasons, there is a plethora of taxation instruments, including many exemptions. If France wants to drive decarbonisation of the economy, notably transport, industry and agriculture, it has to increase its efforts towards creating a comprehensive green energy taxation (based on robust carbon pricing and revised tax exemptions) to reflect the value of mitigation action and to stimulate the reduction in fossil-fuel consumption. The IEA calls for the completion of the green taxation reform as a critical element to support the financing of the energy transition in the long term through private and public investment.

Amid low electricity wholesale prices and low EU ETS carbon price, the energy industry lacks the long-term visibility that is essential for investing in the electricity sector. This is at the heart of the energy transformation given the ageing nuclear fleet and the ambitious energy and climate goals of the Energy Transition for Green Growth Act (see also Chapter 8 on Electricity and Chapter 10 on Nuclear Energy). The first PPE was adopted on 27 October 2016, covering the years of 2016-23, but it did not tackle the question of the long-term future of the French nuclear fleet. The decision to close nuclear power plants or to extend their operating life to beyond 40 years will have to be taken during the second period of the first PPE (i.e. 2018-23), depending on the evolution of many uncertain parameters such as electricity demand (especially peak

demand), the energy mix of neighbouring countries, power imports and exports, or the costs of the nuclear fleet lifetime extension itself. Recent safety concerns in France highlight the challenge and systemic risks of long-term operation and the need to take an ambitious pathway in the energy transition.

It is therefore welcome that the PPE gives clear visibility concerning the fast development of renewables, which – as a no-regret measure – despite decreasing technology cost will need to be strongly supported in order to contribute to achieve the reduction of the current 78% share of nuclear energy in the electricity mix to 50% by 2025. To achieve a share of 50% by 2025, without increasing CO_2 emissions, would require an increase of non-hydro renewable energies (wind, solar, biomass) from their current level of 6.8% to 34% within 10 years, assuming a stable electricity demand.

The investment challenge lies with the energy industry and the public sector, given the large share the government holds in the country's energy sector. Maintaining a low-carbon energy mix and reducing the share of nuclear energy means that investment will need to be redirected to renewable energy, and to be balanced against the cost of the long-term operation of the existing nuclear reactors under safe conditions.

The government is invited to continuously address these challenges in a timely manner both within the scenarios and the PPE and through the capacity mechanism, in light of the decisions by the French Nuclear Safety Authority and along the energy and climate goals, so as to manage the costs of the energy transition.

RECOMMENDATIONS

The government of France should:

- *Ensure the long-term visibility for the financing of the energy transition through pluriannual energy programming and carbon pricing, and assess progress through adopting annual reviews and roadmaps based on robust scenarios.*
- *Use a robust and transparent scenario-based modelling to track progress and investments so as to guide the planning of the pluriannual programming and the national low-carbon strategy amid changing energy markets, to ensure coherence and synergies between the various targets and planning exercises at national and local level.*
- *Work in collaboration with regions and local authorities and strengthen their resources to implement the objectives set out under the Energy Transition for Green Growth Act, notably in the framework of the pluriannual programming and the regional and local plans for energy efficiency, renewable energies, air quality, GHG emissions mitigation and research and development activities.*

References

CdC (Cour des Comptes) (2016), *Maintaining Nuclear Power Plants*, February.

IEA (International Energy Agency) (2016), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA/NEA (IEA/Nuclear Energy Agency) (2015), *Projected Cost of Generating Electricity*, OECD, Nuclear Energy Agency, Paris.

MEDDE (Ministry of Ecology, Energy and Sustainable Development) (2015), *Energy and climate panorama 2015*, Paris.

OECD (2016), OECD *Environmental Performance Reviews: France 2016*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264252714-en.

OECD (2015), *OECD Economic Surveys: France 2015*, OECD Publishing, Paris, http://dx.doi.org/10.1787/eco_surveys-fra-2015-en.

3. CLIMATE CHANGE AND AIR QUALITY

Key data (2014)

GHG emissions without LULUCF (2014)*: 464.4 $MtCO_2$-eq, -15.4% since 1990

GHG emissions with LULUCF (2014)*: 415.7 $MtCO_2$-eq, -20.3% since 1990

2008-12 target: Stabilise GHG emissions at the 1990 level **actual 2008-12:** -7.5%

CO_2 emissions from fuel combustion:** 285.7$MtCO_2$, -17.3% since 1990

CO_2 emissions by fuel **: oil 61%, natural gas 25.7%, coal 11.6%, other 1.7%

CO_2 emissions by sector:** transport 42.4%, residential 15.7%, industry 15.7%, power generation 10.1%, commercial and other services including agriculture 12.4%, other energy industries 3.7%

CO_2 emissions per capita:** 4.32 tCO_2; ranks fifth-lowest among IEA

* UNFCCC (2016) and MEDDE (2016) for GHG emission data. The data also includes indirect CO_2 emissions.

** IEA (2016a) for CO_2 emissions from fuel combustion.

OVERVIEW

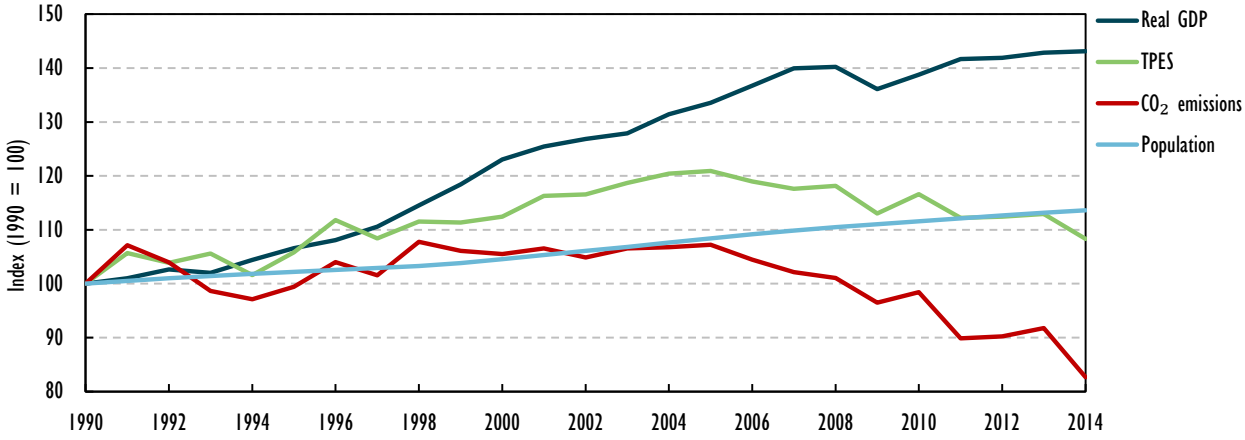
France has one of the lowest carbon dioxide (CO_2) emissions per capita among International Energy Agency (IEA) member countries (ranking fifth). It accounts for 1.2% of global greenhouse gas (GHG) emissions but for 4.2% of global gross domestic product (GDP).

Since the end of the 1990s, France has fully decoupled CO_2 emissions and primary energy supply from economic and population growth (Figure 3.1). The carbon intensity of the French economy has been declining fast in recent years, largely thanks to the reduction in industrial demand, greater energy efficiency, the stable share of nuclear (46% in the energy mix and 78% of electricity generation, the highest share in an IEA member countries and in the world) and the ever-decreasing reliance on fossil fuel combustion.

France ratified the Kyoto Protocol in May 2002 and was able to meet its targets without the purchase of international credits. Its international commitment was to stabilise its average annual GHG emissions at the base-year level of 1990. Not only was France able to meet its Kyoto commitment but it reduced its emissions by 7.5% over the first Kyoto commitment period (2008-12) under the United Nations Framework Convention on Climate Change (UNFCCC).

According to the latest UNFCCC data for France, energy production accounted for 12% of total GHG emissions of France in 2014. Transport is the largest contributing sector (28%), followed by buildings (20%), with agriculture and forestry contributing 19% in 2014. The industrial process sector accounted for 18% while waste accounted for 4% of total GHG emissions.

Figure 3.1 CO_2 emissions and main drivers in France, 1990-2014



Note: TPES = total primary energy supply.

Sources: IEA (2016a), *CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

ENERGY-RELATED CO_2 EMISSIONS

EMISSION TYPES

According to the UNFCCC, CO_2 accounted for 73.5% of total greenhouse gas (GHG) emissions, excluding land use, land-use change and forestry (LULUCF), in 2014, followed by methane (CH_4) for 12.9%, nitrous oxide (N_2O) for 9.3% and hydrofluorocarbons (HFCs) for 4.2%. Perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) collectively accounted for the remaining share. Emissions of all GHG gases (except HFCs) have decreased since 1990. Total GHG emissions fell strongly between 2005 and 2009, remained stable during 2011 to 2013, and declined even further thereafter.

SOURCES OF CO_2 EMISSIONS

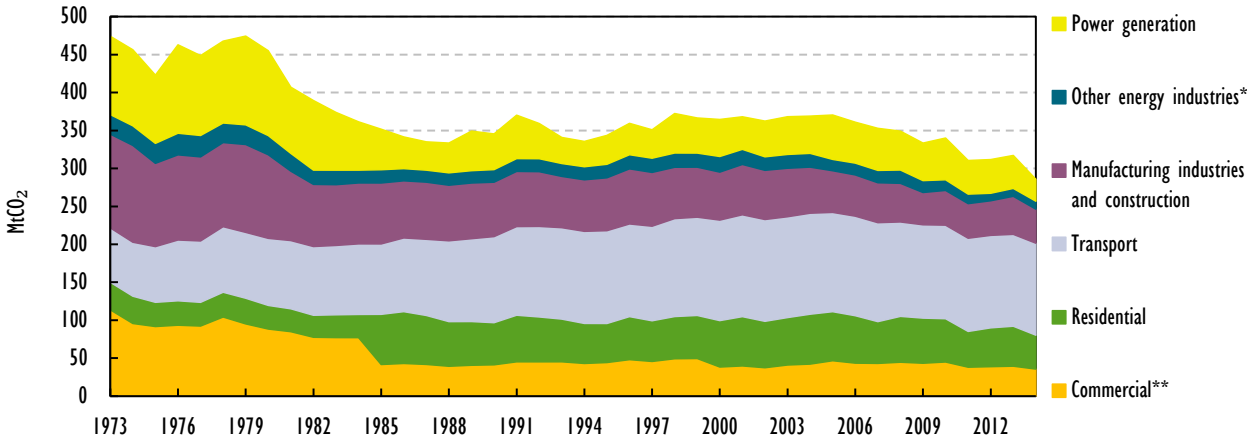
The IEA energy-related CO_2 emissions database recorded 285.7 million tonnes of carbon dioxide ($MtCO_2$) emissions from fuel combustion in France in 2014, which is 22.6% lower than in 2004. In 2014, the transport sector was the largest emitter with 121.2 $MtCO_2$ or 42.4% of the total. Households accounted for 15.7%, while the industrial and commercial sectors accounted for 15.7% and 12.4%, respectively. Power generation and other energy use (including refining and other fuel transformations) emitted 10.1% and 3.7% of total, respectively.

Emissions in 2014 were below 1990 levels across all sectors except transport. This decline was mainly due to emissions reductions in the industry sector (from 71.7 $MtCO_2$ to 44.8 $MtCO_2$ or 37.4%) and in power generation (from 47.1 $MtCO_2$ to 28.9 $MtCO_2$ or 38.6%). For 2014, the low level of emissions for power generation is due to very favourable climatic conditions. The combined share of the power generation and industry sectors in total emissions has fallen from 34.4% in 1990 to 25.8% in 2014. The decline in CO_2 emissions is also the result of reduced fossil fuel consumption thanks to energy efficiency policies and strong industrial energy-demand reduction (relocation/closures) during and after the financial and economic crisis in 2008 and in line with EU environmental rules such as the Large Combustion Plant Directive (LCPD) and the Industrial Emission Directive (IED).

Emissions from the residential and commercial sectors declined by 19.5% and 13.7%, respectively.

Emissions in transport increased by 6.8% during 1990-2014, from 113.4 $MtCO_2$ to 121.2 $MtCO_2$. Their share in total emissions went up by 9.6 percentage points from 32.8% to 42.4%. Emissions from transport recorded a high in 2001, at 134.2 $MtCO_2$, but have declined by 9.7% since. However, they cause increasing amounts of air pollutants due to the growing dieselisation of the car fleet over the past decade. However, the share of new diesel passenger cars has come down in recent years.

Figure 3.2 CO_2 emissions by sector, 1973-2014

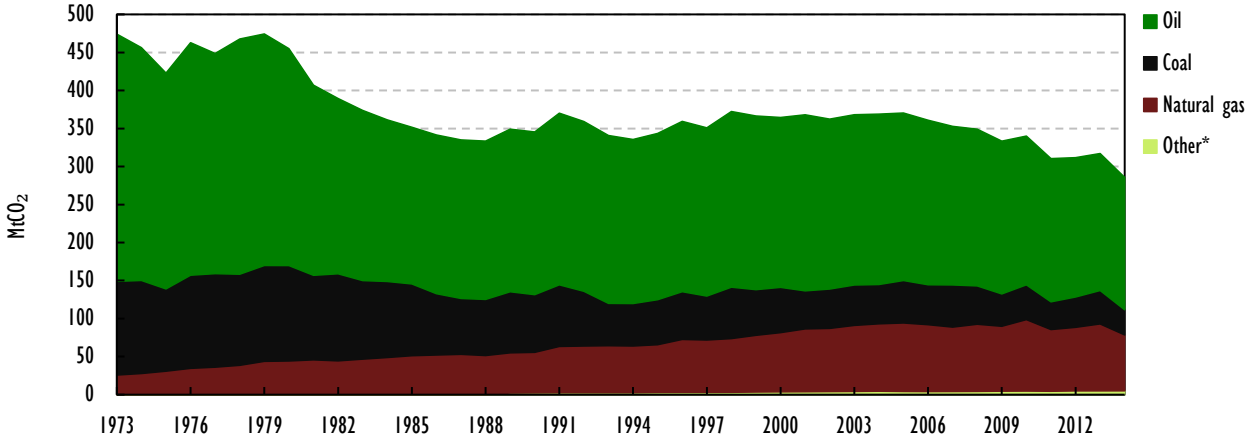


* *Other energy industries* includes other transformations and energy own use.

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

Source: IEA (2016a), *CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

Figure 3.3 CO_2 emissions by fuel, 1973-2014



* *Other* includes industrial waste and non-renewable municipal waste (negligible).

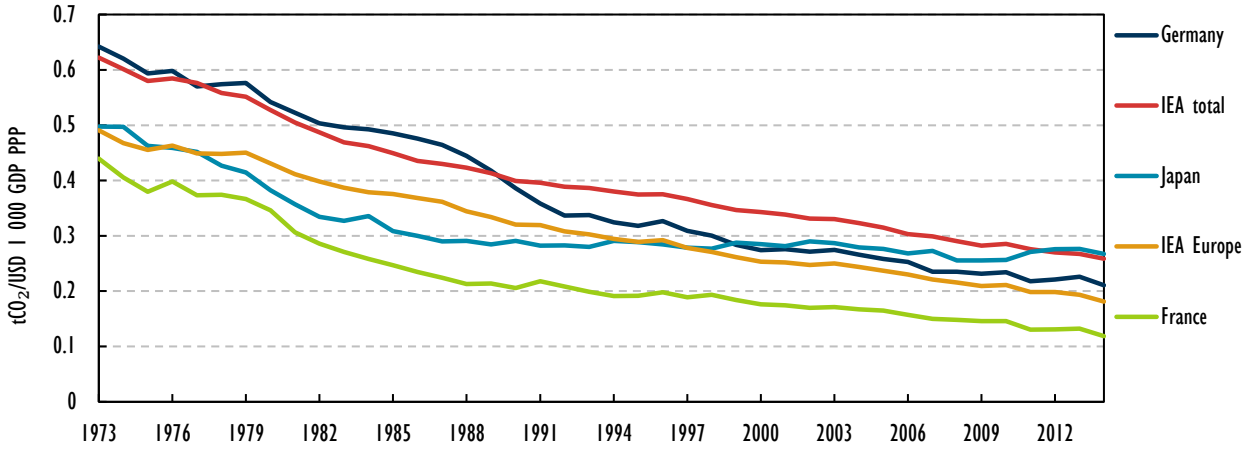
Source: IEA (2016a), *CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

In relation to all CO_2 emissions from fuel combustion in 2014, oil was responsible for 61% of total emissions, while natural gas accounted for 25.7%, coal for 11.6%, and waste for the remaining 1.7%. Since 1990, CO_2 emissions from oil and coal have declined by 18.6% and 56.4%, respectively, while those from natural gas and waste were up by 37.8% and 123.7%.

CARBON INTENSITY

France's carbon intensity, measured as CO_2 emissions by real gross domestic product adjusted for purchasing power parity (GDP PPP), amounted to 0.12 tonnes of CO_2 per USD 1 000 PPP (tCO_2/USD 1 000 PPP) in 2014. France ranked fourth-lowest among 29 IEA member countries, behind Switzerland (0.09 tCO_2), Sweden (0.09 tCO_2) and Norway (0.12 tCO_2). Carbon Intensity/GDP was around 65% of the IEA Europe average (0.18 tCO_2/USD 1 000 PPP) in 2014 or 46% of total IEA average of 0.26 tCO_2/USD 1 000 PPP (Figure 3.4). In addition, the carbon intensity of France's GDP has fallen much faster; it shrank by 42.2% compared to 0.21 t CO_2/USD 1 000 PPP in 1990 and by 28.9% compared to 0.17 tCO_2/USD 1 000 PPP in 2004. The average carbon intensity of IEA member countries declined by 35.2% compared to 1990 and by 19.8% compared to 2004.

Figure 3.4 Energy-related CO_2 emissions per unit of GDP in France and in other selected IEA member countries, 1973-2014



Source: IEA (2016a), *CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

INSTITUTIONS

Unlike many other IEA countries, France has integrated relevant energy, environment and climate change policies in one institution, the **Ministry of Environment, Energy and the Sea** (*Ministère de l'environnement, de l'énergie et de la mer*, *MEEM*). The ministry covers sustainable development, sustainable cities and housing, energy technologies, energy policy and climate change, including global warming and greenhouse gas (GHG) emissions control, transport, fishery and agriculture. European and international climate negotiations are also under the remit of MEEM. Within the ministry, the **Directorate-General for Energy and Climate (DGEC)** plans and implements policies and measures concerning the energy mix, energy efficiency and energy security; and the fight against climate change and air pollution. Energy taxation is shared between MEEM and the Ministry of Economy and Finance.

The **Environment and Energy Management Agency** (*Agence de l'environnement et de la maîtrise de l'énergie*, *ADEME)* is a public agency under the joint supervision of MEEM and the Ministry of Higher Education and Research (MESR), active in the implementation

of public policy with the aim of protecting the environment, managing energy and sustainable development. An important part of ADEME's activities is dedicated to energy efficiency but also to climate, waste and air pollution.

In April 2016, the **French Public Health Agency** (*Santé publique France*) was created as the national public health agency which supervises air pollution, among other issues, through the merger of the French Institute for Public Health Surveillance (InVS), the French Institute for Health Promotion and Health Education (Inpes) and the Establishment for Public Health Emergency Preparedness and Response (Eprus).

Under the authority of MEEM and the regional authorities (*préfets*) are 13 regional directorates, the so-called **DREAL** *(directions régionales de l'environnement, de l'aménagement et du logement)* and DRIEE in the specific case of Ile-de-France (*direction régionale et interdépartementale de l'environnement et de l'énergie*) which intervene in each French metropolitan region. There is also a directorate called **DEAL** (*direction de l'environnement, de l'aménagement et du logement*) in each overseas department. All three regional directorates work closely with the public to implement energy policy objectives through Regional Climate, Air and Energy Schemes (SRCAE) and Territorial Climate-Air-Energy Plans (PCAET).

POLICIES AND MEASURES

TARGETS

2020 targets

Climate and GHG emission mitigation targets are set under the UNFCCC (Kyoto Protocol and Doha amendment) and the EU 2020 Climate and Energy Package, which defines a binding EU target of 20% reduction of total GHG emissions below 1990 levels during the Kyoto second commitment period 2013-20. Under the EU Emissions Trading Scheme (ETS), the European Union as a whole is committed to reduce the emissions from EU-ETS sectors (i.e. power generation, agriculture, refining) by 21% below 2005. Under the EU Burden Sharing Decision, France is required to reduce by 14% below 2005 levels emissions from all other sectors outside the EU-ETS (transport other than aviation, construction, waste, smaller industrial plants). The government expects it will be able to meet its 2020 climate targets with existing domestic measures. In a draft scenario that accounts for policy measures introduced during 2014, the government estimates that emissions in 2020 will be 15% below 2005 levels for the sectors outside the EU-ETS and 26% below 2005 levels for the ETS emissions.

2030 and 2050 targets

Towards 2030 and 2050, France's efforts on climate change are performed under the UNFCCC Paris Agreement and the EU 2030 policy framework for climate and energy (with its target of reaching at least a 40% reduction in GHG emissions by 2030 across the Union). The EU-wide 40% target is the determined contribution of the EU and its 28 member states to the 21st Conference of the Parties (COP21) and the Paris Agreement. It was submitted to the UNFCCC on 6 March 2015 and ratified on 5 October 2016. In order to achieve at least a 40% reduction by 2030, the sectors under the EU-ETS should reduce emissions by 43% below 2005 levels through the reformed EU-ETS. Non-ETS sectors would need to cut emissions by 30% below the level in 2005.

In July 2016, the European Commission presented a draft proposal for the new EU Burden Sharing Regulation of emissions from non-ETS sectors with individual binding targets for each member state. France will need to reduce its emissions by 37% by 2030; however, it can benefit from flexibility provisions in the range of 58.2 $MtCO_2$ of total net removals from deforested land, afforested land, managed cropland and managed grassland that member states may take into account for compliance for the period 2021 to 2030 pursuant to Article 7.

Box 3.1 The Paris Agreement

Under French Presidency of the 21st Conference of the Parties (COP21) negotiations of the United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement on climate change was reached in December 2015 by 197 Parties, marking a milestone in global climate change efforts.

The Paris Agreement is the first-ever global climate deal with obligations for all Parties. It is based on several key elements:

- overall objective to limit the global average temperature rise to well below 2°C and pursuit of efforts to limit the temperature increase to 1.5°C
- aim to reach global peaking of GHG emissions as soon as possible and to undertake rapid reductions thereafter, so as to achieve a balance between emissions and removals in the second half of this century
- self-determined actions by Parties to reduce emissions outlined in their nationally determined contributions (NDCs) and a commitment to review the NDCs every 5 years
- common framework (with flexibility for countries that need it) to track progress toward and achievement of NDCs for all countries on the basis of a robust transparency and accountability system
- periodic collective stocktaking of progress toward the long-term aims of the Agreement.

Other outcomes of COP21 besides the adoption of the Paris Agreement were:

- launch of Mission Innovation and the Breakthrough Energy Coalition and support for accelerating technology innovation
- highlighting role of cities, regions and local authorities, and of non-governmental stakeholders in supporting climate change mitigation and adaptation
- encouraging countries to develop long-term low-emissions development strategies.

With the signature of the Agreement in New York in April 2016, parties began joining the Agreement according to their own legal systems (through ratification, acceptance, approval, or accession). France ratified the Paris Agreement on 5 October 2016. On 4 November 2016, the Agreement entered into force, after the threshold was reached of at least 55 Parties which together represent at least 55% of global GHG emissions joining. As of 30 November 2016, 115 Parties had deposited their instruments of ratification, acceptance or approval.

Domestic targets

In August 2015, France adopted the *Energy Transition for Green Growth Act* (*Loi relative à la transition énergétique pour la croissance verte, LTECV*) which sets 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).

CARBON BUDGETS

Mitigation efforts will need to come from three key energy-consuming sectors, transport, buildings, industry, and agriculture. As a means to implement its 2030 and 2050 objectives, France has chosen a carbon budget approach which sets upper limits for GHG emissions that should not be exceeded on average. In November 2015, France presented a national low-carbon development strategy (*Stratégie nationale bas-carbone, SNBC*) and adopted a regulation that sets emission caps for three successive periods (2015-18, 2019-23, and 2024-28) with sector-specific emissions reduction targets by 2024-28, compared to 2013 and targets for 2050 below 1990 levels (Table 3.1).

Table 3.1 Low-carbon strategy and sector-specific GHG targets: Policies and measures

Sector	2024-28*	2050	Policies and measures
Transport	-29%	-69%	Vehicle energy efficiency: average fuel economy of 2 litres/100 kilometres for vehicles sold in 2030. Low-emission vehicle quotas in public fleets, including buses. Development strategy for recharging infrastructure. Curb demand for mobility (town planning, teleworking, car-pooling). Tax incentives for cycling mobility, development of public transport. Modal shift for freight towards rail and ship.
Buildings	-54%	at least -87%	Implement 2012 thermal regulation and strengthen it towards life-cycle analyses. Renovate the stock of buildings to high standards of efficiency in 2050. Speed up the management of energy consumption (eco-design, consumption awareness-raising for appliances and other, smart meter).
Agriculture and forestry	at least -12%	-50%	Step up agro-ecology projects towards practices with lower emissions per unit of value. Reduce nitrogen surplus by optimising the use of synthetic nitrogen fertilisers, recover energy from effluents, etc.). Deploy production techniques adapted to climate change. Increase wood harvesting to support bio-sourced sustainable products.
Industry	-24%	-75%	Control the demand for energy and materials per product investments and energy efficiency services. Promote the circular economy (re-use, recycling and energy recovery). Reduce the share of energy sources with high GHG intensity.
Energy	below 2013 levels during three carbon budgets 2015-28	-96%	Speed up energy efficiency (factor 2) by reducing the carbon footprint of the energy mix by 2050. Develop renewable energy sources instead of new thermal plants. Improve power system flexibility to increase the share of renewables.
Waste	-33%	-80%	Reduce food waste and prevent the production of waste. Resource recovery by recycling and sorting biowaste at the source by 2025. Reduce methane emissions from landfill sites and purification plants. Ultimately stop incineration without energy recovery.

* Compared to 2013 levels.

Progress under the low-carbon strategy will be reviewed for the first time in 2018 for the adoption of the carbon budgets in 2015-18, 2019-23 and 2024-28 and every five years thereafter.

National pluri-annual programming with plans for transport, energy and agriculture will be supporting these emission budgets. In July 2016, the government presented a strategy on the development of clean mobility. On 27 October 2016 the pluriannual energy programming (PPE) was adopted by law (*Décret n° 2016-1442 du 27 octobre 2016 relatif à la programmation pluriannuelle de l'énergie*).

CARBON PRICING

European Union Emissions Trading Scheme (EU-ETS)

The EU-ETS is a mandatory cap-and-trade system covering CO_2 emissions from energy-intensive industry. It was launched in 2005 and its first commitment period ran until the end of 2007. The second phase covered the period 2008-12. Installations under the EU-ETS can meet their obligations either by reducing emissions on their own, or by purchasing allowances from other installations covered by the scheme, or by purchasing credits under the Kyoto Protocol's flexible mechanisms (joint implementation or the clean development mechanism).

From 2005 to 2012, emission allowances were allocated to the facilities on the basis of a national allocation plan (NAP). The NAP was prepared by the government following criteria set out in the ETS Directive (2003/87/EC, later amended by 2009/29/EC) and approved by the European Commission. More than 95% of the allowances in the European Union were allocated to the companies free of charge. Over-allocation of allowances as well as a decline in economic activity led to a large surplus of allowances, a steep decline in their prices and a need to reform the ETS scheme.

The third phase of the EU-ETS is currently running from 2013 to 2020. It is significantly different from previous phases. NAPs are no longer required and a single EU-wide ETS cap is introduced. The cap is reduced by 1.74% per year from 2010 onwards, resulting in a total reduction of 21% by 2020 below the 2005 levels. More than 40% of allowances will be auctioned and electricity generation will no longer receive free allowances. For the sectors where allowances will still be given away for free, such as manufacturing industry and heat sectors, harmonised allocation rules apply, based on EU-wide benchmarks of emissions performance. A separate cap applies to the aviation sector. From 2021 to 2030, the number of allowances will be reduced by 2.2% per year, and a market stability reserve of allowances is expected to be introduced in 2019.

Comparison of the volume of allowances allocated and the actual emissions from 2008 to 2012 indicates that global economic cycles, along with impacts of renewable and energy efficiency policies, have had more impact on emissions than the ETS itself. In this context, governments have started to complement the EU-ETS with other carbon pricing mechanisms.

Carbon pricing outside EU-ETS sectors

In accordance with the roadmap from the National Environment Conference of 2012, a green taxation committee (*Comité pour la fiscalité écologique*, in 2015 renamed into the *Comité pour l'économie verte)* has been set up in December 2012 in order to enhance

environment taxation. A first carbon tax was proposed in 2009 but it was rejected by the Constitutional Council of France. On 1 January 2014, France introduced a carbon component in the domestic tax on consumption of energy products *(taxe intérieure de consommation sur les produits énergétiques, TICPE)*, under Article 32 of the Finance Law 2014. The carbon component, imposed on sectors outside the EU-ETS, amounted to EUR 7/tCO_2 in 2014, EUR 14.5 /tCO_2 in 2015 and reached EUR 22/tCO_2 in January 2016. For EU-ETS sectors, the tax is limited to EUR 7/tCO_2. The Energy Transition for Green Growth Act includes a target for one tonne of carbon to be valued at EUR 56/tCO_2 in 2020 and EUR 100/tCO_2 in 2030, which will need to be confirmed by annual Finance Acts.

As announced by the President of the Republic in April 2016, a carbon price floor should be put in place by 1 January 2017 in the French power sector: a report published on 11 July 2016[1] proposed to focus this price floor on coal plants. France would lose another 2% of coal-fired generation capacity by 2020 as a result of the new carbon price floor. However, these plans have not been realised by the time of publication of this report.

There are many socio-economically motivated full or partial tax exemptions or refunds on VAT or excise duties on oil products, and a reduced rate of excise duties on fuels used by taxis, machinery used in agriculture and construction, boats, company cars, road freight transport, etc.

There is a difference between taxation on diesel and that on petrol in France, as in other EU countries (see Chapter 2 on General Energy Policy). This difference was very significant a few years ago (about EUR 18 cents/L in 2014) but it is quickly decreasing. With the levels adopted for 2017 in the Finance Law, the difference will be reduced to EUR 12 cents/L.

AIR QUALITY

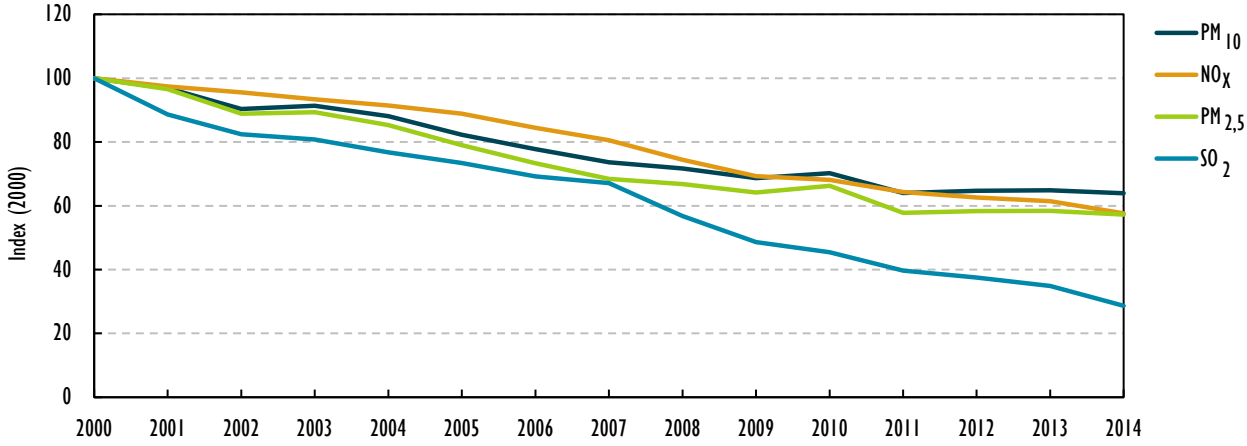
Local air pollution[2] in cities continues to have considerable health and economic impacts. Over the past ten years, air pollutants and concentrations have decreased. However, concentration levels of particulate matter (PM_{10}) and nitrogen dioxides remain above the limits imposed by the EU Air Quality Directive (2008/50/EC). Most of the NO_X emissions stem from diesel use in transport and fossil fuel-fired heating, but also from diesel- or coal-fired power plants (5%). SO_2 emissions stem mainly from industry and energy transformation; PM_{10} and $PM_{2.5}$ are linked to wood- or fossil fuel-based heating, transport, industrial and agricultural activities.

The French state monitors air pollution through regional air quality surveillance by approved associations (AASQA). It records differences and diffuses the findings through the central air quality surveillance laboratory (*Laboratoire central de surveillance de la qualité de l'air, LCSQA*) and through a national inventory (*Centre interprofessionnel technique d'études de la pollution atmosphérique,* CITEPA). In June 2015, the government presented an air quality action plan with four main measures: *i*) introduction of an air quality certificate (*certificat qualité de l'air*) for less polluting cars, *ii)* a call for proposals for breathable cities within five years (*villes respirables en 5 ans*), *iii)* an anti-pollution framework as part of the Energy Transition for Green Growth Act, and *iv)* financial aids for clean cars (bonus).

1. www.developpement-durable.gouv.fr/Les-actions-engagees-sur-le-prix,48284.html

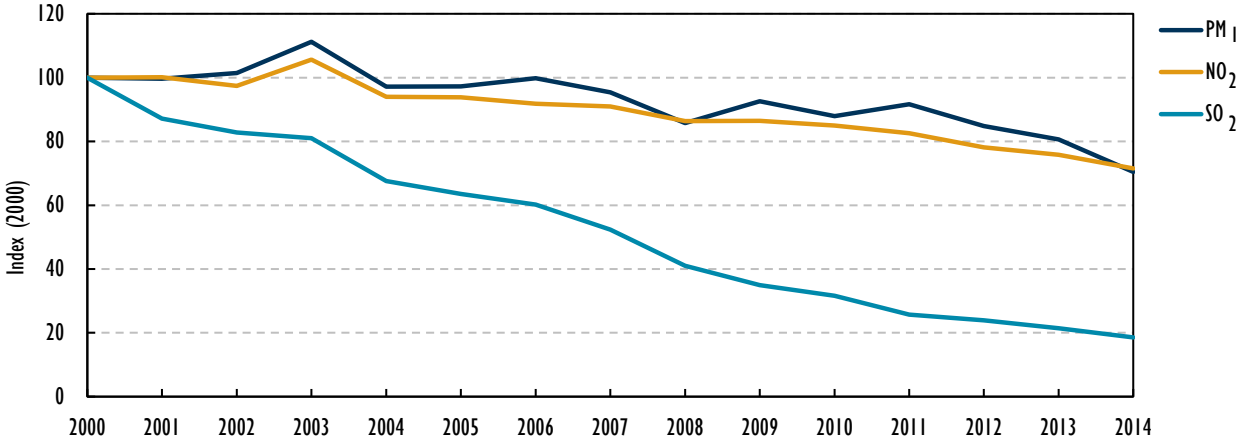
2. Air pollutants include nitrogen oxides (NO_X), sulphur dioxides (SO_2), ozone and particulate matter (PM_{10}, $PM_{2.5}$).

Figure 3.5 Emissions of air pollutants, 2000-14



Source: Citepa (*Centre interprofessionnel technique d'études de la pollution atmosphérique*) (2015), *Rapport Format Secten*, April.

Figure 3.6 Concentrations of air pollutants, 2000-14



Source: *Institut National de l'Environnement Industriel et des Risques* (2015), Géod'Air database, May.

Policy efforts will be set out in the forthcoming National Plan for Air Pollution Reduction (PREPA) and regional climate-air-energy schemes (SRCAE), but also in territorial climate-air-energy plans (PCAET), and local atmosphere protection plans endorsed by the state, in line with Article 23 of EU Air Quality Directive (2008/50/EC).

The 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 (see Box 3.2). Some actions fall within the remit of the state and local authorities need an authorisation to act on its behalf, including some taxation measures.

To address pollution peaks, for instance, the state allows that temporary actions be imposed by local authorities, including urban zonal restrictions, car circulation restrictions and special driving lanes for low-emission cars as recommended by the Ministerial ruling of 26 March 2014 and in local rulings (OECD, 2016).

Box 3.2 Addressing air pollution in Paris

The Paris metropolitan area is home to 12 million people, or almost 20% of France's population. It generates around one-third of the country's gross domestic product. Its climate and geographic morphology favours atmospheric pollutant dispersion and leaching, but these factors are offset by high emissions levels, due to high population density and activity levels. The situation is no longer pressing for certain pollutants, such as sulphur dioxide (SO_2) which has been reduced by 20% over the last 50 years in the Paris metropolitan area, thanks to lower emissions from industrial activities and lead (Pb) which has been removed from transport fuels. The lower benzene content of fuels has also improved the situation. However it is estimated that between 1 and 4 million inhabitants are still exposed to NO_2 and PM_{10} concentrations above the established limits, especially along main streets. Ozone levels also periodically exceed the levels regarded as safe for human health.

The two principal sources of pollution in the Paris region are transport and heating. Road transport accounts for over half of NO_x emissions (of which 80% comes from passenger diesel cars and trucks) and for 30% of primary PM_{10} emissions. Heating, including biomass burning, is responsible for 20% of NO_x emissions in the region and 25% of primary PM_{10} emissions. In the City of Paris, a successful mobility plan – including access to shared bikes and electric vehicles, restricted bus lanes and trams – decreased car use by an estimated 25% (and increased the use of public buses) between 2002 and 2012.

Together with the rising efficiency of the vehicle fleet, this led to a decrease of 30% of NO_x emissions and 35% of PM_{10} emissions over the period. The decrease would have been greater without the higher national fiscal incentives that increased the purchase of diesel cars (and thereby increased NO_x and PM_{10} emissions). These countervailing trends also partly explain why the concentration of nitrogen dioxide (NO_2) in the atmosphere remained relatively stable during those years.

In 2015, the municipality took the further measure of banning the circulation of trucks and buses that are older than 15 years during work days, a measure seen as the first step towards banning old, pre-Euro-5, diesel cars by 2020. In addition to regularly unacceptable levels of certain pollutants, Paris experienced 16 days of acute pollution in 2015. Such episodes are prevalent in the spring. In this season, they are typically due to ammonia emissions from outside the city, stemming from the use of fertilisers, combined with meteorological conditions that favour higher baseline pollution levels in the metropolitan area. Emergency measures to reduce peak intensity in such circumstances include suspending charges for the use of regional public transport and limiting circulation (banning, in turn, the use of vehicles with even and uneven numbered licence plates). Other measures taken by the City of Paris include making residential parking free and providing financial incentives for the use of Autolib (electric car-sharing).

Further air quality improvements require integrating European, national and local approaches: it is estimated that 39% of particulate matter that Paris citizens are exposed to in places with high pollution come from outside the metropolitan area. Improvements also depend on integrated mitigation measures for different sources of pollution: not only do transport policies matter, but the use of biomass in the Paris region also needs to be discouraged, industrial emissions need to be lowered and agricultural sources of particulate matter need to be addressed.

Box 3.2 Addressing air pollution in Paris (continued)

Information is the cornerstone of mitigating the impact of air pollution. In 1979, Airparif was established as the independent air quality monitoring network of the Paris region and constantly monitors several pollutants. Each day, Airparif forecasts expected levels of pollution, especially when air quality is particularly bad, and informs the authorities (which may then adopt short-term measures), the general public and the media.

In December 2016, the mayor of Paris joined efforts with mayors of Mexico City, Madrid and Athens to implement a ban of diesel cars in the cities by 2025 with the goal to improve air quality.

Source: IEA (2016b), *IEA World Energy Outlook Special Report 2016: Energy and Air Pollution*, OECD/IEA, Paris.

Air pollution, in large part caused by fine particulate fuel emissions, kills 48 000 people each year in France, according to the latest findings by the French public health agency (*Santé publique France, 2016).* In July 2016, Paris banned old cars registered before 1 January 1997 from its streets on Monday to Friday, 8 am to 8 pm, to reduce air pollution from old vehicles in the city centre.

France is working towards reducing air pollution through a number of measures:

- *Transport*: reinforced bonus/penalty scheme for cars and a new scrap bonus to change an old diesel car to an electric one (EUR 10 000), or Euro-6 cars (EUR 1 000), tax credit for electric cars terminals, increase in diesel taxation in line with its carbon content towards converging taxation for diesel and gasoline within five years;
- *Urban traffic*: low-emission zones (the legal framework is in place in Paris, Versailles and other towns); low speed limits (on the Parisian ring-road); support to public transportation; company car tax (TVS) to take into account externalities of diesel cars; obligation to renew a fleet of vehicles with a share of low-emitting vehicles, parking and traffic advantages for low-emitting vehicles and car sharing.
- *Industry*: new regulations for combustion plants (the EU Large and Medium-Sized Combustion Plant Directives) entered into force on 1 January 2016; reinforcement of air pollutant emissions tax (TGAP) imposed on industry, including waste-incineration enterprises, extracting and refining, and petrochemical industries.
- *Residential*: household tax credits for renewable energies or efficient appliances or insulation, mandatory station for bicycles and electric vehicles in certain new buildings; mandatory mobility plans for enterprises with over 100 employees in urban areas, and air quality national day.

In line with the EU Large Combustion Plant Directive and the Industrial Emission Directive 2010/75/EU, in 2014, five coal power units (on three sites) were stopped. Over the past five years (2012-16), about 3.3 gigawatts (GW) of coal capacity has been closed. Coal-fired power generation decreased to 11 terawatts per hour (TWh) in 2014 (25 TWh in 2013), and now represents 25% of coal consumption and 1.5% of total electricity production. The production decrease made a significant contribution to the decrease of CO_2 emissions from the power sector. At the beginning of 2016, only four coal-fired power plant sites were still in use (two plants by EDF, two by Uniper). Investments on these units are focused on de-pollution rather than energy efficiency. A retrofit of EDF

power plants in Le Havre and Cordemais (with flue gas desulphurisation and denitrification systems) is ongoing, in order to enhance technical and environmental performance and comply with Directive 2010/75/EU. More precisely, smoke denitrification in these plants will allow capturing 80% of nitrogen oxides, 90% of sulphur dioxide and 99% of fly ash according to EDF.

The IEA estimated that 6.5 million deaths worldwide are linked to air pollution with the number set to increase significantly in coming decades unless the energy sector takes greater action to curb emissions (IEA, 2016b). Energy production and use – mostly from unregulated, poorly regulated or inefficient fuel combustion – are the most important man-made sources of key air pollutant emissions: 85% of particulate matter and almost all of the sulphur oxides and nitrogen oxides. They stem from factories, power plants, cars, trucks, and from the 2.7 billion people worldwide who are still relying on polluting stoves and fuels for cooking (mainly wood, charcoal and other biomass).

The IEA calls for government action in three key areas:

- Setting an ambitious long-term air quality goal, to which all stakeholders can subscribe and against which the efficacy of the various pollution mitigation options can be assessed.
- Putting in place a package of clean air policies for the energy sector to achieve this long-term goal, drawing on a cost-effective mix of direct emission controls, regulation and other measures, giving due weight to the co-benefits for other energy policy objectives.
- Ensuring effective monitoring, enforcement, evaluation and communication: keeping a strategy on course requires reliable data, a continuous focus on compliance and on policy improvement, and timely and transparent public information.

CLIMATE CHANGE ADAPTATION

France has witnessed an increasing number of heat waves and its large nuclear power generation fleet requires significant amounts of water cooling. France also relies on electric heating and cooling during peak consumption periods and depends on hydropower availability for electricity generation.

France has a long coast line, as it borders four seas: the North Sea, the Channel, the Atlantic and the Mediterranean. Rising sea levels or more frequent inundations also impact energy infrastructure, including energy importing-exporting ports, e.g. liquefied natural gas (LNG) terminals.

In 2010, France adopted a first National Climate Change Adaptation Plan (PNACC) for the period 2011-15 with 84 actions in 20 areas, which underwent a mid-term review in late 2013. In the PNACC, the government identified significant consumption peaks during hot and cold spells and lower water availabilities during drought periods as the key risks in the energy sector which require adaptation. Measures include a capacity mechanism in the electricity market to ensure peak generation, efficient heating and cooling from renewable energy sources, and improving the availability and quality of hydrogeological and climate data, integrating climate change impacts in the monitoring of the water beds, as part of the EU Water Framework Directive, and identifying French industrial sectors which are vulnerable to climate change.

Following external evaluation in 2015, a new PNACC 2016-20 is being developed. The government emphasised also the climate change adaptation needs of France's overseas territories, urban resilience, water, biodiversity, research, mountains and coasts.

CLIMATE FINANCING

France is leading international efforts by requiring mandatory carbon disclosure for listed companies, and carbon reporting for institutional investors defined as asset owners and investment managers. Article 173 of the Energy Transition for Green Growth Act requires investors to disclose how they factor environmental, social and corporate governance (ESG) criteria and carbon-related aspects into their investment policies.

Listed companies shall disclose in their annual reports the following elements:

- Financial risks related to the effects of climate change and the measures adopted to reduce them.
- The consequences of climate change on the company's activities and on the use of goods and services it produces (in addition to the reporting on the social and environmental consequences of the company's activity, which is already mandatory in France according to the Grenelle II Act).

Banks and credit providers shall disclose in their annual report the risk of excessive leverage and the risks exposed by regular stress tests (not related to carbon).

Institutional investors are obliged to disclose information on how ESG criteria are considered in their investment decisions and how their policies align with the national energy transition strategy.

At the international level, France will have contributed a total of USD 1 billion by 2018 to the Global Environment Facility and the Clean Technology Fund, and is a member of the Board of the Green Climate Fund.

In 2012 the French Development Agency (*Agence française de développement, AFD*) committed EUR 2.4 billion for 54 climate-related projects. These projects are supported by the French Global Environment Facility (FFEM) and technical operators, including the Institute of Research for Development (IRD), the Environment and Energy Management Agency (ADEME), and ONF International (ONFI) which is the international branch of the National Forests Office.

ASSESSMENT

Climate change remains a top priority of the French government which pursues ambitious climate policies both at home and abroad.

At international level, France's leadership on global climate change mitigation has been strong. In December 2015, France hosted the Conference of the Parties (COP21) and contributed towards the signature of the Paris Agreement on Climate Change in New York on 22 April 2016, its ratification in October and entry into force in November 2016, not even one year after its agreement at COP21.

At home, the government has adopted significant measures in support of the global climate ambitions, notably the Energy Transition for Green Growth Act in 2015 and the national low-carbon strategy (SNBC), and implemented regulations that set out carbon budgets up to 2028.

France already has a very low-carbon energy mix, thanks to the leading role of nuclear energy, which accounted for 78% of electricity generation in 2015, to the role of hydro (10% in the electricity mix) and the gradual closure of old coal- and oil-fired power plants, partly as a consequence of EU air quality requirements. CO_2 emissions per capita are half the IEA average and France ranks fifth-lowest in its carbon intensity among IEA countries.

In 2014, France's GHG emissions reached 464.4 $MtCO_2$-eq, excluding LULUCF, that is 15.4% below 1990 levels. French climate targets under UNFCCC (Kyoto Protocol and Doha amendment) are linked to the EU 2020 Energy and Climate Package. The government met its climate targets under the Kyoto Protocol for the first commitment period (2008-12); when in fact GHGs declined by 7.5%.

Since 1990, GHG emissions have seen a sharp decline, thanks to large reductions in industry and energy production. However, emissions in the transport, waste, and residential and services (buildings) sectors are still growing. Energy-related CO_2 emissions in 2014 stem mainly from the transport sector (42.4%), residential and services (28.1%) and manufacturing industries (15.7%), power generation (10.1%), other energy industries (3.7%). Commendably, policies and measures envisaged under the Energy Transition for Green Growth Act target emission reductions in those sectors and France has put in place five-year emission limits (carbon budgets) in line with the national low-carbon strategy and the carbon trajectory. They target emissions reductions across the economy, including in transport, buildings and industry, in each budget period towards 2030 and 2050. In the medium-term towards 2025 and 2030, the success of these emissions reductions will depend on the actual contribution of renewable energies and the speed of buildings renovation, as well as on efforts to reduce the emissions in the transport sector but, crucially, on the future role of nuclear energy the contribution of which to the electricity mix is targeted to decrease to 50% by 2025 from 78% in 2015.

Building upon earlier attempts to adopt a carbon tax in France, the government successfully introduced, under the 2014 Finance Law, a carbon component in the energy tax which is proportional to GHG emission content. Sectors outside the EU-ETS are subject to the tax, while EU-ETS sectors are charged at a stable rate of EUR 7/tCO_2. For the EU-ETS, the government announced plans to introduce a carbon price floor in 2016 at the level of EUR 30/tCO_2 which would be limited to coal-fired power plants and equal *de facto* to a coal tax. However, these plans were not realised by the time of writing.

Another area of progress is the gradual reduction of the gap between diesel and gasoline taxation within five years. The government has started to tackle this differential in taxation. However, there are many tax exemptions on fossil fuel consumption in place for several sectors which prevent the tax system from adequately reflecting the externalities of transportation, including the cost of infrastructure investment and congestion. The IEA encourages the government to review all energy taxation in order to make it an effective and central instrument of policy implementation. Continuous focus on energy taxation, notably to fully abolish the differential between diesel and gasoline taxation, would be important for emissions reductions in non-ETS sectors (transport, agriculture) and improve air quality. The government should complete the revision of the energy-climate taxation to better reflect the cost associated with climate change and air pollution and to avoid wasteful consumption so as to encourage citizens and manufacturers towards clean mobility, heating and agriculture (as part of the new industrial plans under the Energy Transition for Green Growth Act).

France continues to struggle with local air pollution and levels set for the protection of human health are regularly exceeded in urban areas for concentrations of particulate matters (PM_{10} and $PM_{2.5}$) and NO_2. France has been implementing a series of measures and has a good potential to expand the use of natural gas, biofuels for freight and passenger transport, modal shift as well as to increase the penetration of electric vehicles in urban areas. While the government pursues a large range of policies to reduce air pollution (national plan for air pollution reduction, atmosphere protection plans with a focus on particulate matters and NO_x/SO_x and transport policies), the IEA encourages the government to proceed with the implementation of these important measures, to foster the governance of national, regional/territorial and local action, and to ensure compliance with regulated limit values.

Next to mitigation, adaptation to climate change impacts is becoming increasingly relevant for France, as the country's energy sector is facing significant heat waves, with consumption peaks in hot and cold spells and lower water availabilities during drought periods. However, power generation (with the majority coming from hydro and nuclear) strongly depends on water for cooling purposes. Challenges from climate change cannot be ignored. Commendably, France has adopted a national adaption plan for 2011-15, which contains 84 actions and 230 measures which has been reviewed in 2013 so as to prepare the new 2016-20 plan. France has yet to evaluate the positive/negative impacts of climate change on the industry sector in the longer term and adapt the water framework to the new challenges, including introducing new water-saving policies. The IEA welcomes the opportunity, with the presentation of the new adaptation plan in 2016, to prioritise actions in this regard.

RECOMMENDATIONS

The government of France should:

- *When reviewing the carbon budgets, assess the cost-effectiveness of the various GHG emissions reduction measures to evaluate and adjust the effectiveness of policies over time, including the carbon taxation.*
- *Complete the revision of the energy-climate taxation in France with a view to better reflect costs associated with climate change and air pollution, reducing overlapping instruments and abolishing exemptions that encourage wasteful energy consumption.*
- *Evaluate climate change impacts and devise measures for adaptation within the energy transition framework to foster the resilience of the energy sector to climate change impacts.*

References

Citepa (Centre interprofessionnel technique d'études de la pollution atmosphérique) (2015), *Rapport Format Secten*, April.

Institut National de l'Environnement Industriel et des Risques (2015), *Géod'Air database*, May.

IEA (International Energy Agency) (2016a), *CO_2 Emissions from Fuel Combustion*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016b), *IEA World Energy Outlook Special Report 2016: Energy and Air Pollution*, OECD/IEA, Paris.

MEDDE (Ministry of Ecology, Sustainable Development and Energy) (2016), *2nd Biennial Report of France under the United Nations Framework Convention on Climate Change,* Paris.

OECD (2016), *Environmental Performance Review of France*, OECD Publishing, Paris.

Santé Publique France (2016), *Health Impacts of Air Pollution in France: New Facts and Perspectives,* (*Impacts sanitaires de la pollution de l'air en France: nouvelles données et perspectives)*, Paris.

UNFCCC (United Nations Framework Convention on Climate Change) (2016), *GHG Profiles,* database, accessed on 31 March.

4. ENERGY EFFICIENCY

Key data (2015 estimated)

Energy supply per capita: 3.7 toe (IEA average: 4.5toe), -13.8% since 2005

Energy intensity: 0.1 toe/USD 1 000 PPP (IEA average: 0.11 toe/USD 1 000 PPP), -16.5% since 2005

TFC (2014): 147.7 Mtoe (oil 45.6%, electricity 24.2%, natural gas 19.1%, biofuels and waste 7.4%, coal 2.1%, heat 1.5%, solar 0.1%), -13% since 2004

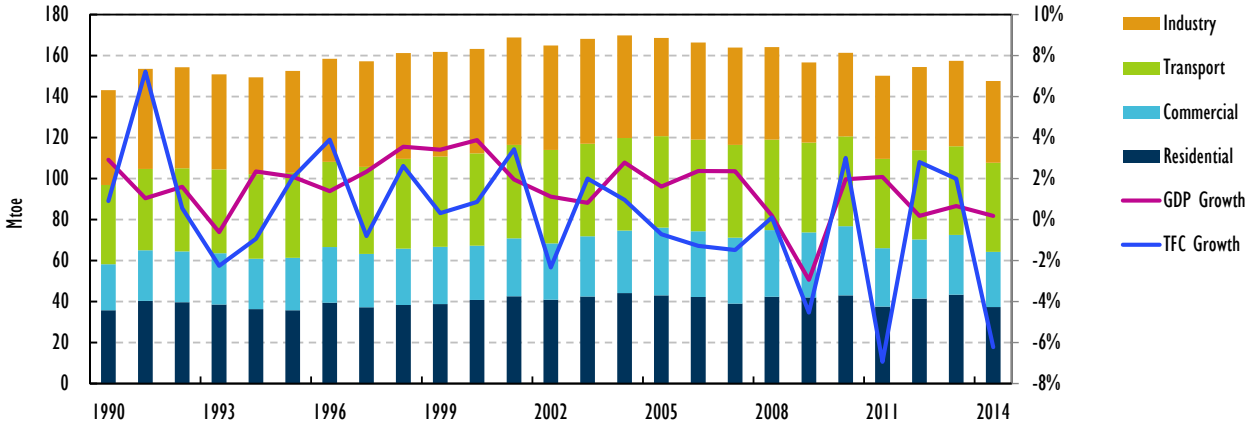
Consumption by sector (2014): transport 29.5%, industry 27%, residential 25.3%, commercial and public services and including agriculture 18.2%

FINAL CONSUMPTION OF ENERGY

France's total final consumption (TFC) was 147.7 million tonnes of oil-equivalent (Mtoe) in 2014. It has been declining since 2004, down by 13% from the record-high of 169.8 Mtoe in 2004 and decreased further to reach 1990 levels (Figure 4.1). The sectoral split of TFC has remained almost stable over time.

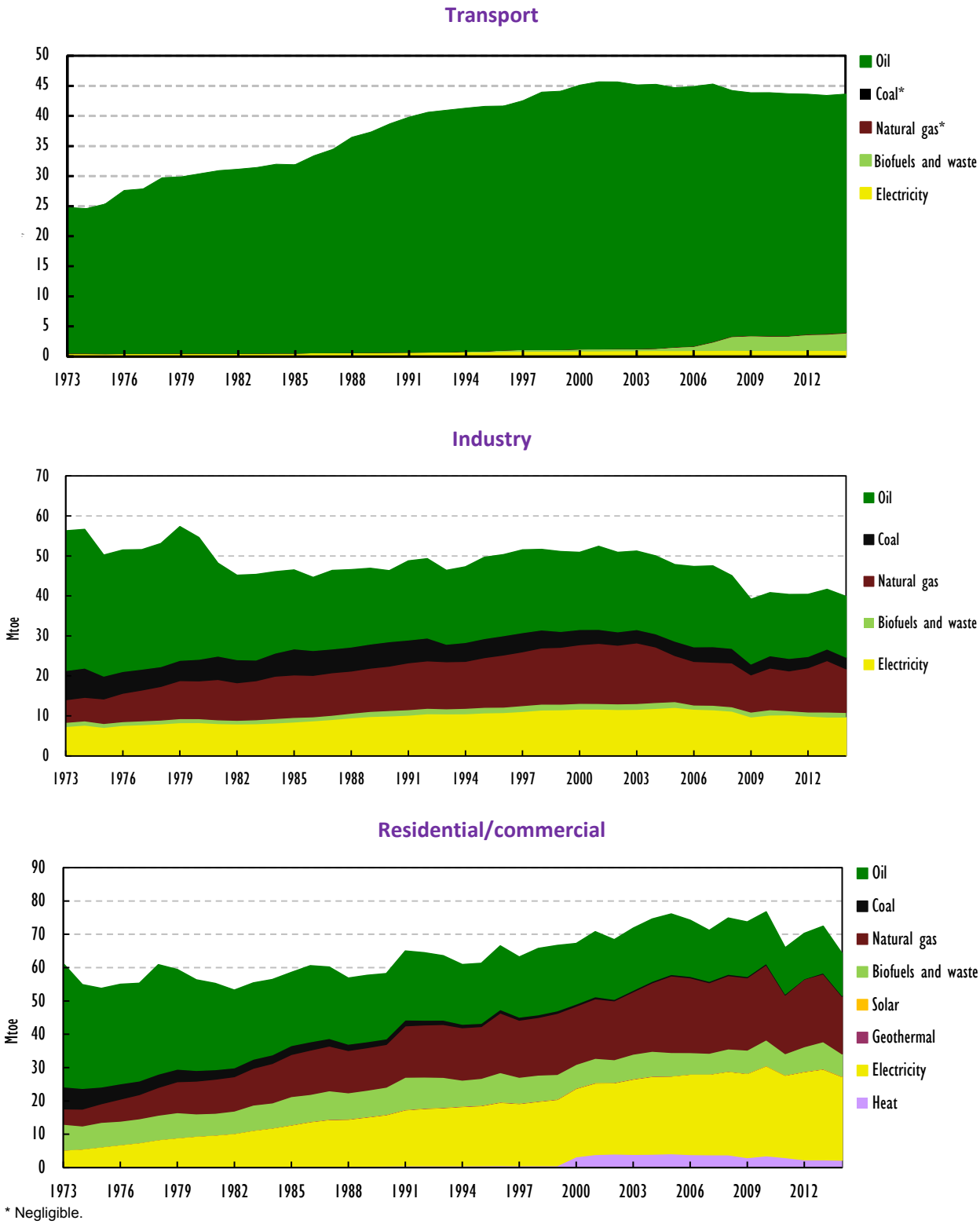
In recent years, there have been significant drops in TFC with negative growth rates, in 2009, 2011 and 2014, mostly driven by declines in industry and linked to the structurally low economic growth. In 2011, France's TFC dropped the first time significantly in 20 years, by 6.9%, but partially recovered over 2012-13 by 4.8%. Again in 2014, TFC dropped by 6%, with the residential/commercial consumption being the most volatile as the sector depends on the performance of the French economy.

Figure 4.1 TFC by sector with GDP and TFC growth rate, 1990–2014



Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/

Figure 4.2 TFC by sector and by source, 1973-2014



* Negligible.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Transport is the largest energy-consuming sector, with final consumption of 43.5 Mtoe in 2014 or 29.5% of TFC. Demand from transport has fallen by 3.6% since 2004. Oil represented 90.7% of total consumption in transport. The remainder is made up of biofuels and electricity, representing 6.7% and 2.5%, respectively. The use of biofuels in transport surged sevenfold over the decade to 2014. (Figure 4.2)

Industry is the second-largest energy consumer, with final consumption of 39.9 Mtoe in 2014 or 27% of TFC, reaching a record high in 2001 with 52.4 Mtoe but decreasing since. Its lowest level was in 2009 (39.2 Mtoe), amid the economic crisis. Demand from industry declined by 20.3% over the past decade to 2014, down from 29.5% in 2004. Industry relies on oil and natural gas to meet almost two-thirds (38.1% and 27.3% of demand, respectively), with electricity representing 24%. The remainder is made up of coal (7.3%) and biofuels and waste (3.3%). Consumption in industry decreased for all energy sources. The use of oil in industry decreased by 21.9%, while the use of natural gas dropped by 21.4%, and electricity consumption by 18.5%.

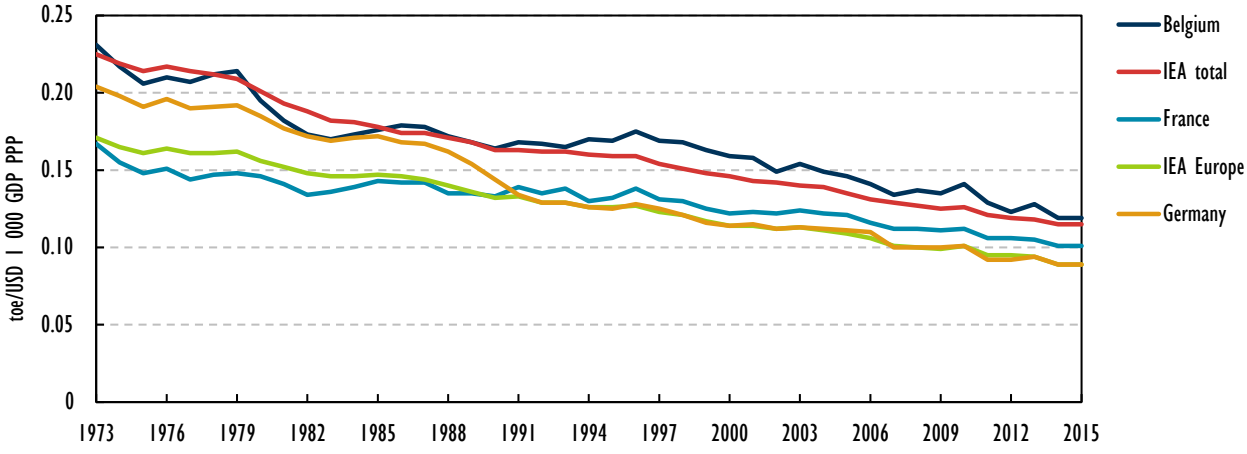
Residential and commercial (includes public services) accounted for 25.3% and 18.2% of TFC in 2014, respectively. Energy demand from the residential sector dropped by 15.4% below 2004 levels, and from the commercial sector by 11.7%. The two sectors consumed mostly electricity and natural gas, which accounted for 39% and 26.8% of total consumption respectively. Oil accounted for 19.6% and biofuels for 10.4%. The remainder is made up of 3.5% heat and a negligible portion of coal.

The energy mix in the residential sector has changed significantly since the 1970s. The use of coal almost disappeared and oil declined steadily, while natural gas and electricity have kept growing. In 1990, oil and electricity were the dominant sources in the residential sector, representing 30.7% and 23.3%, respectively. The share of oil kept decreasing and amounted to 16.6% in 2014, while electricity increased to 34.4%, the largest share, followed by natural gas with 28.9%.

ENERGY INTENSITY

Energy intensity, measured as the ratio of total primary energy supply (TPES) per unit of real gross domestic product adjusted for purchasing power parity (GDP PPP) was 0.10 tonnes of oil-equivalent per USD 1 000 PPP (toe/USD 1 000) in 2015.

Figure 4.3 Energy intensity in France and in other selected IEA member countries, 1973-2015

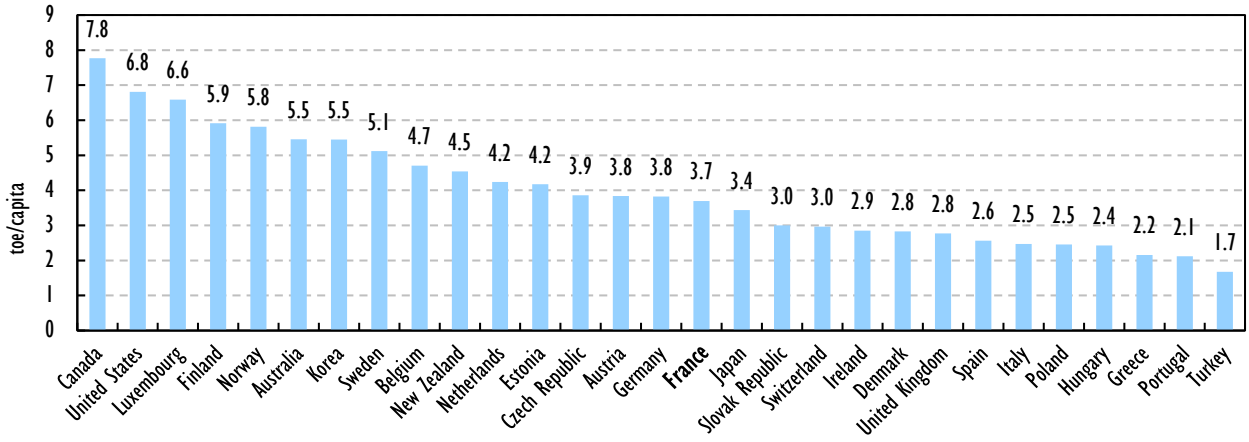


Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

France's energy intensity level is around the IEA average of 0.11 toe/USD 1 000 PPP, but slightly above the IEA Europe average of 0.09 toe/USD 1 000 PPP. It ranked fourteenth-highest among 29 IEA member countries. French energy intensity has evolved much in line with IEA intensities. The ratio for France declined by 16.5% from 2005 to 2015, while the IEA average intensity declined by 16.3% (Figure 4.3).

Another common indicator for international comparisons is energy consumption per capita (Figure 4.4). France's ratio of 3.7 toe per capita in 2015 was sixteenth-highest among IEA member countries, behind Austria and Germany.

Figure 4.4 TPES per capita in IEA member countries, 2015



Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

ENERGY EFFICIENCY PROGRESS

France's TFC in 2014 would have been 24.7% higher than in 1990 without changes in energy savings. To understand how much change can be attributed to progress in energy efficiency, a decomposition analysis is required (Figure 4.5).

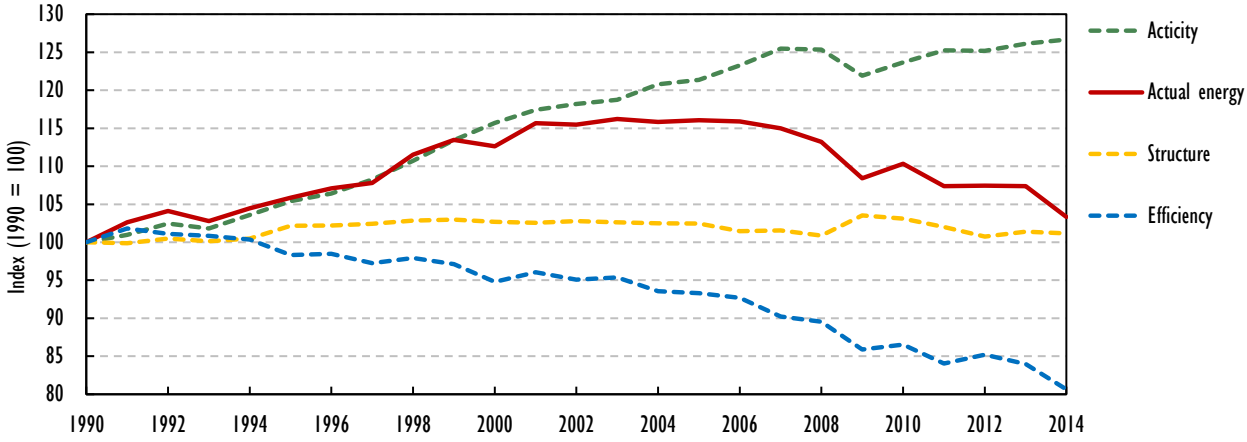
The total activity effect (economic growth in industry, population growth in the residential sector and person-kilometre in transport) puts an upward pressure on TFC. However, energy efficiency had the effect of mitigating this pressure to just 8.9%, reflecting efficiency-related savings of 7 Mtoe, mainly stemming from the residential sector.

With regard to the sectoral savings from efficiency improvements by sector in 2014, around 59% of total saving comes from the residential sector followed by the commercial and services sector (industry) which accounted for 25%, and transport for 16% (Figure 4.6).

The structural effect accounts for economic structural change in industry, floor area per person in the residential sector and modal shift in the transport sector. There was no significant change in the structure since 1990.

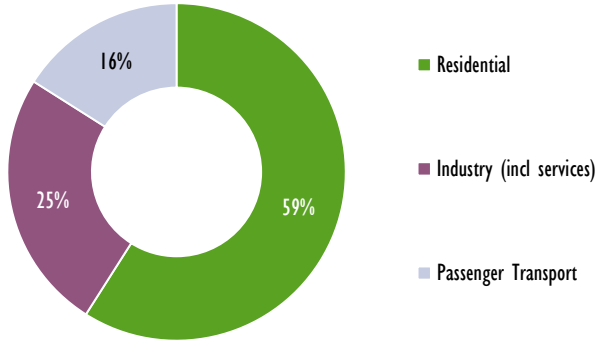
Therefore, the downward trend in TFC in France is mainly the result of overall energy efficiency improvements, as can be seen in the trends of Figure 4.5.

Figure 4.5 Changes in TFC broken down by activity, structure and efficiency effects, 1990-2014



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

Figure 4.6 Savings in TFC from energy efficiency improvements by sector, 2014



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

INSTITUTIONAL FRAMEWORK

The Ministry of Environment, Energy and the Sea (*Ministère de l'environnement, de l'énergie et de la mer, MEEM*) is the ministry in charge of the promotion of energy efficiency. Policies and measures are developed by two directorates, the Directorate General for Energy and Climate (DGEC) and the General Directorate for Development, Housing and Nature (DHUP). **The Regional Directorates for Environment, Spatial Planning and Housing (DREAL)** work under the prefects who perform their functions under the authority of the government (MEEM).

France has a dedicated energy efficiency agency with the **Agency for Environment and Energy Management** (*Agence de l'environnement et de la maîtrise de l'énergie, ADEME*). ADEME is a public entity under the joint supervision of MEEM and the Ministry of Higher Education and Research (MESR). Created in 1992 by merging three national agencies (energy, waste and air quality), ADEME has around 1 000 employees at three headquarters and 26 local offices across the country. ADEME's annual budget is around EUR 590 million, which includes a large Heat Fund and a Waste Fund.

POLICIES AND MEASURES

France's energy efficiency targets and measures are enshrined in both European and national legislation and policy initiatives. Up to 2020, the EU as a whole has the target to reduce total primary energy consumption by 20% below 2005 levels by 2020. The Energy Efficiency Directive (EED) 2012/27/EU requires national efforts to reach this commitment through sectoral targets. The EED includes an energy saving target of 1.5% per year across all annual sales of energy to end customers, excluding transport. In addition, EED requires a 3% target for annual renovations of state buildings and a national strategy for the reduction of consumption in the existing building stock by 2020.

Transposing the EED, the French government set out the goals of reducing by 2020 its TFC to 131.4 Mtoe (residential 31.9 Mtoe, tertiary 16.8 Mtoe, transport 42.5 Mtoe, industry 35.9 Mtoe, agriculture 4.3 Mtoe) and its TPES to 236.3 Mtoe or 219.9 Mtoe when excluding non-energy uses. The Energy Transition for Green Growth Act of August 2015 sets out the ambition to reduce the final energy consumption of fossil fuels by 30% towards 2030 (compared to 2012) and the overall final consumption by 50% towards 2050, compared to 2012, with an intermediate objective of -20% in 2030. The 2030 target translates into an average annual decrease of 1.2% per year.

Table 4.1 illustrates the projected energy consumption levels by sector for 2020 and 2030 with additional measures being implemented, including the Energy Transition for Green Growth Act. The 2020 energy efficiency target will be difficult to reach.

Table 4.1 Expected sectoral distribution of total final energy consumption (TFC) in 2020 and 2030

	Sector	Consumption (Mtoe)
Final energy 2020	Residential	39
	Tertiary	21
	Transport*	45
	Industry	32
	Agriculture	4
	Total	**140**
Final energy 2030	Residential	30
	Tertiary	18
	Transport*	40.6
	Industry	29
	Agriculture	3
	Total	**121**

Note: Transport includes international aviation.

Source: MEDDE (2016a), *Energy and Climate Panorama 2016,* Paris*;* MEDDE (2015a), *Energy and Climate Panorama 2015*, Paris; MEDDE (2015b), *Prospective Energy–Climate–Air Scenarios for France towards 2035*, Paris,

These national efforts will support the EU 2030 Climate and Energy Framework and the EU goal to achieve at least 27% energy savings compared to a business-as-usual scenario.

Over the past decade, France has been guiding energy efficiency policies towards several national targets. The 2005 POPE Law (*Loi de programmation fixant les orientations de la politique énergétique*) set ambitious long-term targets to reduce energy intensity by 2% per year by 2015 and by 2.5% per year by 2030, through the white certificates. Since, the government has been supporting energy efficiency policies across several sectors, through the white certificates scheme (Box 4.1) and taxation policies (Table 4.2).

Box 4.1 White certificates

The system of energy saving certificates (white certificates) was introduced by the POPE Law in 2005 and started its first three-year period in July 2006 with the objective to achieve energy savings in buildings, non-ETS industry, agriculture and transport.

White certificates oblige energy retailers and fuel suppliers (obligated parties) to offer their customers incentives to invest in energy-efficient equipment. Each obligated party receives a target, set in line with the type and volume of energy sold, for a three-year period and certificates are valid for three periods (altogether 9 years).

Parties which do not meet their obligation have to pay a penalty of EUR 0.02 per kWh-cumac, at the end of each three-year period. White certificates can be exchanged between obligated and eligible parties. One white certificate equals one kWh of cumulated savings of final energy (cumac) during the whole duration of an energy-saving action, discounted at a rate of 4% per year.

First period (July 2006–June 2009): During the first phase, the target of 54 TWh-cumac was exceeded (actual savings of 65.2 TWh). Nearly 84% was achieved in residential buildings. The obligation was placed on all energy retailers except road fuel suppliers. The majority of obligations were placed on EDF and GDF, with nearly 80% of the required savings. In 2010, no target was imposed but certificates were collected. By the end of 2010, total savings of 164.3 TWh were achieved.

Second period (January 2011–December 2014): The second phase of the scheme began in 2011 with a massively increased target. The law extended the obligations to fuel suppliers.

The targeted level of 345 TWh was over-achieved with 728.5 TWh-cumac, including the certificates in the process of validation. The second period was extended by an additional year in order to prepare the third period. During this extended period, 115 TWh-cumac additional obligations were imposed.

Third period (January 2015–December 2017): The third phase began with a target of 700 TWh-cumac of energy saving. Individual suppliers of domestic fuel oil are no longer obligated parties.

Since the introduction of the scheme the energy saving certificates issued amounted to 462 TWh-cumac of savings, with 90% of actions carried out in buildings.

Table 4.2 Tax incentives for the promotion of energy efficiency

Buildings		
Tax credit for energy transition (CITE)	Energy Transition for Green Growth Act	The tax credit for the energy transition, or CITE, replaces the CIDD, which was launched in 2005 and stopped on 31 August 2014. Home-owners can benefit from a tax credit for the purchase and installation of high-performance material or equipment in terms of energy savings (exclusively in existing buildings) or for the production of renewable energy. CITE is targeted on the renewal of small domestic biomass heaters rather than the installation of new ones in homes that are not already equipped. This tax credit amounts to a refund of 30% of the total cost of energy renovation work, up to a limit of EUR 8 000 for a single person and EUR 16 000 per couple. CITE brings strong convergent benefits in terms of air quality and energy savings.
Exemption of building property tax (TFPB: *Taxe foncière sur les propriétés bâties*)	Finance Act 2006	Buildings are to be exempted from the property tax for 5 years with a rate of 50 or 100%. Buildings the construction of which was completed before 1 January 1989 and for which major work eligible for CIDD (Sustainable development tax credit) was carried out. Exemption from property tax on developed properties amounts to 50 to 100% for new buildings completed by 1 January 2009 with a high level of energy performance.
Reduced VAT rate for renovation work	Article 279-0 of the general tax code	Since 1 January 2014, energy renovation work on dwellings over 2 years-old benefit from a reduced VAT rate of 5.5% (the normal VAT rate is; 20%). This includes works eligible for CIDD (currently CITE) as well as works associated and inextricably connected to the main works.
Transport		
Annual tax on business vehicles	Finance Act 2006	Since 2006, the total annual tax on business vehicles has been based on the level of greenhouse gas emissions. French businesses are subject to this tax whatever vehicle they use. Since 2014, the tax rate is also different according to the age of the vehicle and fuel used (with highest rates for old diesel cars) to take account of air pollution issues. For vehicles with EC-type approval, tax is assessed according to the number of grams of CO_2 emitted per kilometre. And the rate per gram is determined according to a seven-band scale. For other vehicles, the rate depends on their fiscal horsepower rating. Vehicles using certain alternative sources are partly or entirely exempt from the tax.
Energy		
General tax on polluting activities (*TGAP –Taxe générale sur les activités polluantes*)	Finance Act 1999	TGAP was created by pooling existing taxes and mandatory levies allocated to ADEME. The aim is to encourage the incorporation of biofuels in fuels sold by penalising distributors that sell fuels with a biofuel rate below a certain level. This tax is applied to biofuel distributors since 2005 and the tax rate is growing every year. This tax yielded EUR 772 million in 2014 and is expected to yield EUR 449 million in 2015.
Tax on carbon components	Finance Act 2014	Article 32 of the Finance Act for 2014 introduced the progression of energy tax rates proportional to the amount of GHG emitted by energy products. This carbon component in energy taxation is scheduled to reach EUR 7/tCO_2 in 2014, EUR 14.5/tCO_2 in 2015 and EUR 22/tCO_2 in 2016. The Energy Transition for Green Growth Act sets the goal for the carbon component to reach EUR 56/tCO_2 in 2020 and EUR 100/tCO_2 in 2030.

Subsequent French National Energy Efficiency Action Plans (2008, 2011 and 2014) specified actions to reduce primary energy by 15% and total final energy consumption by 9% in 2020, compared to 2013. Law 2009-967, in line with the energy saving obligations for 2010 and 2016 under the EU Energy Service Directive, required France to save 12 Mtoe through measures in the buildings and transport sectors by 2016.

Detailed sectoral environmental objectives were set out in the Grenelle Environment I Act (*Grenelle de le l'environment I of* 2009-10 with a strong focus on the building sector, in line with the EU Energy Performance in Buildings Directive (EPBD 2010/31/EU) and on the transport sector which will be described below for each sector.

PROGRESS AND POLICIES IN THE RESIDENTIAL SECTOR

Despite rising activity and structural changes in the residential sector, considerable efficiency progress contributed to the decline in final consumption in the sector to around 90% of the 1990 level.

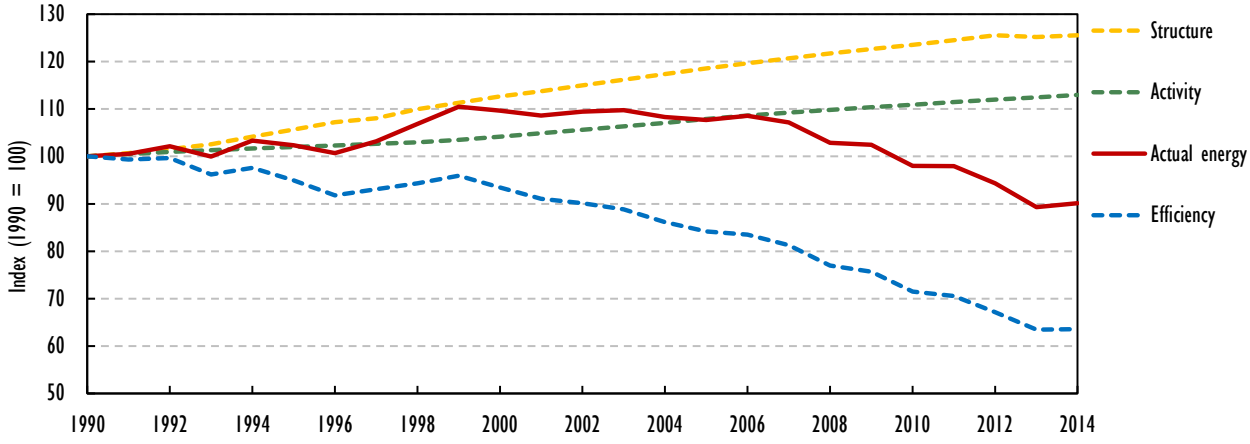
The activity effect, reflecting population growth, showed a 13% increase since 1990 and the structure effect, accounting for the floor area per capita and dwelling structure, put a 26% upward pressure on energy consumption. However, efficiency improved by 36% over the period.

Residential energy consumption is mainly for space heating (Figure 4.8). Space heating makes up 70% of energy use and has undergone significant transformation.

France used to have an energy performance in space heating worse than any other European country (ADEME, 2011), because of the old housing stocks, relatively low diffusion of efficient equipment and low heating fuel prices.

Heating intensity has improved, indicating an energy consumption per unit of floor heating, of more than 40% over the period. Most of this intensity improvement was achieved since 2000, owing to both the wide retrofit of dwellings and the improved heating system efficiency. Penetration of more efficient equipment also contributed to improving overall efficiency, such as condensing boilers and heat pumps. Improvement of housing insulation through the retrofitting of existing dwellings also helped to lower energy consumption in the residential sector, including wall and roof insulation, double-glazing, with enforced energy efficiency standards. However, in comparison to other IEA member countries, residential energy efficiency still falls behind the leaders in the area.

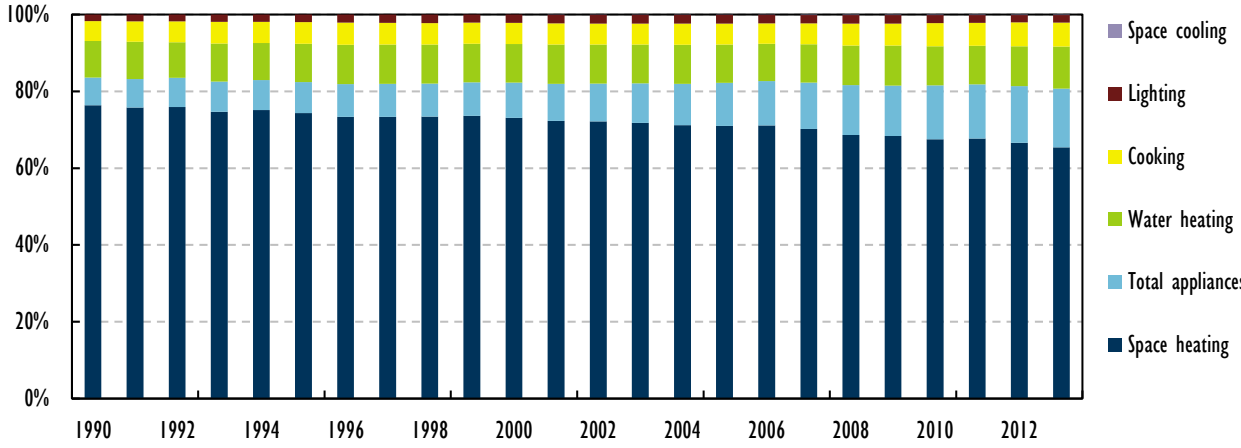
Figure 4.7 Changes in TFC in the residential sector broken down by activity, structure and efficiency effects, 1990-2014



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

There has been a noticeable change in the fuel use in the residential sector. Electricity and natural gas are now the dominant sources of energy used in French buildings. Oil and electricity were the dominant source in the residential sector during the 1990s. Coal has practically disappeared and the share of oil keeps decreasing, while electricity has become the main source, followed by natural gas, which together have largely replaced fuel oil.

Figure 4.8 Energy consumption in households, 1990-2013



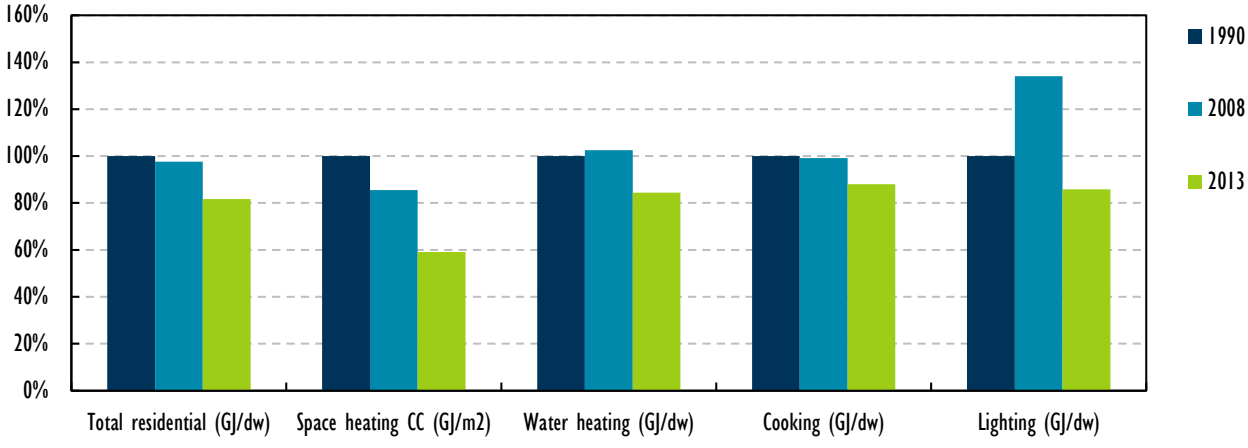
Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

The large majority of French buildings use central heating systems rather than stand-alone boilers, which makes renovation a complex undertaking, where all single-family dwellings or apartment owners need to jointly invest in heating upgrades.

The overall energy intensity in the residential sector has been decreasing since 1990 over 2008 to 2013 (Figures 4.9 and 4.10), largely reflecting the construction of new more energy-efficient dwellings with more efficient space heating and lighting.

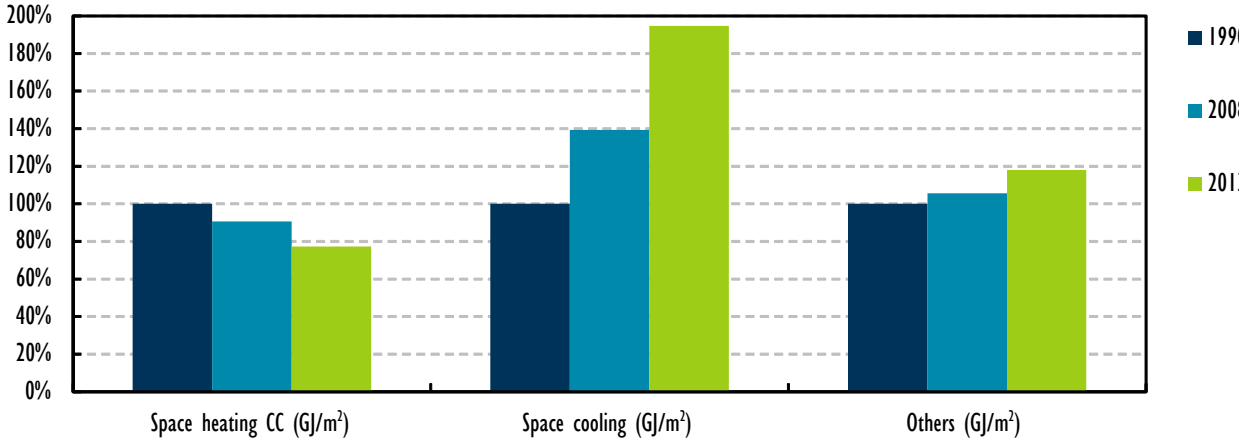
In the service sector, electricity is the main source, particularly with the growing penetration of information/communication technologies and air conditioning. The energy intensities in the commercial services sector have gone up, notably for cooling purposes.

Figure 4.9 Energy intensities in the residential sector, index for 1990 (100%), 2008 and 2013



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

Figure 4.10 Energy intensities in the commercial sector, index for 1990 (100%), 2008 and 2013



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

BUILDING STOCK

The building sector accounted for around one-third of France's total energy consumption, with residential buildings making up two-thirds. There were 34 million housing units in 2013. The building stock in France is characterised by a high share of dwellings owned by one-family households (60%), with only a few rented dwellings, a large share of social housing (5.3 million) and a high share of state-owned property.

Around 60% of buildings was built before 1975 (the date of the first thermal regulation), and 40% of new buildings has been constructed under the new energy efficiency standards. There has been a strong increase in newly constructed blocks of flats in urban areas in recent years (around 400 000 per year) which follow the latest energy efficiency requirements. The average consumption of social housing was 160 kWhPE/(m² and year), while the overall average annual consumption of primary energy (PE) in French buildings is 240 kWhPE/(m² and year) for housing (EP consumption class D) with 8 million dwellings consuming more than 330 kWhPE/(m² and year) (class F or G).

BUILDINGS

Targets

With regard to existing buildings, the Housing Plan (*Plan Bâtiment*) of 2010 and the 2013 Plan for Energy Renovation in Housing (*Plan de rénovation énergétique de l'habitat, PREH*) set out detailed targets for renovation. The PREH aims at a renovation rate of 500 000 dwellings per year by 2017, including 120 000 social dwellings and 380 000 private ones. The Grenelle Environment I Act and PREH require energy savings of 38% by 2020 in buildings. The Act also had a separate target for reducing energy consumption in government buildings by 40% up to 2020. As of 2017, the Energy Transition for Green Growth Act requires further 500 000 renovations per year, out of which at least 50% in social housing with a view to reduce energy poverty by 15% by 2020.

By 2025, all private dwellings with primary energy consumption above 330 kWh per square metre (m^2) and year will need to be renovated under the new energy efficiency standards. By 2050, all buildings have to be renovated in line with the low-energy-consumption rules (*Bâtiment basse consommation, BBC*). The Energy Transition for Green Growth Act

requires building codes for new buildings in 2018 to account for GHG emissions, considering the life cycle of buildings and a leading role for public buildings. Cities are allowed to set up higher standards in their planning documents and extra construction rights can be given by cities for energy-positive or low-energy consumption projects.

Despite these ambitious targets, progress towards renovation remains low. France is behind its renovation targets for private dwellings. By 2014, there have been 280 000 renovations against the targeted 500 000 per year by 2017. Around 120 000 social housing (HLMs) underwent renovation as planned (ADEME, 2015).

Policies and measures

France has significantly strengthened building codes and renovation programmes over the past decade. With regard to new buildings, as part of Grenelle Environment II Act, the thermal regulations (*règlements thermiques*, *RT*) of 2012 strengthened requirements for the thermal performance of new buildings which are defined as those that applied for a building permit after 1 January 2013.

RT 2012 has three performance indicators which are among the most innovative and stringent in the EU. New buildings (permits were requested after January 2013), must comply with *i)* bioclimatic design and insulation (heating, cooling and lighting), *ii)* primary energy consumption level below 50 kWh/m^2 per year for five uses – heating, domestic water-heating, lighting, cooling and auxiliary systems (equivalent to low-energy building label), and *iii)* the summer maximum temperature as well as requirements for lighting, thermal bridges, renewable energies and an air-tightness test. RT 2012 aims to reduce by three the energy consumption of new buildings, below 2005 levels. RT 2012's requirements are adjusted to geographical location, altitude, building use and average surface area, including small houses (since 2014).

RT 2012 discourages electric heating and encourages more efficient forms of heating. France is highly dependent on electric heating systems, as one-third of existing homes and three-quarters of new ones are equipped with an electric heating system. Every Celsius degree drop in temperature increases the electricity generation needs by around 2.3 gigawatts (GW), leading to unexpected peak loads for the grid operator. In terms of energy efficiency, electric heating has several vulnerable points which relate to conversion losses and low continuity of heat performance. Electric heaters warm the air but do not capture heat over longer periods, unlike district heating systems.

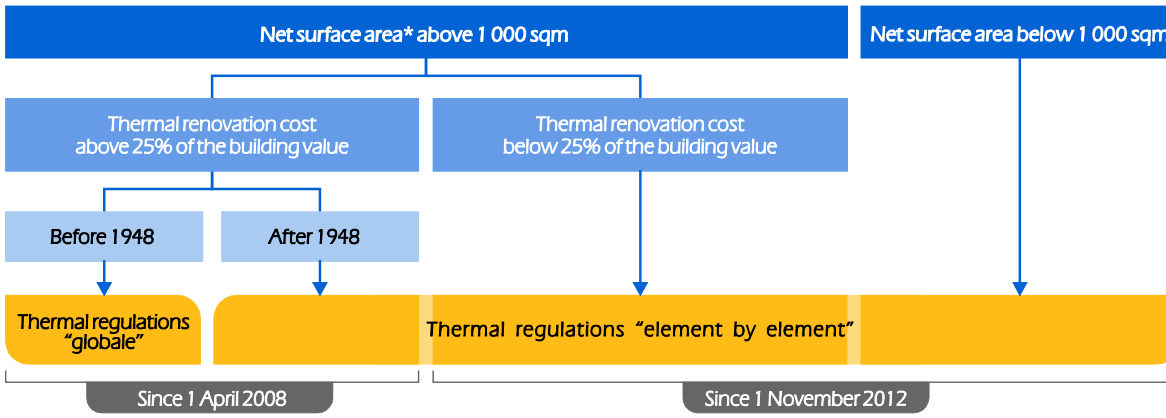
For existing buildings, building codes are complex, largely relying on the thermal regulations RT 2008 and codes differ in terms of the size and age of a building and its renovation requirements (Figure 4. 11). Very old and large buildings (over 1 000 m^2 and built before 1948), which require large renovation works; need to apply the so-called "global thermal regulation" which sets an energy performance target for whole building and not its elements. This discourages deep renovation. But two-thirds of the building stock was built before 1975. For residential dwellings, regulations put a ceiling of 80 to 195 Kwh/m^2/year on energy consumption. For non-residential buildings, renovation work must lead to a 30% saving of energy consumption compared to the previous level. For buildings under 1 000m^2, or those above 1 000m^2 with minor renovation works, thermal regulations set performance criteria for existing or new equipment, "element by element", including insulation, heating, cooling and ventilation systems.

A compulsory audit is required within 5 years (as of 1 January 2012) for blocks of flats with more than 50 units with a common heating system.

Since 2008, all buildings above 1 000 m^2 and undergoing major renovation work must undergo a feasibility study of energy supply. This scheme is designed to encourage the developers to use renewable energy or a highly efficient system.

The Energy Transition for Green Growth Act also requires compulsory insulation when a facade or a roof is renovated and when this is cost-effective. Major building work (re-roofing, facade renovations and extensions) should be used to improve energy efficiency.

Figure 4.11 Building codes for existing buildings and renovation work in France



Labelling and training

An energy performance certificate (EPC) is mandatory since 2006 for selling or renting a flat or a building. Since 2013, the EPC data collection for monitoring and control has been improved through a centralised database at MEEM (2.5 million EPC) with assessment software.

Several labels were introduced in the buildings sector: high energy performance (HEP) label for new buildings, Effinergie+ label for top performance for a consumption level of 20% below RT 2012, "high energy performance renovation, HEP 2009" label for buildings with primary energy consumption below 150 kWh/m^2/year for five uses and a "low-energy consumption building renovation, LEB 2009" for buildings with a primary energy consumption below 80 kWh/m^2/year.

Building on the *Plan de rénovation énergétique de l'habitat (PEH)*, around 450 platforms were created to provide technical, legal and financial advice, including the training of experts through the Organisation of the building sector enterprises (*Reconnu garant environnement (RGE)*).

Economic incentives

France has a large number of tax incentives and special loan programmes to support renovation. All buildings complying with RT 2012 regulations can benefit from financial aid, including interest-free loans and exemption from property tax.

Since January 2014, the reduced VAT rate (5.5%) is applicable (normal rate is 20%) for dwellings older than 2 years, which undergo energy renovation works. Collective buildings are exempted from property tax (Finance Act 2006) for five years with an exemption rate of 50% or 100%. Buildings constructed before January 1989 can apply for

the tax exemption of the renovation work carried out (if works are eligible). New dwellings constructed before January 2009 can also benefit if they are rated with an LEB (low-energy building) label.

These refunds are possible under the energy transition tax refund (*crédit d'impôt transition énergétique, CITE*) and previously, under the sustainable development tax reduction (*crédit d'impôt développement durable, CIDD*) which was introduced in 2005. Home-owners can benefit from a 30% refund (CITE) when purchasing and installing energy-saving material or equipment (for existing buildings) or material which supports the production of renewable energy (for existing buildings and those built before December 2012). From January 2015 onwards, for some equipment and materials, owners have to involve certified enterprises. During 2005 to 2011, works worth more than EUR 9 million benefited from CIDD as did 7 million dwellings in total, out of the 27 million residential buildings stock. In 2008, the CIDD cost the French state budget EUR 2 800 million and in 2016 EUR 1 400 million.

The interest-free eco-PTZ loan (*prêt à taux zéro*) is in place for home-owners or landlords faced with major renovation works. The loan finances up to EUR 30 000 of renovation works directed at improving energy performance for a period of 10 years (that can be extended to 15 years). Since its launch in 2009 to September 2013, an estimated number of 235 000 eco-loans were given. The average expenditure for renovation works amounted to EUR 19 200. For 2009-11, the cost of this supporting scheme is estimated at EUR 75 million.

Landlords of social housing can benefit from the Eco-PLS (*éco-prêt logement social*), an interest-free loan with 15 years duration which is based on a convention between the government and the Deposits and Consignments Fund (*Caisse des dépôts et consignations*). For the 5.3 million social housing units there are specific subsidies and advice for low-income households under the Better-Living Programme (*Programme Habiter mieux).* During 2010-15, the programme supported around 140 000 households against an objective of 300 000 for 2010-17. It is co-ordinated through the French National Housing Agency (*Agence Nationale de l'Habitat, Anah*).

The Energy Transition for Green Growth Act has created an energy renovation guarantee fund which was established in August 2016 and will be implemented by the *Société de Gestion des Financements et de la Garantie de l'Accession Sociale à la Propriété (SGFGAS)*.

In addition, 4 million low-income households shall benefit from energy vouchers (*chèque énergie*) to help them pay either their energy bill or renovation works. Since May 2016, it has been introduced as a pilot scheme in four of France's departments.

PUBLIC SECTOR

The EU Energy Efficiency Directive (EED) includes the obligation for the state to act in an exemplary manner, particularly as regards public buildings (Article 5) and public procurement (Article 6). The French state owns a large quantity of buildings. The role of the government in leading on energy efficiency and renovation in these sectors is therefore significant.

Public buildings

Under the Grenelle Environment II Act, France adopted various approaches to reduce energy consumption in public buildings by 40% by 2020. Targeted buildings are federal buildings occupied by state services, including offices, educational and sports buildings, health and social facilities, cultural centres, shops and dwellings. These buildings cover 22.2 million m^2 while agricultural and technical buildings, Ministry of Defence buildings, religious buildings, monuments and memorials are not included. According to ADEME, expected savings amount is 10 131 GWh of primary energy through 2014-20.

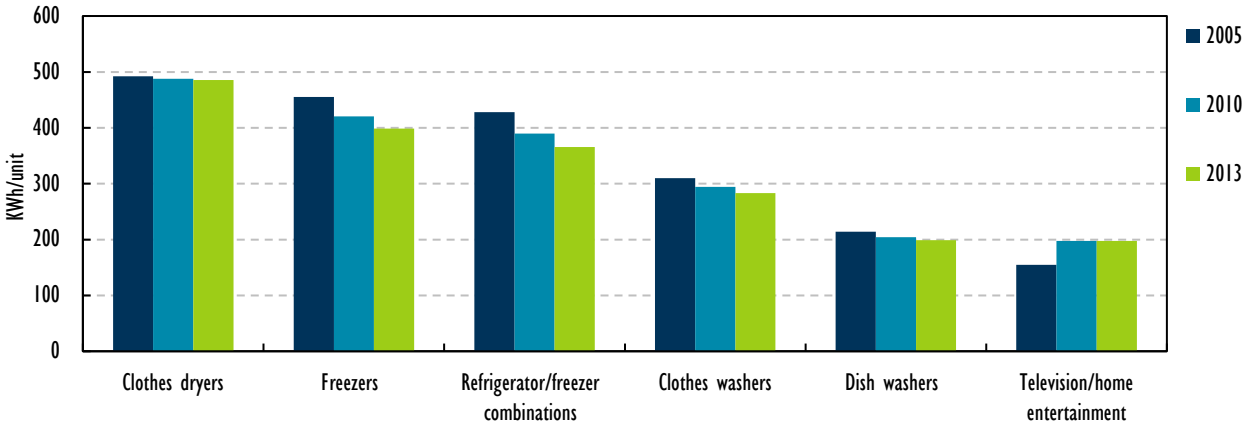
Public procurement

The public procurement economic observatory (OEAP) was set up in 2005 as part of the Ministry of Economy and Finance. OEAP's mission includes the collection and gathering of compatible, financial and economic data relative to public procurement. It establishes relevant economic analysis and creates collaboration between the players of public procurement regarding its technical and economic aspects.

APPLIANCES AND EQUIPMENT

The overall energy intensity of home appliances has been improved. On the other hand, energy demand is growing for televisions with a larger screen size, and for an increasing number of personal computers and other network devices. Energy consumption by these devices is growing despite efficiency gains (IEA, 2015).

Figure 4.12 Annual unit energy consumption of large appliances, index for 2005, 2010 and 2013



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

The energy consumption of France's home appliances has steadily improved mainly thanks to electricity savings with the deployment of more efficient equipment. This improvement was driven by regulatory measures, also encouraged by the European Union standards, through banning the sale of appliances under a given level of energy efficiency requirements, and eco-design and energy label measures.

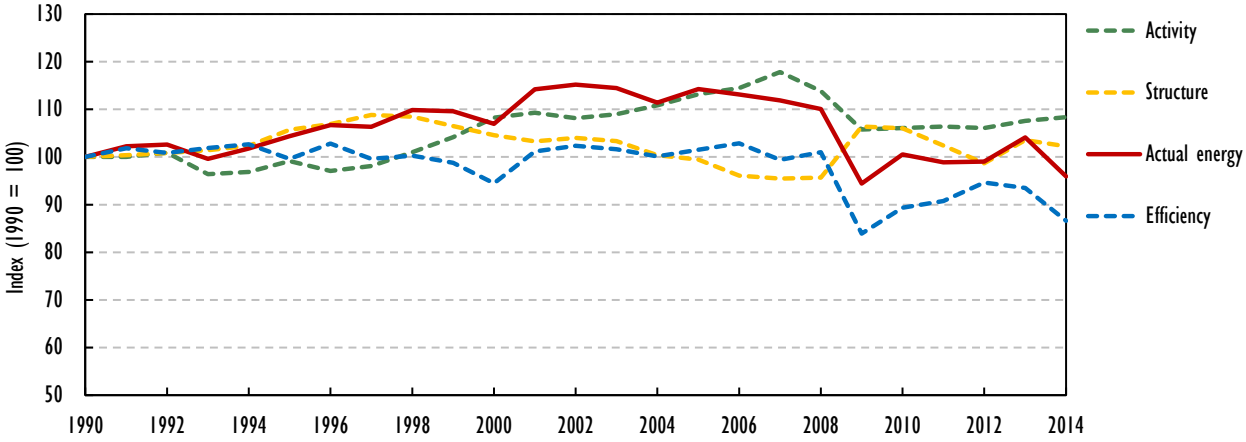
In 2009, the European Commission introduced an ambitious requirement and banned products less efficient than class A from the EU market. The measurement tolerance was tightened over time. In 2011, the new energy label including class A+++ has been introduced. Since July 2014, new models can be classified into classes A+, A++, A+++.

Since December 2011, eco-design regulations came into force, banning washing machine models not reaching energy efficiency class A from the EU market. The new eco-design and eco-labelling regulation is expected to be introduced in 2016.

PROGRESS AND POLICIES IN THE INDUSTRY SECTOR

Since 1990, efficiency improved by 13%, which is equivalent to 4.7 Mtoe in energy savings, and most of the improvement has been achieved since 2008. Energy demand in industry has decreased by 1.7% per year over the 2000-14 period. Lower energy consumption in industry can be explained by several factors, including lower growth in industrial production due to the economic crisis in 2008, relocation of production capacity, energy efficiency improvements and the shift in demand in favour of the services sector. Energy consumption has been decreasing in energy-intensive industries (metals, refining and petrochemical industry, paper, pulp and others), whose energy consumption largely reflects GDP trends (see Figure 4.14). The activity effect in industry (excluding non-energy use) increased by 8% (outside the services sector). There was a noticeable structural effect, with positive impacts derived from innovation and process changes within the industry sector over the period 1990-2014.

Figure 4.13 Industry sector (excluding non-energy use) changes in TFC broken down by activity, structure and efficiency effects, 1990-2014*

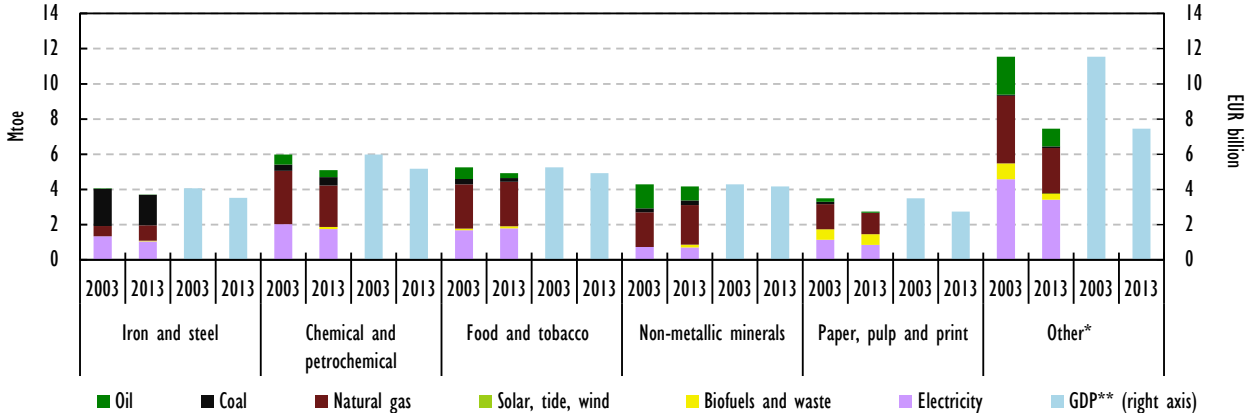


* TFC in industry includes non-energy use. However, for the decomposition analysis, data for category "non energy use" are not available and figure 4.14 does not reflect the category "non-energy use".

Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

Over the last four decades, the structure of French industry has changed significantly. With the growth of the service sector, industry's share in TFC fell to 27% in 2014, versus 39.6 % in 1973. In recent years, part of the industry sector's energy savings came from lower production. Fossil fuel use was lower as consumption decreased. The downward trend of the steel industry, which originally consumed about three-quarters of the coal used in industry, caused a major reduction in fossil fuel use. Similarly, the decline in the chemical industry's activity lowered the consumption of oil products. The contraction of fertiliser production contributed to a lower consumption of natural gas. As the recycling of metal, paper, glass and plastics increased, primary material production (steel, pulp and paper, etc.) decreased as innovation brought about new production methods and materials.

Figure 4.14 TFC in industry, by fuel and GDP (EUR), 2003 vs. 2013



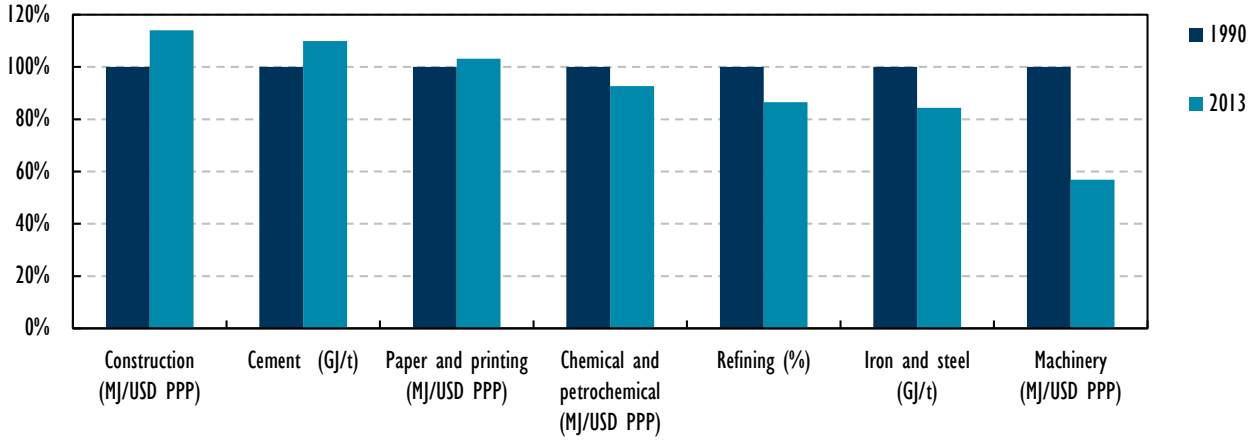
Note: Right axis illustrates the GDP in billion euros and the left axis the total final consumption in the sector in Mtoe.

* Other industry sector includes machinery, non-ferrous, transport, mining, wood, construction, textile and non-specified.

Sources: IEA (2016a), *Energy Balances of OECD Countries*, www.iea.org/statistics/.

Since 1990, the specific energy consumption in steel industry has been decreasing as a result of the increased penetration of less energy-intensive processes and the closure of old and less efficient steel mills. Almost half the steel production is based on the use of recycled scrap metals. However, the main furnaces in Dunkirk and Fos-sur-Mer produce from iron ore and coal. Thanks to the use of electric motors, several ways to improve efficiency were developed. These improvements may have a significant impact on overall energy consumption, as the steel industry is one of the most energy-intensive industry sectors in France, together with cement and petrochemicals and chemical industries (Figure 4.15).

Figure 4.15 Energy intensities in selected industries, 1990 (index 100%) and 2013



Note: Refining's energy-intensity = refinery fuel over refinery intake.

Sources: IEA (2016a), *Energy Balances of OECD Countries*, IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

Aluminium production is highly electricity-intensive. The energy intensity could be lowered both by improving energy efficiency and by increasing the use of scrap. Aluminium production from scrapped material requires around 10% of the energy input of primary aluminium production, including the additional energy that is required for

scrap cleaning and alloy dilution. There have also been a large number of closures, as refineries shut down and aluminium and steel producers relocated away from EU production locations. France has maintained a highly active cement production, which next to construction is a strong energy using sector.

POLICIES AND MEASURES

In 2005, the POPE Law imposed mandatory saving targets on energy companies through the market-based white certificates (Box 4.1).

France has many large industries and many small business units (ECEEE, 2012). Large industry units account for 5%, but consume around 80% of the total energy consumed in the sector. The performance of large business impacts therefore much more the energy efficiency of the sector, hence, the focus of the French government has been traditionally placed on large industry.

French energy efficiency policies in the industry sector are based on EU legislation, notably the EU Emissions Trading Scheme (EU-ETS) and energy audits. The EU-ETS introduced a cap and trade system for CO_2 emissions of the main industrial sectors in the Union. In France, there are 1 120 facilities subject to the ETS, but the scheme does not cover the thousands of medium and small business entities. In line with the EU Directive EED (2012/27/EC), companies with more than 250 employees or EUR 50 million annual turnovers and EUR 43 million on the balance sheet in total, have to perform an energy audit every 4 years. This law is applicable to all businesses except SMEs.

Therefore, small and medium-sized enterprises (SMEs) still have large energy-saving potential, but energy normally does not account for a large share of their expenditure. Awareness of energy costs and potential savings is thus relatively low and they are not subject to emissions trading or energy audit obligations.

ECONOMIC INCENTIVES

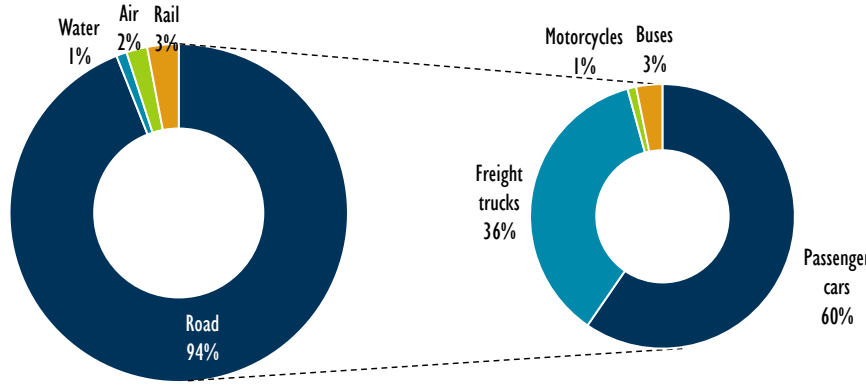
ADEME funds and supports energy efficiency studies in the industry sector, mostly in SMEs. Through ADEME, the French government also supports the development of energy efficiency technologies to boost the competitiveness of France's industry; through the Rational use of energy – investments, and through the Programme for Investment in the Future (*Programme d'investissements d'avenir, PIA*) programme which has a total budget of EUR 6.5 billion for industry and SMEs for the period 2010-20.

A green loan programme dedicated to the industry sector was launched in July 2010 with a EUR 500 million budget (EUR 300 million for loans, EUR 200 million for guarantees). SMEs benefit from soft loans and guarantees for their investments. A EUR 340 million budget is available for the period 2014-17 managed by BPI-France. Eco-energy loans have been implemented since 2013 by BPI-France, with the state funding EUR 33 million. This allows funding the installation or the upgrade of certain energy-intensive facilities in lighting, heating, air conditioning and electric motorisation. A loan can range from EUR 10 000 to EUR 50 000 for a 5-year period with a 1-year grace period at a low interest rate of 2% and no guarantees required.

PROGRESS AND POLICIES IN THE TRANSPORT SECTOR

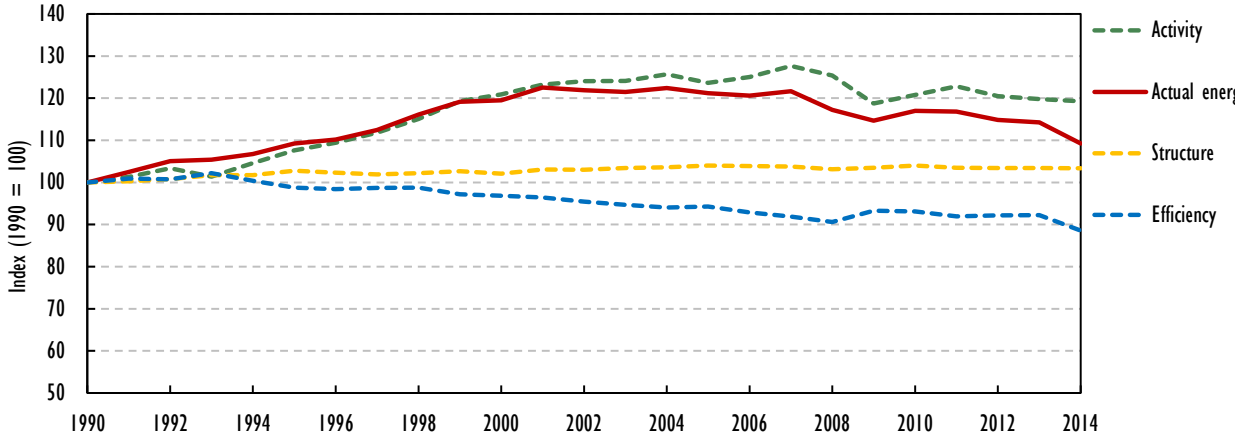
In 2013, road traffic made up 94% of energy consumption in transport where oil continues to be a dominant fuel (Figure 4.16); however, the use of biofuel and waste and electricity is on the rise, starting from a low level (Figure 4.2).

Figure 4.16 Transport energy by subsector and mode/vehicle type, 2013



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

Figure 4.17 Changes in TFC in passenger transport broken down by activity, structure and efficiency effects, 1990-2014



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

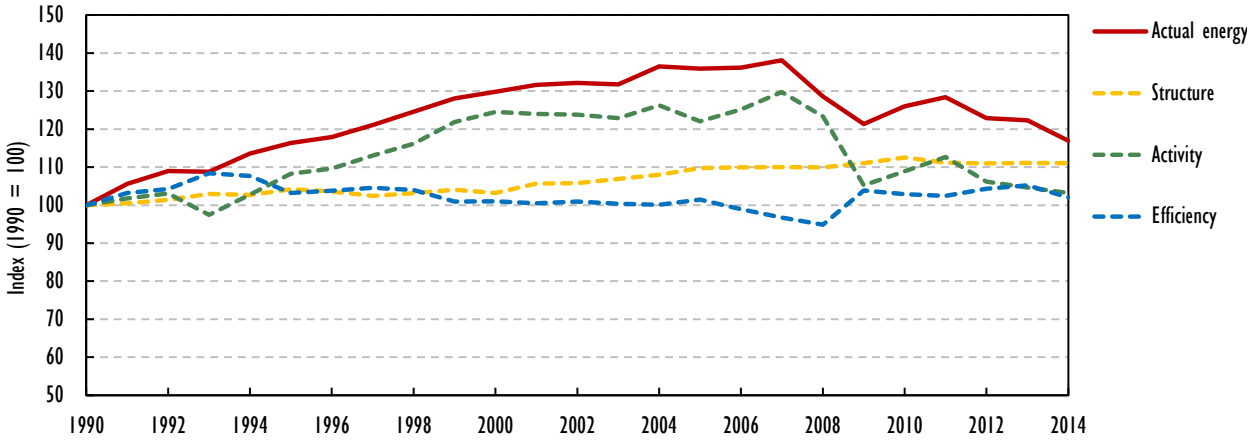
Figure 4.17 and 4.18 show the energy consumption for passenger transport and freight transport from 1990, broken down into changes in activity, structural factors and energy intensity.

Passenger transport activity (in terms of passenger kilometres) has increased by almost one-fifth from 1990 to 2014. Despite this significant growth in activity, energy consumption for passenger transport has increased by only half that rate over the same period. This is an effect of decreased energy intensity as vehicles get more efficient (shown as the blue curve in Figure 4.17). Structural changes, such as shift in means of transport, have made a small but positive contribution to the increased energy

consumption. Passenger transport activity increased significantly from 1990 to 2007 but has since declined somewhat. Recent energy efficiency development has thus lead to decreasing energy consumption in the sector.

Freight transport has had a different development in terms of energy consumption over the period from 1990 to 2014. The activity (in terms of tonne kilometre) has increased by just over 3%, and only slightly contributed to the 17% increased energy consumption in the sector. The main contributor has been structural changes, which have led to a 10% increase in the energy consumption. Energy efficiency in freight transport has not improved at all recently, but rather contributed slightly positive to the growing energy demand in the sector, as the energy intensity increased by 2% from 1990 to 2014.

Figure 4.18 Changes in TFC in freight transport broken down by activity, structure and efficiency effects, 1990-2014



Source: IEA (2016b), *Energy Efficiency Indicators*, www.iea.org/statistics/.

POLICIES AND MEASURES

There are two EU directives promoting the use of biofuels: the Renewable Energy Directive (RED, 2009/28/EC) and Directive on the Quality of Petrol and Diesel Fuels (FQD 2009/30/EC). France is obliged to comply with RED targets to achieve 10% of transport energy demand from renewable sources by 2020 (compared to 2010). In addition, France has to meet the target under the FQD which requires member states to reduce the emissions intensity of their transport fuels by at least 6% until 2020 compared to the 2010 baseline level.

At national level, France set an ambitious goal under the Grenelle Environment I Act (2009-967), Article 10, of bringing GHG emissions in the transport sector down to the level recorded in 1990 by 2020. Policies implemented to achieve this goal are mainly based on three pillars: support low-emission means of transport, promote modal shift; and improve the efficiency of the means of transport used. Under the Energy Transition for Green Growth Act, the government presented a low-carbon mobility plan in 2016, as part of the pluriannual energy programming (PPE).

Focus has been on road transport and rail. The so-called Mobilité 21 Commission considered that the realisation of the National Transport Project Scheme (*Schéma national sur les infrastructures de transport, SNIT)* proposed in 2011 would require

investment of up to EUR 245 billion. The Mobilité 21 Comission's report "for a national sustainable mobility scheme" of June 2013, prompted the Ministry to adopt new priorities for the sustainable improvement of existing networks (road, rail and waterway) and the continuation of several projects. Under this framework, studies were carried out for a new railway line between Montpellier and Perpignan, as well as studies for the Paris-Normandy travel connection project. National priorities are updated every five years to reflect new territorial dynamics and the evolution of the economic context.

Box 4.2 The bonus-malus scheme

The automotive bonus-malus scheme was introduced in 2007 and updated in 2015. It entails three main elements:

Bonus: Allocating a premium or bonus for all purchases or rentals of a new vehicle with low CO_2 emissions. Since 2007,the bonus has been refocused mainly on electric vehicles and plug-in electric vehicles. There are three different bonuses awarded for the purchase of clean vehicles: EUR 6 300 for vehicles emitting less than 20 grams of CO_2 per kilometer (gCO_2/km), EUR 1 000 from 20 to 60 gCO_2/km and EUR 750 for hybrid cars emitting up to 110 gCO_2/km.

Scrapping scheme for diesel cars: The scheme, introduced in April 2015, aims to accelerate the rate of renewal of the vehicle stock and to reduce its average emissions. The scheme is granted when the purchase of a new car implies the retirement of a diesel vehicle registered before 1 January 2006. The amount depends on the purchase cost of the new car. It reaches EUR 3 700 for an electric car (and even EUR 10 000 when the two bonuses, buying and scrapping, add up). A scrapping scheme is also granted under revenue conditions when replacing an old diesel car by a gas or gasoline one, meeting Euro 5 (EUR 500) or Euro 6 (EUR 1 000) standards and CO_2 emissions below 110 gCO_2/km.

Malus: Malus is applicable to highly polluting vehicles. The malus adds a tax on the purchased vehicle that ranges from EUR 150 for vehicles emitting more than 130 gCO_2/km up to EUR 8 000 for those emitting more than 200 gCO_2/km. A reduction of 20 gCO_2/km was introduced for vehicles per dependent child and for large families as well as an exemption from the malus for handicapped people. An annual tax of EUR 160 is applicable for highly polluting vehicles registered after January 2009.

According to the Ministry of Environment, Energy and the Sea (MEEM), in 2015, the malus scheme raised revenues of EUR 23.3 million. The market share of electric vehicles reached 0.92%, an increase from 0.6% in the previous year. From 2010 through 2015, annual electric car registrations increased to 980, 4 313, 9 314, 13 594, 15 045, 22 187 respectively. A strengthened malus rate came into force in January 2014, which provides an even stronger incentive to purchase a new more energy-efficient and low-CO_2 emitting vehicle. According to the MEEM data, this scheme has reduced average emissions of registered vehicles in France. From 2007 through 2015, the emissions of new registered vehicles lowered to 149, 140, 133, 130, 128,124, 117, 114 and 111 gCO_2/km, respectively.

Freight transport

France aims to induce a modal shift from road transport towards cheaper and lower-emitting means of transport, notably by encouraging rail freight. The target is to shift 5% to 10% of the traffic. In 2013, the Ministry of Transport announced the creation of a third motorway between Lille and Bayonne. The government supports the development of new sea motorways on the French Atlantic and Mediterranean coasts in order to offer an alternative to crossing the Pyrenees and the Alps.

Passenger transport

The third phase of the Development Plan of Reserved Public Transport Corridors (*Programme de développement des transports en commun site proper, TCSP*) was launched in May 2013. Projects include underground, tramway, tram-train, high efficiency bus service, waterway or river shuttle, investment in bicycles and innovative actions in the field of sustainable mobility. In September 2013, the Ministry of Transport announced the approval of almost 120 projects with a total funding of EUR 5 billion.

Road transport

France has been relying on the bonus-malus scheme to support the purchase of low-emission vehicles (Box 4.2). Other measures have been implemented to encourage the purchase of more efficient vehicles in terms of energy consumption and GHG emissions. The annual tax on business passenger cars, established since 2006, is based on the vehicle's level of polluting emissions not its horsepower. Businesses are subject to this tax. A tax exemption is granted to those vehicles which emit up to 50g CO_2/km. However, business vehicles enjoy price rebates for fuel consumption which does not encourage vehicle fuel economy.

CASE STUDY: ELECTRIFICATION OF THE TRANSPORT SECTOR

Progress in battery technology and stronger support mechanisms in recent years have enabled a rapid deployment of electric vehicles (EV), with different policy approaches worldwide.

France is an emerging EV market today and offers good conditions for the electrification of the car fleet. With nuclear electricity providing 77% of electricity, electrification of the transport sector will ensure an important part of the transformation and decarbonisation of the transport sector. The government is looking into support for the development of an EV market and can use other countries' strategies as an inspiration for developing efficient policies and measures.

BENEFITS AND CHALLENGES

Transport consumes on average one-third of total energy use in IEA member countries and the sector is the main emitter of greenhouse gases globally. EVs are more energy-efficient than internal combustion engine vehicles (ICV) and enable low-carbon emissions if the electricity is supplied from low-carbon energy sources. Furthermore, EVs can reduce local air pollution and noise levels in urban areas. For oil-importing countries with high reliance on fossil fuels in the transport sector, EVs can also provide improved energy security.

Despite the potential benefits of EVs, the market development has been slow. Important barriers to growth in the EV market are high capital costs for the vehicles, limited driving range, lack of charging infrastructure and consumers' lack of confidence in the technology (IEA, 2016c). The driving range is mainly a technical challenge that will be met by improved battery technology, while other challenges need policies for EVs to be more competitive.

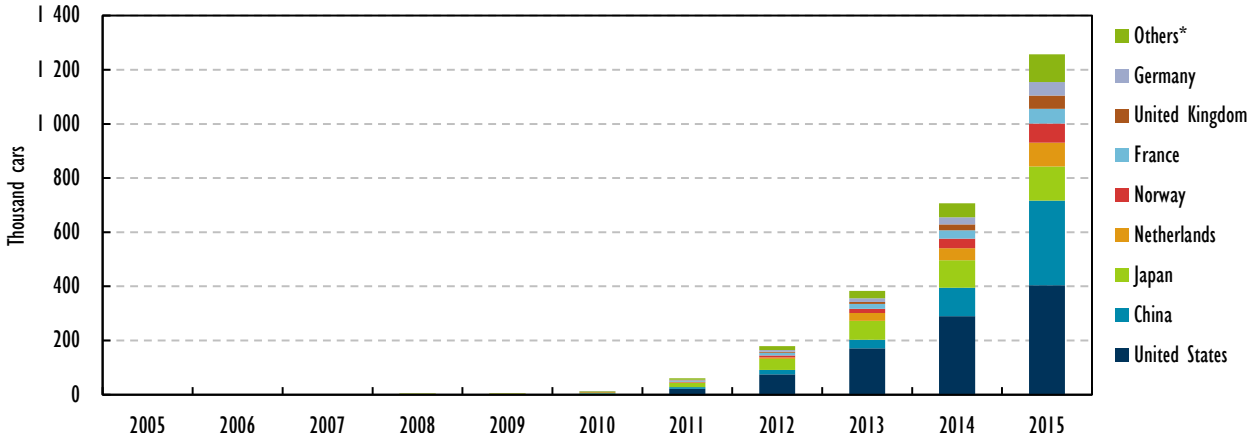
Table 4.3 Summary of benefits and barriers for EV market development

Benefits	Barriers
Low GHG emissions	High investment cost
Improved local air quality	Limited driving range
Reduced noise levels	Lack of infrastructure
Increased energy security	Lack of consumer confidence

EV MARKETS WORLDWIDE

The global EV car fleet has grown rapidly in the last five years, with a hundredfold increase from 12 500 in 2010 to 1.26 million in 2015 (Figure 4.19). The United States had the largest number of EVs with 404 000 in 2015, followed by China, which tripled its EV fleet in one year to 312 000. Norway had the fifth largest EV fleet worldwide with 71 000 cars, and by far the highest share of EVs per capita.

Figure 4.19 Global electric vehicle fleet per country, 2005-15



**Others* includes Canada, Sweden, Italy, India, Spain, Korea and Portugal with more than 2 000 EVs, and another 25 countries with smaller shares.

Note: Both battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) are included.

Source: IEA (2016c), *Global EV Outlook 2016*, OECD/IEA, Paris.

In 2015, France had the second-largest EV vehicle fleet in the EU with 54 300 EVs, behind the Netherlands (87 500 EVs). The French EV market accelerated its growth in 2015 (IEA, 2016b) and the IEA considers France one of the countries likely to maintain a double-digit growth to reach a 20% market share (or 2 million EVs) in 2020, as targeted by the Energy Transition for Green Growth Act. In 2015, 17 629 electric

passenger cars were registered in France. Compared to 2012, the sale of electric vehicles (passenger cars and light commercial vehicles) increased by 200%.

Policies implemented to support the EV market development can be divided into regulatory measures, financial incentives and other instruments. Tailpipe emissions and fuel economy standards, such as the Euro classification in Europe, are regulatory measures used by most countries. Financial incentives can be either investment support such as a VAT exemption, or incentives to lower the cost of owning a car, such as the exemption from annual or circulation taxes.

Incentives can target EVs directly or be based on emission standards, enabling other low-carbon technologies to utilise the system. Other support instruments can be non-financial, such as waivers on access restrictions, providing EV drivers access to bus lanes or specific parking spaces. Many countries also support investment in charging infrastructure.

Norway is the world leader in EV market development, thanks to a comprehensive support system. This includes investment support through large tax exemption (VAT and registration tax), discount on road tolls and access to bus lanes. EVs constituted 23% of all new cars sold in Norway in 2015, far more than in any other country.

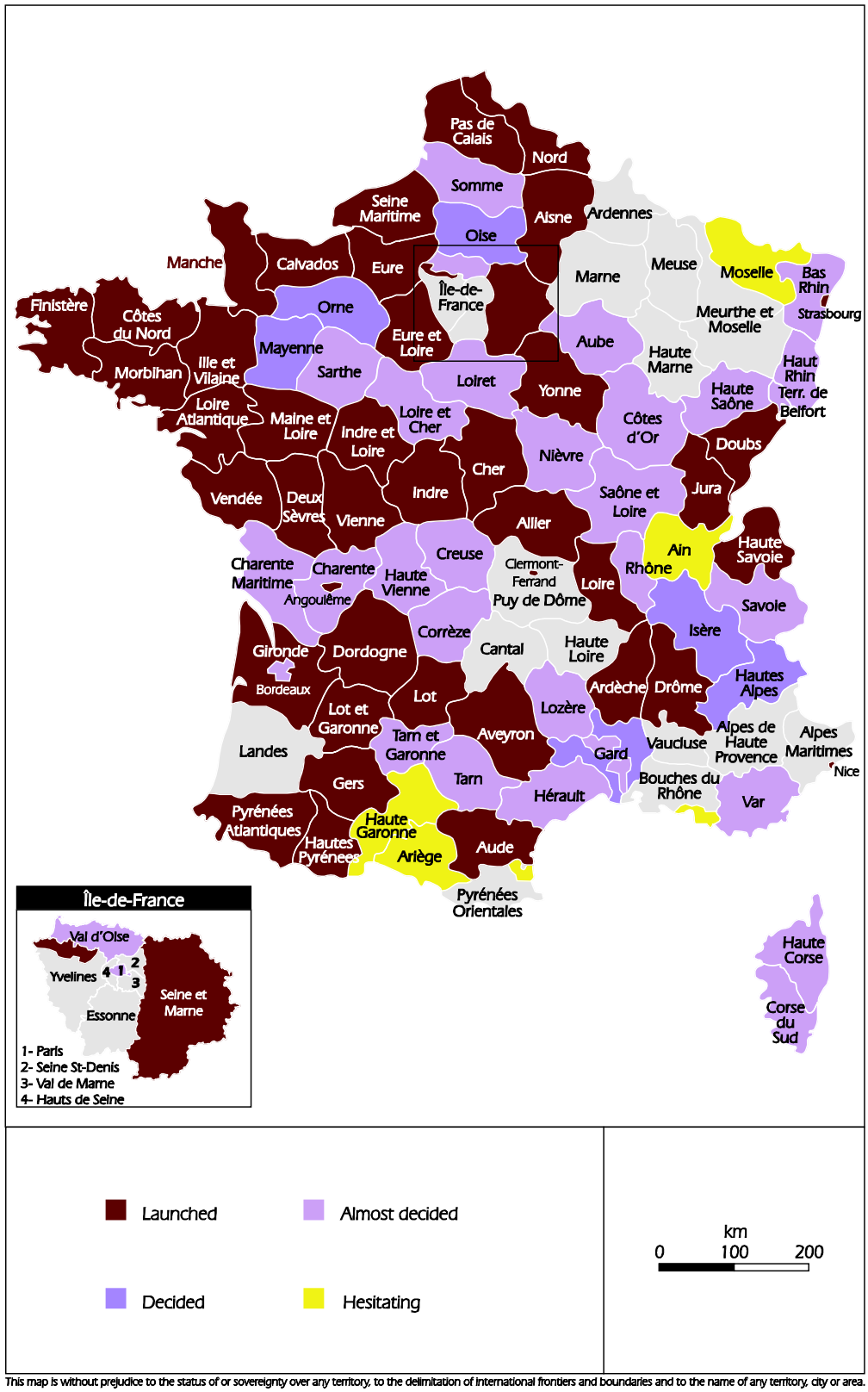
EV MARKET DEVELOPMENT IN FRANCE

France has seen the fast uptake of EVs thanks to its low-carbon electricity generation, enabling greater shares of the low-carbon transport sector and at the same time reducing oil imports. National and regional-local policies have supported this development as well as a "feebate" system[1], the so-called bonus-malus mechanism (see Box 4.2). Tax incentives linked to the annual eco-label (with average CO_2 emissions of passenger cars) are offered for new vehicles through the bonus-malus system that favours low-CO_2 emission vehicles (Box 4.2; MEEM, 2016b and 2016c). In France, battery electric vehicle (BEVs) and some plug-in-hybrid electric vehicles (PHEVs) are exempted from annual taxation of company cars. The government administration has the obligation of procuring BEVs and PHEVs for 25% of their new public vehicle fleet. French car manufacturers offer more and more EVs and plug-in-hybrid vehicles.

Measures have also been taken with respect to developing infrastructure for the use of electric and hybrid vehicles. The French government is supporting the creation of a network of charging stations and battery development, lifting thus two of the most important barriers to the roll-out of electric vehicles. Since 2009, and reinforced in 2012, a national plan for the development of electric and hybrid vehicles has been implemented with public funding allocated to projects for battery-loading infrastructure, aimed at creating a value chain to produce batteries in France. In 2010, the government formed a charging infrastructure working group to co-ordinate installation of a standardised national charging network for plug-in hybrid electric vehicles (PHEVs) and battery-powered vehicles (BEVs). Fiscal deductions are awarded to private operators investing in, maintaining or operating charging outlets in currently public spaces in at least two different regions, with the goal of building a national charging network (IA-HEV, 2015). The government aims to install at least 7 million charging points for public and private electric and hybrid vehicles by 2030 (MEEM, 2016d).

1. Feebate refers to a bonus/malus system in which those who perform badly pay a fee that is rebated to the better performers. A bonus/malus system is currently being considered by the Swedish government.

Figure 4.20 Electric charging point network



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: FNCCR, 2015.

Local governments are empowered to install public charging infrastructure with a quota of parking areas in work places and shopping areas reserved for electric vehicles and charging spots. Builders of collective residences must install charging facilities at parking places upon request of the inhabitants.

Interoperability has been increasing. France's municipalities (*collectivites territoriales*) have signed agreements to ensure the interoperability of the charging network infrastructure. In 2016, the Federation of municipalities (*Fédération nationale des collectivités concédantes et régies (FNCCR)* signed an agreement with Gireve (*Groupement pour l'itinérance des recharges électriques de véhicules*).

The impact of EVs on the electricity system's adequacy can be positive, and it is expected that EVs will outpace electric heating in the system over time. If the peak consumption in large cities coincides with peak charging hours of EVs, France could be exposed to local system operation constraints, notably in large cities during evening hours.

IEA 25 ENERGY EFFICIENCY RECOMMENDATIONS

The IEA 25 Energy Efficiency Recommendations offer a framework for a comprehensive portfolio of policies. Table 4.4 summarises the recommendations and assesses French energy efficiency policy priorities against this framework.

Table 4.4 IEA 25 energy efficiency recommendations

Recommendation	Implementation and progress
	Energy efficiency across all sectors
1. Energy efficiency data collection and indicators	ADEME and MEEM collect energy data and lead international efforts in the area. *Continue to develop data and policy metrics on sector-specific energy end-use data and energy efficiency to develop and evaluate energy policies, targets and measures over time*.
2. Strategies and action plans, institutional structure (resources)	France has established a comprehensive policy package for energy efficiency, namely a National Energy Efficiency Action Plan (NEEAP), across various sectors. The third edition of the French NEEAP was delivered in 2014. The NEEAP regularly evaluates progress towards the targets and adjusted actions. MEEM is the main ministry in charge of promoting energy efficiency. ADEME is the national agency in charge of energy efficiency actions, under the supervision of MEEM and of the Ministry of Higher Education and Research.
3. Competitive energy markets, with appropriate regulation	A new mechanism has been set up through the NOME (New Organisation of the Electricity Markets) law, the "ARENH mechanism" *(accès régulé à l'électricité nucléaire historique)* which has been implemented since July 2011. This mechanism aims at promoting competition in the retail market by allowing alternative suppliers to supply their clients in the same economic conditions as the incumbent. It provides every supplier with an access to wholesale baseload energy produced by the nuclear power plants owned by EDF at a regulated price reflective of costs. A capacity market will be first implemented in 2017. It aims at ensuring that the level of security of supply defined by the government is reached at least cost. Security of supply is a major challenge in France, whose electricity market is characterised by an intense peak demand.
4. Measures to increase investment in energy efficiency (private/public)	The main instruments for France to finance energy savings in buildings, industry and transport are the white certificates and the tax credits (CITE). Government-sponsored economic instruments for energy efficiency include soft loans, tax credits to industry for voluntary energy efficiency measures and direct grants, as well as awareness-raising campaigns. France is part of the EU-ETS. It is also operating white certificate schemes, which have entered a third phase from the beginning of 2015.

	Focus should be placed on small and medium-sized enterprises which are not covered by audits or the ETS.
5. Monitoring, enforcement and evaluation of policies and measures	*The implementation of the NEEAP and the annual monitoring should be done in connection to the Low Carbon Strategy and the carbon budgets as well as the pluriannual energy programming (PPE).*
Buildings	
6. Mandatory building energy codes and minimum energy performance requirements	The RT 2012 thermal regulations have strengthened requirements regarding the thermal performance of new buildings. Especially for building permits requested after January 2013, these buildings must have a primary energy consumption below 50 kWh/m^2/year on average for the five regulatory uses (heating, domestic water heating, lighting, cooling and auxiliary system).
7. Aiming for net zero-energy consumption buildings	The definition of nZEB (near-zero energy building) in France comprises a numerical target for primary energy use and the criteria have become stricter along with the RT 2012.
8. Improving energy efficiency of existing buildings	The thermal regulation of existing buildings aims to ensure a significant improvement of their energy performance. The French government promotes refurbishment for dwellings, with the target of 500 000 units per year by 2017. This plan is supported by diverse financial instruments, including tax credits, soft loans and white certificates.
9. Building energy labels and certificates	A high energy performance renovation label, the Low Energy Building (*Bâtiment bass consummation, BAT*), was created in 2007 for new buildings complying with the RT 2012. In 2013 the BBC had become a mandatory performance level and is no longer a label.
10. Energy performance of building components and systems	*Maintain and develop emerging low-energy building measures along EU standards such as switching off signs and billboards during the night. Since the beginning of 2012, new signs and billboards must be switched off between 1 and 6 a.m.*
11.Minimum energy performance standards and labels for appliances and equipment	MEPS and labelling policies for boilers and air-conditioning systems are aligned with the EU Eco-design Framework.
Appliances, equipment and lighting	
12. Test standards and measurement protocols for appliances and equipment	Regulatory measures are aligned with the European directives, including eco-design and eco-labelling.
13. Market transformation policies	*Develop an energy efficiency service market*.
14. Phase-out of inefficient lighting products and systems	France follows the Eco-design Directive which bans the use of incandescent light bulbs. The EU started to phase them out in 2009.
15. Energy-efficient lighting systems	Regarding streetlights, a national convention has been signed by France and by the Lighting Union in order to bring forward the withdrawal date of low-efficiency light bulbs.
Transport	
16. Mandatory vehicle fuel efficiency standards	Progress is driven by the bonus-malus scheme. This scheme has been able to reduce the average emissions of new vehicles by 5 gCO_2/km in 2013. It has also encouraged the expansion of the EV market in France.
17. Measures to improve vehicle fuel efficiency	The bonus-malus scheme is based on the CO_2 emissions per kilometre of new vehicles. It rewards the purchase of low CO_2 emission vehicles and penalises the purchase of high-emission vehicles.
18. Fuel-efficient non-engine components	European Directive 2006/40/EC bans the use of hydrofluorocarbons with high global warming potential in car air-conditioning.
19. Improving operational	The professional haulage road drivers are now trained in eco-driving as part of their initial

efficiency through eco-driving and other measures;	and 5-year training. For car drivers, a set of questions for the driving theory test has been prepared.
20. Improve transport system efficiency	The French government encourages modal shift to less polluting modes of transport. The "Mobility 21" commission gives priority to the existing networks. This will include upgrading and modernisation of networks. National priorities shall be updated every 5 years to take account of all new territorial dynamics. A low-carbon mobility plan is in place.
Industry, energy utilities and end-use	
21. Energy management in industry	France operates diverse incentive measures concerning energy use in the industrial sector, ADEME's "Help in decision" is funds studies on the energy efficiency of the industry sector.
22. High-efficiency industrial equipment and systems	The eco-energy loan by the French Banque *publique d'investissement*'s allows funding the installation and working necessary to upgrade certain premises that consume a lot of energy. ADEME's funding system "Rational use of energy – investments" allows supporting the investments made by businesses to purchase energy-saving equipment or make changes to processes or equipment in use.
23. Energy efficiency services for small and medium-sized enterprises	The Green Loan support scheme is in place exclusively for SMEs and allows SMEs and industry to benefit from low-interest loans and loan guarantees for those investments allowing increased competitiveness and the energy and environmental performance of their processes or products.
24. Complementary policies to support industrial energy efficiency	The French government supports RD&D for innovative technologies in the industry sector. On an annual basis, numerous calls for projects are implemented through ADEME's Programme for Investment in the Future (PIA).
25. Governments should establish regulatory and other policies to ensure that energy utilities support cost-effective, verifiable end-use energy efficiency improvements	France aims to encourage energy savings across all sectors via the white certificates programme and tax credits. However, they are mostly used in buildings. The government is engaged with industry on energy efficiency and carbon reduction goals, focusing on energy intensity, and fostering efficiency actions on the basis of energy audits.

ASSESSMENT

France has improved the energy intensity of its economy by 16.5% over the decade since 2005. Energy intensity continued to fall at the same rate as the IEA average. Total final consumption (TFC) has been declining since 2004, down by 13% from the record-high of 169.8 Mtoe in 2004. However, the current rate of decline is not yet enough to meet France's energy saving targets for 2020, which requires 131 Mtoe versus 147.7 Mtoe in 2014. France is currently not on track towards meeting its ambitious 2020 targets and further efforts are needed.

The sectoral split of TFC has remained stable over time. In 2014, energy consumption was highest in the transport sector (29.5%), followed by industry (27%) and residential (25.3%). TFC has been declining in line with GDP growth. Energy savings came from energy efficiency improvements mainly in the residential sector (60%), followed by the commercial/services sector (industry), which accounted for 25%, and transport (16%).

The French government continues placing a high priority on energy efficiency improvements. France has gradually increased its energy efficiency targets and maintains a strong set of policy measures which have been reviewed, improved and strengthened over time. France is a leader in terms of operating a comprehensive policy package for energy efficiency, which includes regulation, information and a large range of tax and loan incentives. The regulatory measures and tax incentives have focused on

buildings and transport, less on industry where France covers a few very large companies under the EU-ETS and energy audits, but not the many SMEs.

Three major environmental legislative packages came into force in France over the last 10 years with energy saving targets, including the POPE Law (2005), the Grenelle Environment I and II Acts *(Grenelle de l'environnement*) and the Energy Transition for Green Growth Act (2015). In 2005, the POPE Law imposed mandatory saving targets on energy companies, through the market-based white certificates regime. Long-term energy efficiency benefits and cross-sectoral co-ordination are being implemented under 2015 Act, along the national low-carbon strategy (SNBC) and the pluriannual energy programming (PPE). The Act requires the reduction of final energy consumption by 20% in 2030 and by 50% in 2050 and the 30% reduction of fossil fuel consumption of by 2030, all compared to 2012 levels.

The main instruments to finance energy savings in buildings, industry and transport are the energy saving certificates (ESCs) and tax credits (CITE), zero-interest loans, ADEME's Heat Funds and the new carbon component of the consumption tax.

The ESC instrument was already introduced in France in 2005; it has been revised twice since, in 2008 and 2014, and includes the transport sector (fuel vendors). France is aiming at fulfilling almost all of its energy efficiency obligations under the EED article 7 with the ESC system. The targets of the first and second period of the ESCs were successfully achieved. However, the majority of obligations focused on a small number of players. A fully competitive transaction market for the certificates is not yet established. When more market players enter the certificate market, the system could become more active. The government has carried out important simplifications in the administration of the system (for instance making it easier to deposit a request for certificates) which will contribute to the reduction of its operating cost. The French government should keep monitoring this scheme and ensure cost efficiency as a market mechanism.

BUILDINGS

The building sector has been traditionally considered the sector with the highest potential for improving energy efficiency in France. The government focused its efforts in reducing energy consumption in the building sector by encouraging consumers to renovate, build new and more energy-efficient houses and purchase energy-efficient appliances and materials, through tax refunds (CITE/CIDD), zero-interest eco-loans and new building codes (for new dwellings) which should encourage higher energy efficiency performance, including in the heating and insulation of houses.

Energy efficiency is already improving for new buildings, with targets for energy positive buildings and a targeted 40% reduction rate of energy consumption in government buildings by 2020. New dwellings which apply the thermal regulation RT 2012 have better insulation and thus consume less energy for space heating and cooling. RT 2012 discourages electric heating and fosters more efficient forms of heating.

The Energy Transition for Green Growth Act includes several measures for the thermal refurbishment of buildings. Service points for information on renovation have been set up to help home-owners in their decision making. The Act also sets out the objective of 500 000 extensively renovated dwellings per year and to renovate all privately owned buildings with a primary energy use above 330 kWh/m^2 per year by 2025, as required by RT 2012.

The French government simplified its zero-interest loans, namely Eco-PTZ, and increased the number of loans from 30 000 per year today to 100 000 per year. The tax reduction CITE, formerly CIDD, was simplified and raised to 30% of total expenses, whatever the thermal refurbishment action. Since January 2016, the CITE may be combined with the zero-interest loan.

According to ADEME's building observatory (*Observatoire permanent de l'amélioration énergétique du lodgement, OPEN),* 3.5 million dwellings were renovated in France in 2014, with an average investment of EUR 10 000 each, of which 288 000 were very extensive renovations (still below the targeted 500 000), 1.8 million medium and 1.44 million light renovations. A recent survey found that 6 out of 10 households in France know at least one of the support incentives (most people are aware of tax incentives but know much less about white certificates and eco-loans; see ADEME, 2015). Only 20% of households engaged in renovation used a loan; only 41% carried out a deep renovation and 11% used an eco-loan. France is faced with deep renovations, as it has to renovate its historic, public buildings and social housing but faces a large number of structural barriers, including low energy prices, and a large share of electric heating and administrative barriers. For instance, in private collective housing (*co-propriété*), the renovation of central heating systems or roofs requires a joint renovation decision by all owners.

The majority of the energy saving certificates issued is linked to investments in energy savings in buildings, and has seen strong performance, with established target levels exceeded during every period. The exchange price has fallen considerably and reached EUR 1.41/MWh in August 2016. The objectives will need to be strengthened, in order to improve the value and use of the certificates.

District heating networks are rapidly developing, also combined with the use of renewable energy sources. Eco-friendly construction materials saw fast growth, as well as high-performance windows and thermal insulation materials. The heating systems of the building stock are being transformed to central heating systems. The deployment of efficient and renewable heating systems, such as condensing boilers, heat pumps and solar thermal, promoted by several subsidies or tax credits, improved the average heating energy efficiency. In the meantime, the spread of air conditioning has steadily increased. Space heating represented the largest share of household energy use, and is very much dependent on weather conditions.

The Better Living programme has supported energy efficient renovation for those households that needed it the most, low-income households. During 2010-15, about 140 000 households benefited from the programme, well below the targeted 300 000 for 2010-17. However, progress is under way: 50 000 dwellings were renovated in 2014 and 2015, and the objectives for 2016 are to renovate 70 000 households. The government is confident that the targeted 300 000 social housing renovations for 2010-17 are achievable. Energy vouchers and eco-loans for social housing should improve the performance and ensure beneficiaries of social housing support are better targeted. Under the Energy Transition for Green Growth Act, the creation of an energy renovation guarantee fund (to apply for social renovation loans) will enable the provision of aid to finance works in one's home. The funding is to come from a partnership with industry under the white certificates financing system.

TRANSPORT

France has been delivering energy efficiency in transport thanks to the successful bonus-malus scheme, first introduced in 2008 which continuously leads to the scrapping of old vehicles and supports the deployment of electric vehicles. This bonus-malus scheme has stimulated continuous improvement in fuel economy for vehicles and fostered the penetration of more energy-efficient and electric vehicles, where France has high growth rates and is among the leaders in Europe. The penetration of biofuels is advancing thanks to blending requirements. However, its funding will need to be revised.

INDUSTRY

Energy demand in industry has decreased by 1.7% per year from 2000 to 2014. Energy intensity has improved in French industrial sectors as a result of relocation or withdrawal of production capacity, and of the economic crisis; after 2008, the improvement in processes and technology led to energy savings. There were no major structural changes in the industry sector and energy efficiency was increasing slowly. Since 1990, efficiency improved by 13% which is equivalent to 4.7 Mtoe energy savings, and most of the improvements have been achieved since 2008.

Given the low energy consumption of industry, policy emphasis on energy savings in industry has been considerably lower than in the buildings sector. For industrial companies outside the EU-ETS, there is no substantial regulation of energy savings, apart from eco-design and energy audit requirements imposed by EU legislation. France relies mainly on tax incentives and white certificates, but they are mainly used in buildings. White certificates cannot be obtained in installations that take part in the EU Emissions Trading Scheme (ETS), but installations outside the EU-ETS can obtain the certificates. However, since 2015, the share of non-ETS industry has gone up progressively; it accounted for roughly 20% of certificates delivered. Different support schemes have been put in place, including green loans, eco-energy loans, energy audits, tax incentives (e.g.: art. 142 of Law No 2015-990). Large energy users pay substantially less energy tax because of exemptions or ceilings in the tax system, but the Energy Transition for Green Growth Act foresees that those companies will have to undergo energy efficiency audits and prepare management plans.

Energy audits have been made compulsory for large industries but not for SMEs. Incentives exist for energy audits in SMEs, including from EU and international standards (ISO 50001 certification). The lessons learned in the large industry from applying energy efficiency management audits should be transferred to SMEs for voluntary actions in sectors not covered by the current measures. Energy audits in SMEs can lead to significant energy efficiency gains.

RECOMMENDATIONS

The government of France should:

- ☐ *Update the National Energy Efficiency Action Plan, building on the PPE and clarify the actions required to achieve the ambitious goals in renovation of buildings and on reducing energy poverty, including the roles and responsibilities of the various authorities and their interaction.*

- *Place policy emphasis on energy efficiency in SMEs to ensure the appropriate participation of the various sectors and give recognition to the role industry can play in the energy transition to green growth. Engage with industry on energy efficiency and carbon reduction goals, focusing on energy intensity, and foster efficiency actions on the basis of energy audits.*
- *Examine the effect of overlapping energy efficiency instruments, for example energy saving certificates, tax credits and energy taxes.*

References

ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie) (2015), *Observatoire permanent de l'amélioration énergétique du logement (OPEN)*.

ADEME (2011), Odyssee, *Quantitative evaluation of explanatory factors of the lower energy efficiency performance of France for space heating compared to European benchmarks*, August.

ECEEE (2012), *Harnessing Potential energy saving in the French Industry*, European Council for an Energy Efficiency Economy, Cassel, www.eceee.org/.

IA-HEV (2015), *Implementing Agreement Hybrid Electric Vehicles*, 2015.

IEA (International Energy Agency) (2016a), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris. www.iea.org/statistics/.

IEA (2016b), *Energy Efficiency Indicators: Fundamentals on Statistics*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016c), *Global EV Outlook 2016*, OECD/IEA, Paris.

IEA (2015), *World Energy Outlook 2015*, OECD/IEA, Paris. www.iea.org.

MEEM (Ministry of Environment, Energy and the Sea) (2016a), *Energy and Climate Panorama 2016* www.developpement-durable.gouv.fr, Paris.

MEEM (2016b), *Bonus-Malus: Definitions and Pricing Scheme for 2016*, www.developpement-durable.gouv.fr/Bonus-Malus-definitions-et-baremes.html.

MEEM (2016c), *Electric and Hybrid Cars: Eligibility Conditions for Obtaining the new EUR 10 000 bonus,* www.developpement-durable.gouv.fr/Voitures-electriques-et-hybrides.

MEEM (2016d), *Strengthening the Publicly Accessible Charging Infrastructure*, www.developpement-durable.gouv.fr/Le-renforcement-de-l.html.

MEDDE (Ministry of Ecology, Energy and Sustainable Development), (2015a), *Energy and Climate Panorama 2015*, Paris.

MEDDE (2015b), *Prospective Energy-Climate-Air Scenarios for France towards 2035*, Paris. http://www.developpement-durable.gouv.fr/IMG/pdf/Synthese_scenarios_2014-15_mis_en_ligne.pdf.

MEDDE (2014), *Energy Efficiency Action Plan for France-2014 (2014 NEEAP),* Paris.

Odyssee-mure (2015a), *Trends and Policies for Energy Savings and Emissions in Transport,* www.odyssee-mure.eu.

Odyssee-mure (2015b), *Energy Efficiency Trends and Policies in Industry; an Analysis based on the ODYSSEE and MURE Database,* www.odyssee-mure.eu.

PART II
SECTOR ANALYSIS

5. NATURAL GAS

Key data (2015 estimated)

Natural gas production: 0.021 bcm, -98.2% since 2005

Net imports: 39 bcm, -17.1% since 2005 (imports: 44.4 bcm, exports: 5.4 bcm)

Share of natural gas: 14.3% of TPES and 3.5% of electricity generation

Consumption by sector (2014): 36.7 bcm (industry 33.4%, residential 33.1%, commercial and public services and agriculture 19.8%, power generation 9.3%, other energy 4.1%, transport 0.3%)

SUPPLY AND DEMAND TRENDS

SUPPLY

Natural gas supply amounted to 35 million tonnes of oil-equivalent (Mtoe) or 39.1 billion cubic metres (bcm) in 2015. Its share in total primary energy supply (TPES) was 14.3% and in electricity generation 3.5%. Gas supply peaked at 42.5 Mtoe or 48.3 bcm in 2010, and has fallen by 17.6% since, with a 16.4% drop in 2014 alone.

France relies on imports for gas supply; domestic gas production is negligible (0.02 bcm). Domestic gas production has fallen dramatically since 2005 by almost 99%.

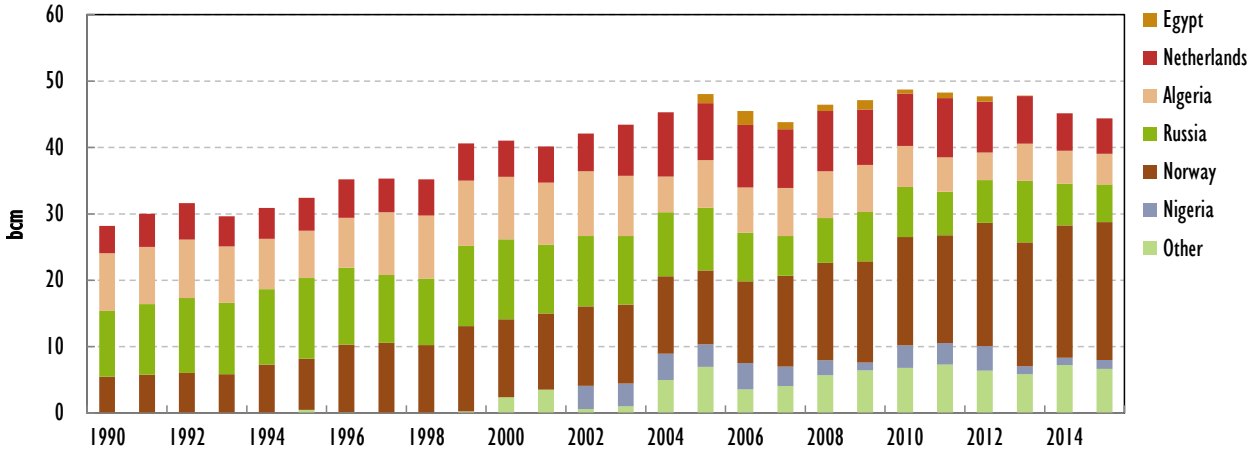
Compared to other IEA member countries, France ranks seventh-lowest (23rd) with regard to the share of natural gas in TPES and sixth-lowest (24th) for electricity generation.

IMPORTS AND EXPORTS

In 2015, the total imported, 44.4 bcm came from diverse suppliers: Norway (46.8%), Russia (12.7%), the Netherlands (12%), Algeria (10.5%), Nigeria (3%) and others (15%) (Figure 5.1). In 2014, 85% of the total was imported by pipeline and the remaining 15% used LNG terminals.

Over the past decade to 2015, imports from Russia and the Netherlands decreased by 40.2% and 37.8%, respectively. Conversely, imports from Norway increased by 87.4% over the same period. In 2010, imports from Norway accounted for 33.4% of the total and have increased since.

Figure 5.1 France's natural gas imports by country, 1990-2015



Note: *Other* includes other countries and imports from unspecified sources.

Source: IEA (2016a), *Natural Gas Information 2016*, www.iea.org/statistics/.

DEMAND

France is the fourth-highest gas-consuming country in the European Union (EU) behind Germany, the United Kingdom and Italy. Gas use was 36.7 bcm in 2014. The share of gas in TPES (14.3%) is much lower than the EU average (23%), given the significant use of (nuclear) electricity in the heating sector and France's lower population density (below EU average), which has resulted in many rural areas still largely using fuel oil or biomass as they have no gas network connection.

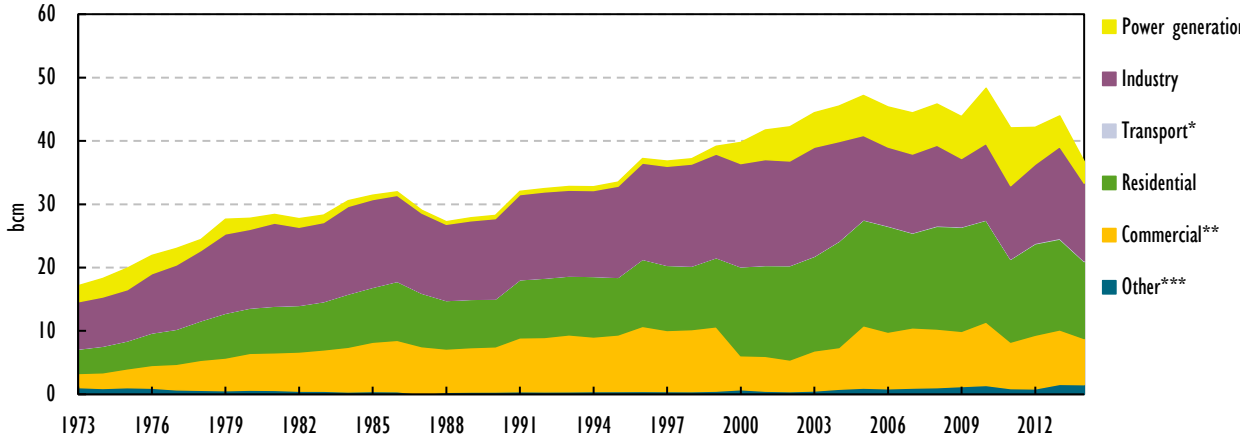
Industry and households are the largest gas-consuming sectors in France. Industry has a share of 33.4% in total demand in 2014. Households and the commercial sector (including agriculture, fishing and forestry) consumed 33.1% and 19.8%, respectively. The power generation sector consumed 9.3%, other transformation sector 4.1% and transport the remaining 0.3% (Figure 5.2).

Since 2004, overall gas consumption has contracted by 19.3%. In 2014, gas consumption further declined by 7.2 bcm compared to 2013. Gas demand had reached its record high in 2010 with 48.3bcm and demand in 2014 was 24% lower compared to this peak. Much is related to the cold winter in 2010 and the milder winters in recent years, but also the economic and financial crisis which lowered gas use in industry.

In 2014, demand in the power generation sector decreased by 2.2 bcm or 39.2% compared to 2004. Industry and household sectors' demand were lower 21.9% (3.4 bcm) and 27.5% (4.6 bcm), respectively.

Conversely, the transformation sector and commercial sectors showed increase in the demand of 89.7% (0.7 bcm) and 10.7% (0.7 bcm), respectively. Transportation sector demand increased by 118.8% (0.1 bcm) though its share is marginal.

Figure 5.2 Natural gas demand by sector, 1973-2014



* *Transport is* negligible.

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

*** *Other* includes petroleum refineries and energy own-use.

Note: TPES by consuming sector.

Source: IEA (2016a), *Natural Gas Information 2016*, www.iea.org/statistics/.

GAS REGULATORY FRAMEWORK

The legal basis for the functioning of the French natural gas system is provided by EU regulations and national laws implementing EU directives.

The European Union has harmonised the natural gas sector with the aim of creating a single market. Natural gas market integration has focused on two areas: *i)* integrating national and regional gas markets and co-ordinating system operations via commonly agreed network codes and, *ii)* constructing cross-border interconnections and co-ordinating network infrastructure planning under the guidance of the European Network of Transmission System Operators for Gas (ENTSO-G) and the ten-year network development plan (TYNDP) and related regional plans.

The relevant EU directives and regulations (the so-called third package) for natural gas are:

- Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal natural gas market and repealing Directive 2003/55/EC (the "Gas Directive").
- Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005 (the "Gas Regulation").
- Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators (the "ACER Regulation").
- Regulation (EU) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency (the "REMIT Regulation").

The cornerstone of the 2009 Gas Directive is the effective separation of network activities from supply, generation or production activities, so-called unbundling. The directive also strengthened the independence of national regulatory authorities from the governments and promotes their co-operation at EU level through ACER. It also increased the independence of the transmission system operators (TSOs) and their co-operation at EU level through ENTSO-G.

The Gas Directive was transposed into national legislation (the French Energy Code). In line with the EU requirements, the national regulatory authority – the *Commission de régulation de l'énergie (CRE)* – has the competence to certify the TSOs, to review the national ten-year network development plan (TYNDP) each year which they have to prepare under the Energy Code, and to ensure its coherence with the Europe-wide TYNDP.

France's natural gas network is split up into three distinct regional transmission network areas, operated by two TSOs. CRE regulates the two gas operators, GRTgaz and TIGF. In line with Energy Code Article L 111-3 and L 111-4, in 2012, CRE certified GRTgaz as independent transmission operator (ITO), as part of a vertically integrated undertaking. GRTgaz is owned by ENGIE (75%) and a consortium made up of the *Caisse des Dépôts et Consignations (CdC)*, CdC Infrastructures, and CNP Assurances holding the remaining 25%. *Transport et Infrastructures Gaz de France (TIGF)* was recertified as ownership-unbundled TSO in 2014, following the change in the shareholder's structure. TIGF is owned to 45% by the Italian gas operator SNAM Rete Gas, by the Singapore GIC Limited (35%) and EDF (20%).

Distribution system operators (DSOs) have to be legally and functionally unbundled under the Third Package. CRE monitors the independence of the DSOs to ensure that their governance and marketing are in line with the unbundling requirements under the Third Package.

Unlike in electricity, the Ministry of Environment, Energy and the Sea (MEEM) continues to set tariffs for the still regulated parts of the retail market. CRE approves the annual network investments plans of the gas system operators (French Energy Code, Art. L134-3 para 2).

With regard to upstream regulation, a ban on hydraulic fracking was introduced in 2011 due to social and environmental concerns.

GAS INFRASTRUCTURE

France imports almost 100% of the natural gas it consumes (37 bcm) through an extensive network of pipelines and LNG terminals. The country totals 37 500 km of transport network and 195 000 km of distribution network, has four operating LNG terminals (including the new Dunkirk facility) and 15 natural gas storage sites.

At the end of 2014, the daily import capacities on the French territory amounted to around 3 800 gigawatt-hours (GWh) or 283 million cubic metres per day (m^3/d), 80% of which was pipeline gas and 20% LNG. In aggregate, this equals to more than 2.5 times France's average daily consumption and could cover up to 95% of daily demand during a peak cold day with a 2% probability. The start-up of the large 13 bcm Dunkirk LNG terminal in summer 2016 has further increased the country's ample import capacity.

France is also a transport corridor country for gas coming from the North Sea and North-West Europe and directed to Spain and Italy (via Switzerland). At the end of 2014, export capacity totalled around 400 GWh/d (roughly one-tenth of its entry capacity) while actual exports averaged 230 GWh/d.

Cross-border capacity between France and Spain has increased in recent years in line with the EU priority objective to strengthen the integration of the Iberian peninsula with the rest of the European gas market. In 2009, interconnection capacity between the two countries totalled 2.3 bcm/year (in Larrau). It was raised to 5 bcm/year in 2013, thanks to the reinforcement of this interconnection which allowed gas flows from France to Spain to increase by 25% in 2014. In 2016, the establishment of reverse flows in Biriatou is set to bring the gas interconnection capacity between the two countries to 7 bcm/year in both directions: equivalent to 20% of French consumption and 27% of Spanish consumption (as of 2014).

The realisation of a new large-scale pipeline project – the Midcat project in the East of the Pyrenees – is currently under discussion. The project is part of the EU list of projects of common interest and could, if realised, triple the gas exchange capacity between the two countries The EU Commission President Jean-Claude Junker and heads of state and government of France, Portugal and Spain signed on 4 March 2015 the so-called Madrid Declaration where they agreed to pursue the further studies needed to move forward with the project. In April 2016 the project was allocated a grant of EUR 5.6 million from the Connecting Europe Facility (CEF) aimed at funding up to 50% of the feasibility studies.

TRANSMISSION

France has an entry/exit system with 6 entry/exit points, 15 gas storages and 4 LNG terminals. The natural gas transmission network is operated by two operators GRTgaz and TIGF. Over time, the number of market areas was reduced from eight in 2004 to three virtual trading points in 2009 (PEG North, PEG South and PEG TIGF), until in 2015 the new Trading Region South was created, merging PEG South and TIGF, merely leaving two market areas in France. Figure 5.3 illustrates the two networks and two market areas (TRS and PEG North).

GRTgaz operates 8 110 km of main network and 24 043 km of regional network. This is more than 85% of the gas transmission network in France. TIGF operates 650 km of main network and 4 450 km of regional network in the south-west of France, which is around 14% of the country's total network.

Despite a generally well-developed gas infrastructure, GRTgaz network has suffered from congestion in the north-to-south link between PEG North and PEG South in recent years. These internal bottlenecks are yet to be resolved. Looser LNG balances since mid-2014 have helped reduce the price differentials between north and south (because of the heavy dependence of southern France on LNG imports). Yet transmission capacity in the north to south direction remains heavily used and congestion problems could easily reappear should LNG markets tighten up again. In late 2013 and early 2014 the spread between PEG Nord and PEG South reached levels above EUR 10 per megawatt-hours (MWh). This led the French government to implement measures to reserve some of the interconnection capacity for energy-intensive consumers in the south who were suffering from the much higher gas price resulting from the infrastructure bottleneck. In March 2015, CRE adopted an auction-based procedure to allocate capacity between the northern and southern market areas. The congestion income is entirely redistributed to

consumers in the south of France. TSOs have fully recognised such vulnerabilities and are in the process of addressing them. Two projects with a total cost of around EUR 900 million are expected to be operational by 2018-19 and should help to reduce congestion:

- The Val de Saône project (188 km pipeline plus 3 compression stations with a cost of about EUR 700 million for GRTgaz).
- The Gascogne Midi project (60 km pipeline plus 3 compression stations for a cost of about EUR 150 million for TIGF and EUR 20 million for GRTgaz).

Strengthening the internal infrastructure is a key requirement to achieve a single marketplace in France by 2018, and is an important step towards further improving the functioning of the wholesale and retail gas markets for end-customers.

LNG FACILITIES

France has three operating LNG terminals and a fourth has started commercial operations in 2016 (Table 5.1). The country's total regasification capacity stands at around 35 billion cubic metres (bcm), making France the third-largest LNG capacity holder in Europe. Since 2011, the utilisation of the French LNG infrastructure has been low, but better than the EU average, because of the significant fall in Europe's gas demand and the diversion of LNG cargoes to higher-priced markets in Asia (re-export).

Table 5.1 LNG terminals in France, 2015

Name	Capacity (bcm/year)	Put in service	Utilisation 2013*
Fos-Tonkin	3.4	1972	56%
Montoir-de-Bretagne	10	1980	11%
Fos-Cavaou	8.25	2010	48%
Dunkerque LNG	13	2016	-
Total	**34.65**		

Note: For utilisation rates, see CEER (2014).

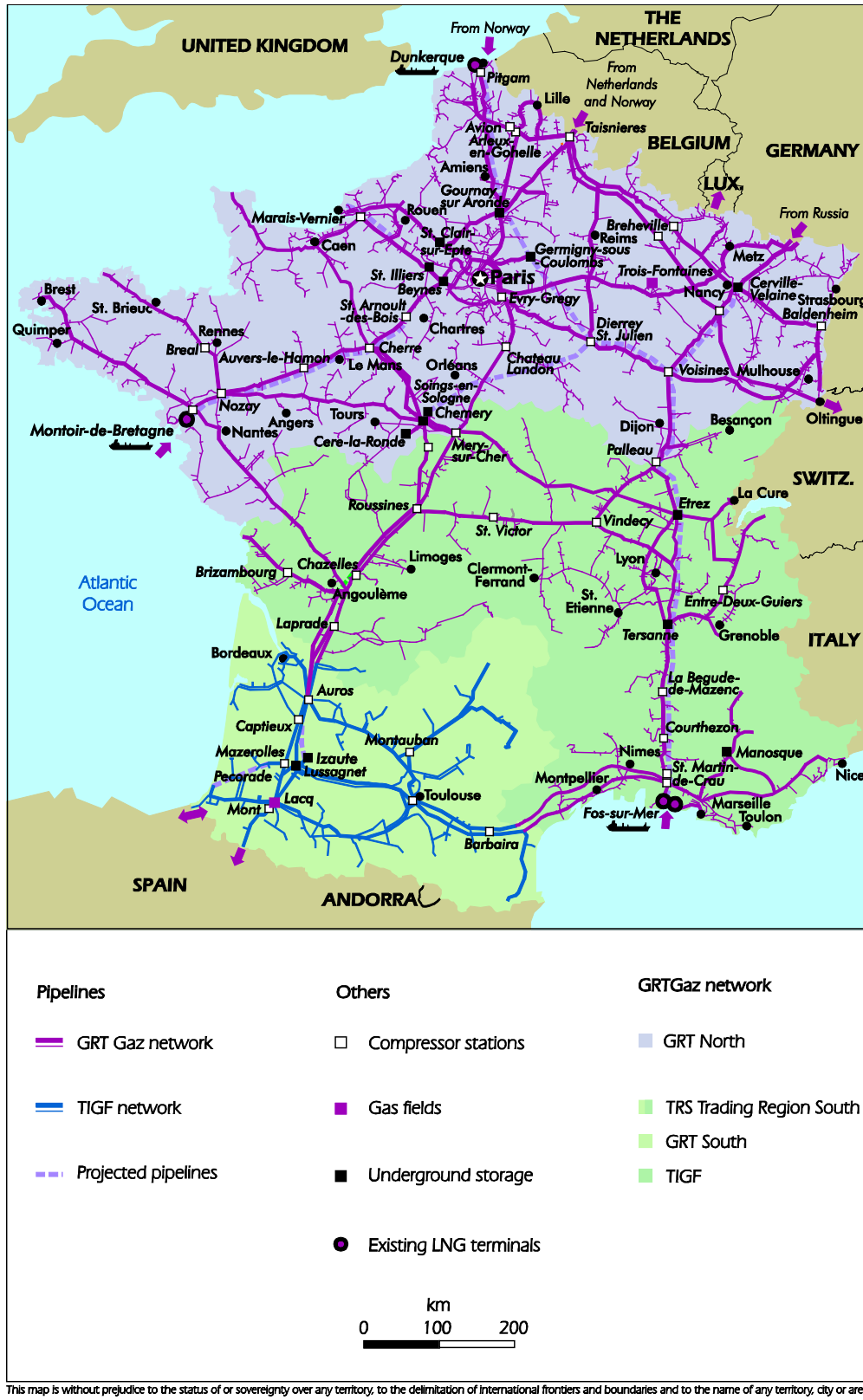
Source: Gas Infrastructure Europe LNG Map 2015.

The facilities at Fos-Tonkin, Fos-Cavaou and Montoir-de-Bretagne follow a regulated third-party access (TPA) regime and tariffs for capacity use at these facilities are set in a fashion similar to that for network tariffs.

In contrast, the Dunkirk LNG terminal, after having received a final investment decision (FID) in 2011, was granted full exemption from third-party-access (TPA) and tariff regulation. These exemptions apply to all the capacity of the terminal for a period of 20 years from the date of commissioning. Exemptions were granted by the European Commission under the European Directive 2009/73/EC Article 36.

The sharp drop in Asian prices during 2015 and early 2016 amid the projected strong increase in global LNG supplies will likely result in higher LNG deliveries into Europe over the next five years and help improve somewhat the utilisation rate of existing facilities.

Figure 5.3 Map of high-pressure natural gas infrastructure



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

UNDERGROUND STORAGE

France has 15 gas storage facilities, of which 13 or 80% are operated by Storengy, a subsidiary of ENGIE (formerly GDF Suez). Ten of those 13 sites are aquifers located in the Paris Basin; the remaining 3 are salt caverns located in the south-east. Storengy operates 100 TWh of storage capacity, or around three-quarters of the country's total. TIGF operates two aquifers with a total capacity of 32 TWh or 20% of the gas storage.

Since 2012, three storage facilities (Trois-Fontaines, Soings-en-Sologne and Saint-Clair-sur-Epte) have been mothballed, reflecting worsening economics for storage operators. In France – as in much of Europe − storage capacity is overwhelmingly designed for a winter-summer cycle to respond to the typical seasonal demand fluctuations of temperate climates. The value of storage is, therefore, primarily determined by seasonal price spreads (the price of buying gas in summer versus the price in winter): if the spread exceeds the cost of storage market participants have an incentive to buy gas in summer, store it and sell into the winter, rather than relying on futures transactions or direct spot purchases in winter.

Theoretically, the value of storage should reflect factors other than the simple summer-winter spreads and seasonal demand fluctuations. Storage has also an important "system" value as it provides a high level of flexibility to the operations of the entire gas system as well as a "security of supply" value for consumers. In reality, market participants tend to neglect these additional values of storage. As seasonal spreads have fallen sharply to levels well below the cost of storage in recent years (mainly due to a sharp fall in European gas demand), storage capacity bookings have also declined significantly. This has led to the closure of the three sites mentioned above.

History shows that storage plays a crucial role in responding to sudden supply disruptions or unexpected increases in demand: during the cold spell in early February 2012, gas from storage provided almost 60% of French domestic demand. There is a risk therefore that, under current market conditions, low bookings of storage capacity could lead to physical supply deficits during unusually high peak demand periods. Additionally, because of the physical characteristics of aquifers, mothballing facilities could result in permanent damage to the reservoir and in the permanent loss of storage capacity. Against this backdrop, the French government has been consulting with various stakeholders since December 2013, to change the regulatory framework for gas storage access with the aim of maximising its use and ensure that its security of supply value is fully recognised.

Under the current regulatory framework, all suppliers to French final customers hold storage access rights, which give them priority in accessing storage facilities in order to meet variations of their customers' demand. Moreover, suppliers are obliged to meet the equivalent of 80% of the storage rights of their protected customers at the beginning of winter (the extent of the storage obligation was substantially increased following the winter 2012/13; before, the obligation was limited to domestic customers and customers providing services of general interest). Access to storage is prioritised for:

- TSOs for the implementation of their duties
- residential customers and buildings
- other customers pursuing missions of general interest
- other final customers with firm supply contracts.

Table 5.2 Storage facilities in France

Name	Type	Working capacity (mcm)	Peak output (mc m/day)
Céré-la-Ronde	Aquifer	570	9.0
Chémery	Aquifer	3 710	55.1
Soings-en-Sologne*	Aquifer	220	1.5
Beynes profond	Aquifer	330	9.6
Beynes supérieur	Aquifer	167	4.3
Saint-Illiers	Aquifer	690	16.7
Saint-Clair-sur-Epte*	Aquifer	530	4.8
Germigny-sous-Colombs	Aquifer	880	8.8
Cerville-Velaine	Aquifer	650	7.5
Gournay-sur-Aronde	Aquifer	1 310	29.7
Etrez	Salt cavern	640	35.9
Manosque	Salt cavern	277	13.7
Tersanne	Salt cavern	162	17.5
Trois-Fontaines*	Depleted	80	0.6
Izaute	Aquifer	1 455	13.0
Lussagnet	Aquifer	1 223	26.0
Total		**12 894**	**254.0**

* Storage facilities highlighted in bold have been mothballed.

Note: Data at end 2013.

Source: MEEM (2016) and IEA (2014), *Energy Supply Security 2014*, OECD/IEA, Paris.

The remainder of storage capacity is regarded as commercial storage and available to all suppliers. However, today's high storage obligations mean that almost all of the capacity is allocated under the access-right mechanism.

A new storage model under discussion embraces both market-based mechanisms and residual storage obligations. The planned auction mechanism for subscriptions should be introduced to allow shippers to subscribe the capacity they wish at market-based prices. If a minimum level of storage is not subscribed, additional obligations will be introduced to ensure that security of supply is maintained. This will be combined with a financial regulation of storage assets to ensure the economic viability of storage operators amid changing business cases and storage use in Europe.

GAS MARKET STRUCTURE

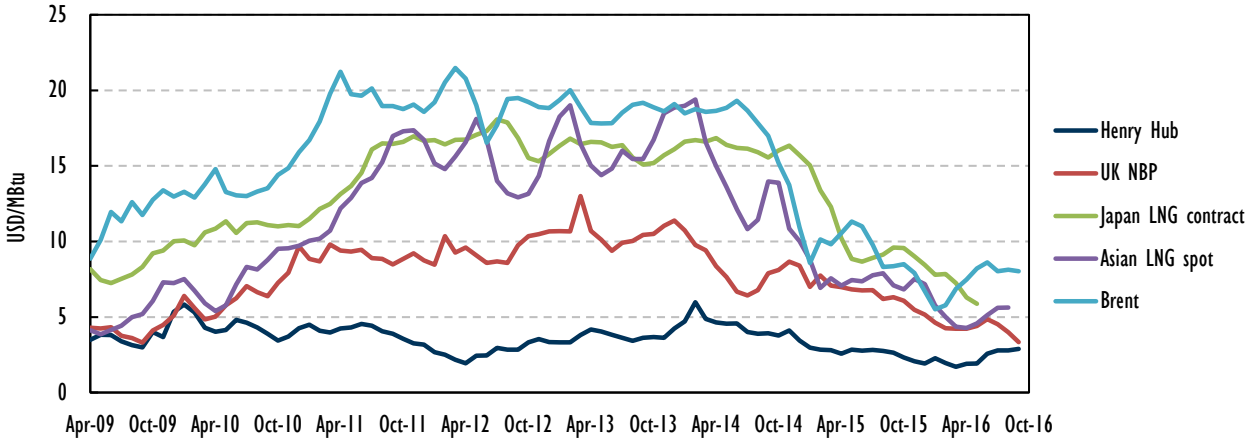
The price regulation model in France allows for regulated prices to co-exist with market-based contracts for all consumer segments, thus integrating price regulation in the broader market opening context. The gas market has been fully opened to competition since 2007 and final consumers have been able to choose between regulated tariffs and market-based prices with the supplier of their choice. While all suppliers have to offer market-priced products, regulated prices can only be offered by incumbent suppliers for some categories of customers, largely households. Today, regulated prices represent less than 20% of all sold volumes for gas.

WHOLESALE MARKET

Access to the wholesale market has improved with market mergers and market integration within the EU. Liquidity at domestic trading hubs in France has increased, but is still below the key EU gas hubs (the British NBP or the Dutch TTF).

Prices at the gas exchange point are in line with other northern European benchmarks of UK NBP of EUR 13/MWh in 2016 (see Figures 5.4 and 5.5). Volumes and liquidity have increased since 2008, also thanks to the PEGAS project, a co-operation agreement between Powernext and the European Energy Exchange (EEX). Today traded volumes in France are comparable to the traded volumes at German hubs (Gaspool and NetConnect Germany NCG).

Figure 5.4 Trends in quarterly wholesale gas and oil prices, 2009-16



Source: IEA (2016b), *Medium-term Gas Market Report*, IEA/OECD, Paris.

France is currently simplifying its market design and is taking steps to create one single market area by 2018 (CRE, 2014), following CRE public consultation from 2012 to 2013. As a first step, in April 2015 a single trading region was implemented in the south of France (called "Trading Region South" or TRS) resulting from the merger of GRTgaz South and TIGF zones. The merger, which was implemented successfully, did not require any investment in new physical capacity as there was no congestion between the two trading zones. It has created one single trading point while maintaining two distinct balancing zones. There is no transmission fee between GRTgaz and TIGF and both TSOs have the same balancing rules.

The next step in the creation of a single gas market in France entails the merger of the PEG Nord trading point and the newly created Trading Region South. Achieving this will require the removal of physical capacity constraints in the north-south direction (Val-de-Saône and Gascogne-Midi pipelines) and is therefore dependent on the timely completion of two major infrastructure projects worth a combined EUR 900 million (see section on infrastructure above).

DISTRIBUTION

With a total length of approximately 195 000 km France's gas distribution network is the second-largest in Europe after Germany. Overall, this network supplies gas to 11.5 million customers and to over one-quarter of the 36 000 French communes.

Distribution networks are owned by local communities and are managed through a concession-based system whereby concession agreements govern the relationship between local authorities and GRDF (a subsidiary of ENGIE that operates and distributes gas to 96% of the grid), Régaz-Bordeaux and Réseau GDS (which serve each around 1.5% of the market) and the other 22 local distribution companies which cover the remaining 1% of the market and offer their own regulated tariffs based on their own-cost-basis. Almost all communes with more than 10 000 inhabitants are served. Those that are not have the option to call for a proposal with the operator of their choice subject to approval by MEEM.

RETAIL MARKET

The opening of the gas market to competition has advanced in the non-residential sector. Regulated tariffs were phased out for large and medium-sized non-residential customers. Tariffs were abolished in a three-stage process:

- 19 June 2014, for large professional customers connected to the transmission grid
- 31 December 2014, for sites with consumption above 200 MWh/year
- 31 December 2015 for all other customers with consumption above 30 MWh/year.

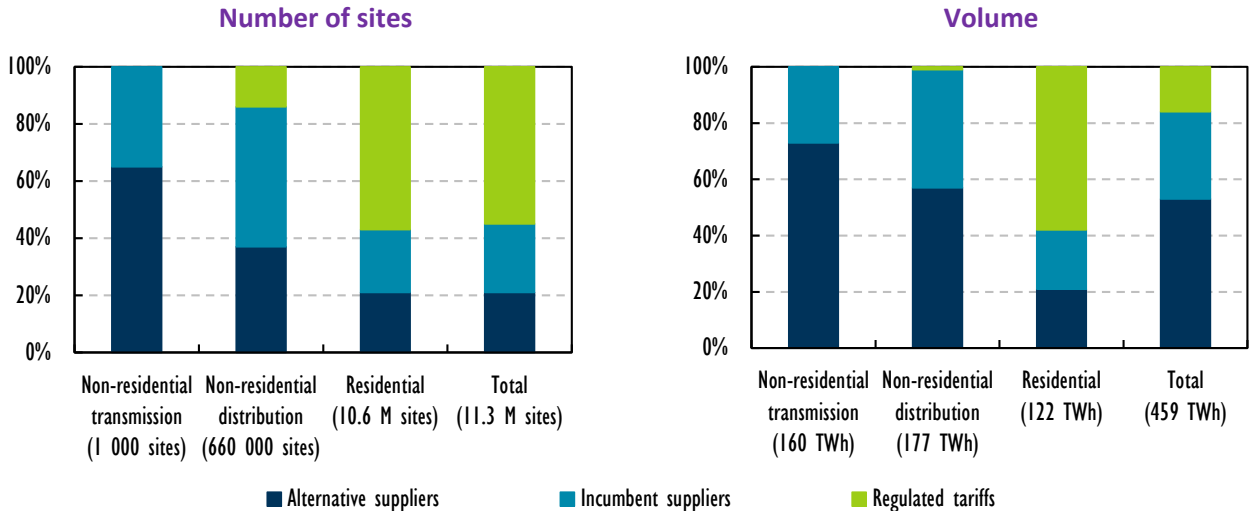
Therefore, as of 1 January 2016 only residential customers and professionals using less than 30 MWh/year remain eligible for regulated tariffs. "Historic suppliers" are the only suppliers who can offer regulated tariffs to consumers located on their territory (ENGIE and 22 distribution companies). There are currently no deadlines set under the French Energy Code to end the regulated tariffs for households.

Alternative suppliers have steadily increased their market share: since the end of 2009, they have multiplied the number of customers by around three in the residential sector and by two in the non-residential segment. Across all customers, the market share of alternative suppliers is substantially higher when measured in terms of market volume rather than of customers (number of sites) and exceeds 50% (CRE, 2016). Their regulated tariffs are at 16% of the total market volume. For residential customers, the market share of alternative suppliers stood at 21% in terms of volumes in Q12016 and at 58% in terms of regulated tariffs; 73% of large industry consumers are now supplied by alternative suppliers (CRE, 2016; see Figure 5.6).

In 2016, there were 11 alternative suppliers to households (Alterna, Antargaz, Axpo, Dyneff Gaz, Énergem, Énergie du Santerre, EDF, ENI, Direct Énergie, Lampiris, Alterna) besides the historic supplier ENGIE (formerly GDF Suez) and 40 suppliers in total;

22 historic suppliers, the entreprises locales de distribution, ELDs (CRE, 2016). Since the end of regulated tariffs for large and medium-sized consumers, there has been a slight increase in supplier switching rates of the non-residential segment (reaching up to 5.5% by the end of 2014). According to the regulator CRE, between 2008 and 2015, total switching rates have only increased from 0.02% to 2.3%.

Figure 5.5 Gas market opening in France, 2015



Source: CRE (*Commission de Régulation de l'Énergie*) (2016), *Observatory of Wholesale Electricity and Gas Markets (Observatoire des Marchés de Gros de l'Électricité et du Gaz)*, Q1 2016.

In the context of the phase-out of regulated tariffs for large and medium-sized customers, most users moved without major problem to new contracts. The fact that regulated tariffs for gas, (based on the cost of ENGIE's long-term contracts) are roughly 10% above the level of wholesale gas prices did motivate an increase in switching rates (to around 55 000 consumers/month).

However, some users (5%) were slow in switching supplier and did not take up the market offer by 1 January 2016. The government forced the historic supplier to terminate the contracts offering a regulated price and instead to provide a new "transitional" offer until 30 June 2016, with a 5% top-up over the regulated prices. As consumers still did not switch, the government ordered the CRE in 2016 to assign gas consumers to new suppliers chosen by competitive auctions by 1 July 2016 and to increase the top-up to 30% to encourage supplier switching.

The phasing out of tariffs has also given more room for newcomers. While, overall, the number of players in the wholesale gas market has increased in recent years, there is still scope for improvement in the retail market. As of 31 March 2016, the total market share of historic suppliers has come down to 35% in the large non-residential distribution segment; however, 57% of residential sites maintain a regulated tariff in addition to the 22% market offers by the historic supplier. On the import side, the historic suppliers (ENGIE, Total) accounted for 52.5% of total gas imports in 2015.

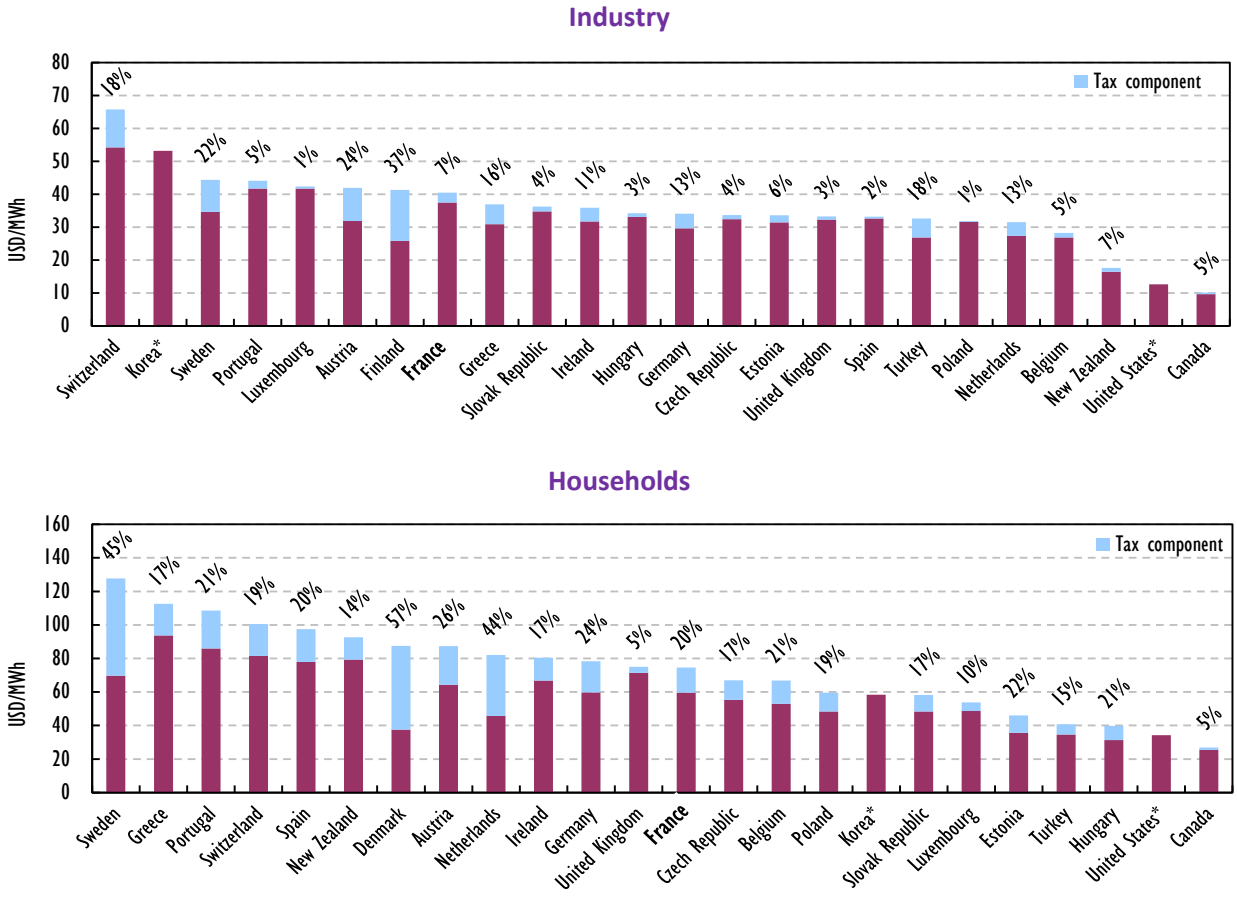
Barriers to entry exist in the retail sector and competition could be improved through enhanced market transparency and by setting a final date for the end of regulated prices. ENGIE's gas consumption data files have already been made available to

alternative suppliers, following the decisions of the French Competition Authority at the end of 2014. However, the quality of data is not yet satisfactory. There is also a transparent procedure for alternative suppliers to access all consumption data from the DSO, if the consumer agrees.

GAS PRICES AND TAXES

Thanks to strong (and expanding) physical connections with the rest of north-west Europe and enhanced competition in the French market, wholesale prices at PEG Nord (the main trading point in France) are now well in line with other European benchmarks. Differences in prices between the two marketplaces in the north and south have been greatly reduced. This, however, is mainly due to developments in global gas markets and the price collapse for LNG – which is a major source of supply for southern France – rather than to a structural improvement in the size of cross-country interconnection capacity. By 2018, physical bottlenecks within France are poised to be resolved, which should allow for one wholesale pricing point for the whole country.

Figure 5.6 Gas prices in IEA member countries, 2015



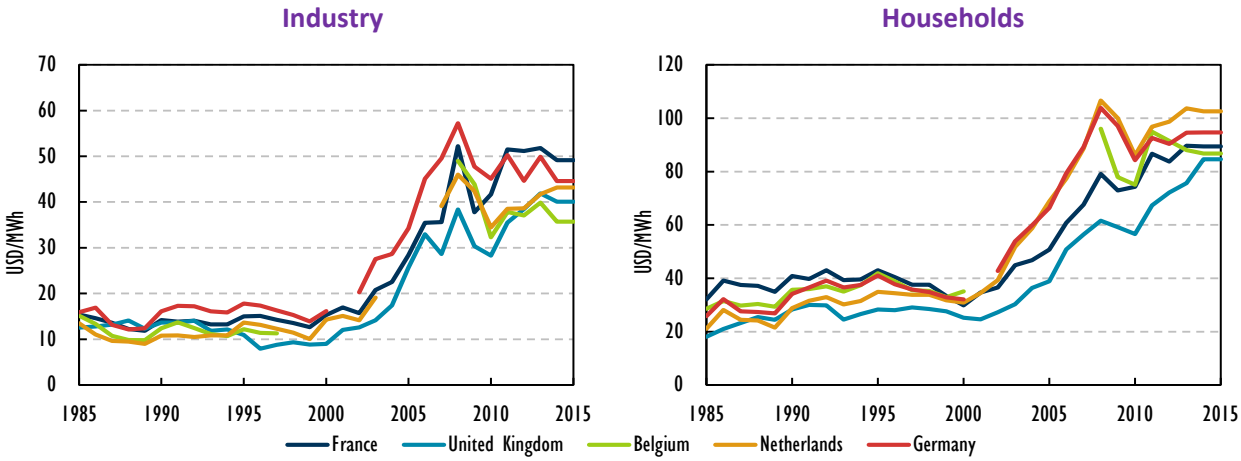
* Tax information not available.

Note: Data not available for Australia, Italy, Norway, Denmark (industry) and Finland (households).

Source: IEA (2016c), *Energy Prices and Taxes 2016 Q1*. www.iea.org/statistics/.

The level of regulated tariffs is set by the Ministry (MEEM), following an opinion from the regulator CRE, as defined in articles L. 445-1 and in line with the French Energy Code. In the case of households, roughly 45% of the regulated tariff relates to procurement costs, 25% to infrastructure costs (transmission, storage and distribution), 10% to marketing costs and 20% to taxes and contributions. The fiscal share includes several items: a domestic natural gas consumption tax, which, since January 2016, includes a contribution to the special gas solidarity tariff and the biogas contribution, the supply tariff-based contribution (that funds pensions in the electricity and gas industries) and the value-added tax (VAT).

Figure 5.7 Gas prices in France and in selected IEA member countries, 1980-2015



Notes: Data are not available for Germany 2001, Belgium 1998-2007 (2001-07 for households), and the Netherland 2004-06 (industry).
Source: IEA (2016c), *Energy Prices and Taxes 2016 Q1*, www.iea.org/statistics/.

GAS SECURITY OF SUPPLY POLICY

French natural gas security of supply relies on well diversified import sources, infrastructure and supply routes (pipe gas and LNG), and extensive gas storage facilities.

The French approach to ensure gas supply security rests on three pillars:

- *A prospective vision on gas system development*. MEEM, in consultation with gas sector participants, develops a multiannual gas investment plan aimed at identifying and addressing any investment needs. Under the Energy Transition for Green Growth Act 2015, the plan is replaced by the pluriannual energy programming (PPE) for all forms of energy, including natural gas. GRTgaz also runs a Winter Outlook ahead of the winter seasons to assess supply-demand adequacy including storage levels.
- *Public service obligations.* These are obligations assigned to TSOs, DSOs, operators of LNG terminals and storage and suppliers aimed at ensuring the continuity of supply to domestic customers, including in the case of a 1-in-50 year cold winter, 1-in-50 year case of extremely low temperatures for a 3-day peak period, and the failure of the major source of supply for 6 months.

- *Emergency Action Plan.* When preventive actions are not sufficient to maintain the flow of supplies, specific measures are enforced. The Emergency Action Plan contains those measures, the legal framework in which they are embedded, and the principles regarding their implementation. This plan is guided by the EU Regulation 994/2010. The plan contains graduated measures:
  - recommendation of energy demand reduction
  - use of interruptible contracts
  - supply cuts by the TSO, beginning with industrial customers.

In order to meet the reliability obligations, storage rights are attributed to all suppliers with French final consumers (priority access). Suppliers have an obligation to hold gas stocks at the beginning of winter and storage prices are negotiated between suppliers and storage operators. Decree No. 2006-1034 on access to underground storage of natural gas sets out a system of priority right of access to storage capacity (defined by consumer category and geographic area) so that gas suppliers can access sufficient capacity depending on the structure and consumption patterns of their customers. However, the system did not prevent a sharp decline in capacity bookings over the past five years owing to changing markets and storage economics. This led the government to modify the regulation on rights of access to storage (Decree No. 2014-328) which now prescribes minimum quantities of gas in storage at the beginning of winters. Further modifications are planned (see section above on underground storage).

While demand restraint is listed as a way to manage an emergency situation, there is little scope for demand restraint in reality. The flexibility provided by interruptible contracts covers only about 2% of peak demand. Moreover, industrial customers have stated that in case of an emergency, they could cut consumption volumes by around 5% of peak demand. The French government has recognised the limited ability of gas demand response to contribute to the balancing of the system in an emergency situation and has added measures in the Energy Transition for Green Growth Act to encourage the development of higher demand-side response.

France odorises gas at its borders and this can create inter-operability issues with neighbouring countries. In a regional gas emergency, France could only make a limited contribution. With the connection of the new Dunkirk LNG terminal, a new exit point to Belgium has been created (Alveringem) which can export non-odorised gas to Belgium.

France also uses a small amount of low-calorific gas (L-gas) for around 10% of the consumers, mostly residential in the northern parts of France. The decisions of the Dutch government to lower the production of L-gas have not yet had any impact on the security of gas supply. However, France works closely in the Gas Platform with Belgium, the Netherlands and Germany. Today, there is a lack of visibility of future decisions and on for conversion, which will take place during 8 to 10 years starting in 2019. Any substantial reduction of L-gas production could impact France well before 2020. Regulatory measures are being prepared to address complex safety issues related to the adaptation of equipment.

ASSESSMENT

Following the market opening in 2007, competition in the French gas market has improved substantially. Access to the wholesale market has improved thanks to the

market integration within France and EU gas markets, leading to increased trading volumes and liquidity at domestic trading hubs in France, similar to German gas hubs. Gas wholesale prices at the gas exchange point are now in line with other Northern European benchmarks (UK NBP, Dutch TTF).

Progress on the opening of the retail market has not been as fast. The share of the incumbent supplier remains high and regulated prices persist. While competition has improved after tariffs were deregulated for non-residential customers, market concentration is still high. As of mid-2015 the overall market share of historic suppliers is still above 50% and for residential customers above 80%. The process of ending regulated prices has not been easy, despite the fact that wholesale prices have been on a downward trend. Non-residential consumers have not switched fast to competitive market offers and the government and CRE had to intervene. There are no deadlines set under French law for ending regulated gas prices to household consumers.

Cross-border transmission has been expanded and entry capacity into France has increased notably in recent years (40% expected between 2008 and 2018): upgrades at the border have eased congestion in the France/Spain direction. The forthcoming start-up of the Dunkirk LNG terminal (13 bcm of capacity) and the build-up of associated transmission infrastructure to Belgium will further enhance the connectivity of the French market with Western European markets. All these are welcome developments.

Internal bottlenecks in the north-south direction are yet to be resolved. Much looser LNG balances have helped reduce the price differentials between north and south – because of the heavy dependence of southern France on LNG imports − yet transmission capacity in the north-south direction remains heavily subscribed and congestion problems could easily reappear should LNG markets tighten up again. The TSO is in the process of addressing these existing bottlenecks with two major projects worth around EUR 900 million due to be online over the next three years.

Strengthening the internal infrastructure is a key requirement to achieve a single marketplace in France by 2018, which is an important step towards further improving the functioning of the wholesale and retail gas markets for end-customers. In April 2015, a single trading region (TRS) was implemented in the south of France resulting from the merger of GRTgaz South and TIGF zones. The merger, which was smoothly implemented without the need to invest in new physical capacity, creates one single trading point while maintaining two distinct balancing zones.

France is almost entirely dependent on imports to meet its gas consumption needs. However, import capacity is very well diversified with seven major interconnection points and four LNG terminals offering access to various sources of supplies. Recent expansions, against a backdrop of falling demand, have resulted in a growing level of flexibility in the system. However, the high share of residential demand in total gas consumption makes France particularly sensitive to weather variations, with large swings in overall demand across seasons (2 000 GWh/day on average between August and January). Such high modulation in the demand profile leaves the system dependent on storage withdrawals to meet weather-related variations in consumption. Since 2013 three storage sites have been mothballed while low summer/winter spreads have resulted in lower storage subscription levels, raising concerns over security of supply.

In France, storage capacity rights are granted to shippers according to their portfolio of end-consumers. There is an obligation for shippers to store gas at the beginning of winter. The regulatory framework governing third-party access (TPA) to storage is a

negotiated model where prices and services are set by the storage system operator (SSO). Because of security of supply concerns about the low storage levels at the beginning of winter 2012/13, the French ministry raised the storage obligations to 80% of shippers' capacity rights, corresponding to all customers connected to the distribution grid (previously the obligation was limited to domestic customers and customers providing services of general interest). Higher obligations on shippers pose challenges in a context of negotiated TPA. Additionally, the current model where access to storage is prioritised to shippers with final customers is less justifiable than it once was, considering today's higher traded volumes, higher liquidity in the wholesale market and the end of regulated prices to non-residential users. The government is currently reassessing its regulation on storage access with the aim of having a new regulatory framework in place by 2017.

France has small network areas where it uses L-gas from the Netherlands and work has been slow in preparing for the transition. The Dutch government has been reducing L-gas production in recent years much faster than anticipated. To date, these decisions have had no impact on France as current Dutch gas export contracts are fully honoured by Gas Terra towards clients in France, Belgium and Germany. The French government has no indication that the commitments by Dutch suppliers would not be met in future. France should, however, assess its emergency preparedness and work towards the timely conversion process which should be finalised by end 2029.

Despite shale-gas reserves in France, the low social acceptance and high environmental protection concerns have led the French government to ban hydraulic fracking. However, a more in-depth evaluation of the shale-gas potential with exploratory drilling has not been carried out to date. The government should weigh its potential by taking account of the considerable experience gained in the United States and in other countries, and of international best practices in technology development, in line with the *IEA Golden Rules* (IEA, 2012) approach.

RECOMMENDATIONS

The government of France should:

- ☐ *Continue its efforts to advance effective competition in the retail gas market.*
- ☐ *Ensure that the necessary projects are carried out to address the remaining infrastructure bottlenecks within France, particularly in the north-south direction, and that the single trading zone in France is developed by 2018.*
- ☐ *Ensure that the storage regulation enables the gas system to respond promptly and flexibly to winter demand variations, without creating unnecessary costs for consumers or unduly restricting competition.*

References

CEER (Council of European Energy Regulators) (2014), *CEER Status Review on Monitoring Access to EU LNG terminals in 2009-2013*, Brussels.

CRE (*Commission de Régulation de l'Énergie*) (2016), *Observatory of Wholesale Electricity and Gas Markets (Observatoire des Marchés de Gros de l'Électricité et du Gaz),* Q1 2016.

CRE (2014), *Deliberation of the French Energy Regulatory Commission dated 7 May 2014 setting out guidelines for the creation of a single marketplace in France by 2018*, Paris.

IEA (International Energy Agency), (2016a), *Natural Gas Information 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016b), *Medium-term Gas Market Report*, IEA/OECD, Paris.

IEA (2016c), *Energy Prices and Taxes 2016, Q1*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2014), *Energy Supply Security 2014*, OECD/IEA, Paris.

IEA (2012), *World Energy Outlook 2012 Special Report: Golden Rules for a Golden Age of Gas*, OECD/IEA, Paris.

6. OIL

Key data (2015 estimated)

Crude oil production: 0.833 Mt

Crude oil, NGL and feedstocks imports: 57.6 Mt, -31.6% since 2005

Oil products net imports: 19.7 Mt (imports 40.2 Mt, exports 20.4 Mt), +99.5% since 2005

Share of oil: 28.8% of TPES and 0.3% of electricity generation

Supply by sector (2014): 70.2 Mtoe (transport 56.2%, industry 21.7%, commercial and public services and agriculture 9.1%, residential 8.8%, other energy 3.2%, power generation 1%)

SUPPLY AND DEMAND TRENDS

The share of oil in France's total primary energy supply (TPES) has declined markedly since the early 1970s, from 66.5% in 1973 to 28.8% in 2015. Oil use in power generation has been replaced by nuclear energy which increased its share in TPES from 2.2% in 1973 to 46.4% in 2015. Although oil is no longer a major source of energy, it still has a significant share in TPES given its strong role in transport and industry.

Oil is the second-largest energy source in France, accounting for 28.8% of TPES. Oil supply totalled 70.7 million tonnes of oil-equivalent (Mtoe) in 2015, 0.6% higher than in 2014, but down from 86.3 Mtoe in 2005.

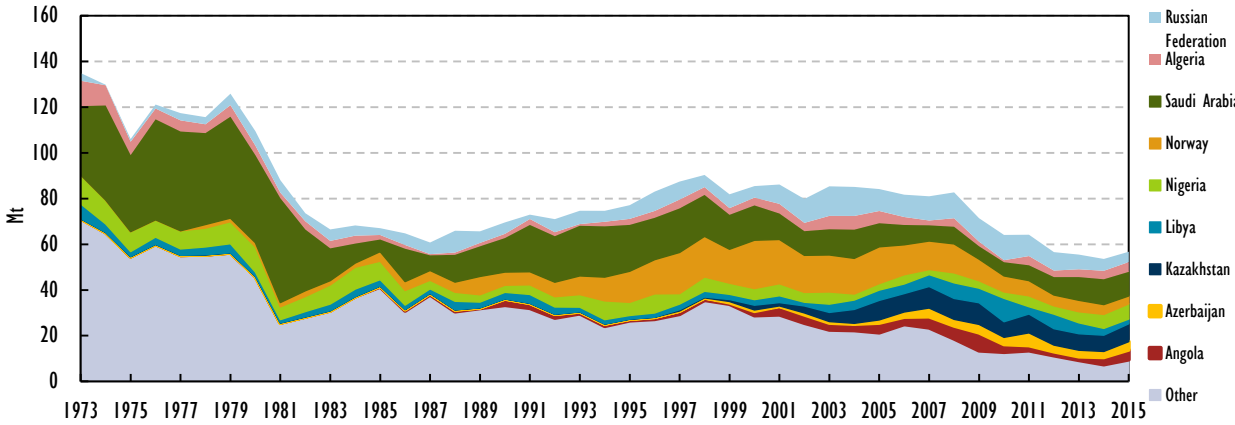
Crude oil

France is a net crude oil importer. Because there is no substantial national production, France imports nearly all crude oil used to supply its refineries. French crude oil, natural gas liquids (NGL) and feedstocks imports have declined sharply, from 84.2 million tonnes (Mt) in 2005 to 57.6 Mt in 2015.

In 2015, France produced 833 kilotonnes (kt) of crude oil, 8.7% higher than in the previous year and 22.8% lower than in 2005. The amount of domestic production is only equivalent to 1.5% of total supply.

Almost all imported crude oil and oil products enter into France through three main sea ports, at Le Havre (42.5%), Marseille (42.1%) and Saint-Nazaire (15.4%). Unloaded oil is processed in the refineries near these ports or inland refineries connected via pipelines to the ports. Some portion of oil transits France by pipeline to Switzerland and Germany. The major suppliers of crude oil are Saudi Arabia (18.6%), Kazakhstan (13.8%), Nigeria (11.7%), Russia (7.9%) and Angola (7.6%). Members of the Organization of the Petroleum Exporting Countries (OPEC), including Saudi Arabia, Nigeria, Algeria, Angola and Libya, collectively represent more than half the total supply.

Figure 6.1 Crude oil imports by source, 1974-2015



Note: Data are estimated for 2015.

Source: IEA (2016a), *Oil Information 2016*, www.iea.org/statistics/.

Oil products

France is also a net importer of oil products, with 40.2 Mt of oil products in 2015 versus exports of 20.4 Mt. Net imports amounted to 19.7 Mt, up by 99.5% compared to 2005. Domestic refinery output was 58.7 Mt in 2015, slightly up from 57.6 Mt in 2014, made up of gas and diesel oil (43.1%), motor gasoline (19%), fuel oil (10.8%), naphtha (8.3%) and others.

In 2016, France had eight refineries. Since 2010, four refineries have stopped their operation. This led to the increase in imports of oil products, notably diesel and to the reduction in crude oil imports to France. Since 2005, the gross production of French refineries decreased by 32.4%. In 2015, imported oil products were coming from Russia (18.8%), the United States (11.9%), the Netherlands (10.4%), Belgium (7.4%), Germany (5.6%), Spain (5.4%) and others.

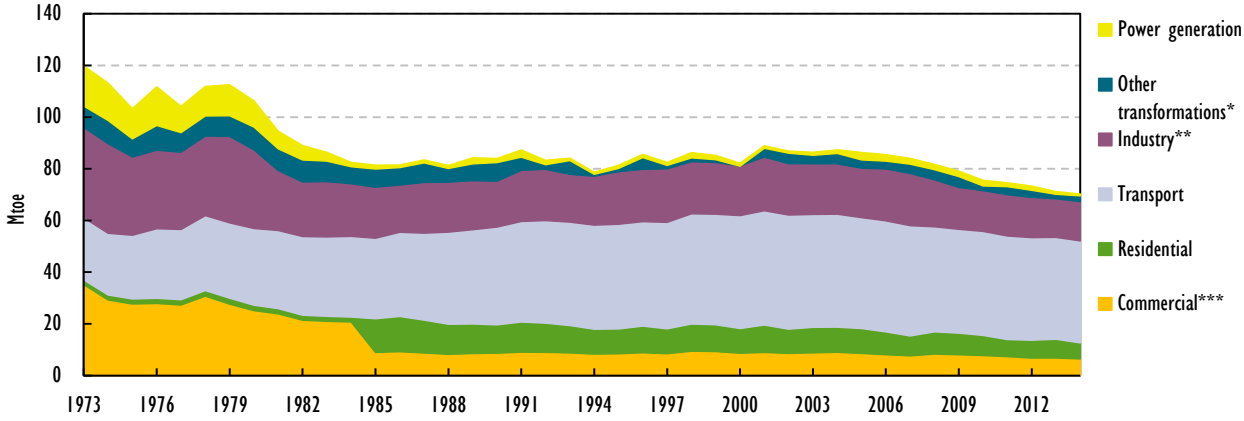
DEMAND

Oil is mainly used in transport which represents 56.2% of total consumption, followed by industry (21.7% of total demand in 2014) and the commercial sector (9.1%). The remaining 13% is made up of residential use (8.8%), energy own-use and other energy use (3.2%), and power generation (1%) (see Figure 6.2). Over the past decade to 2014, oil demand decreased across all sectors. Demand was 9.7% lower in transport and by 21.9% in the industry sector. Demand in the commercial and residential sectors experienced 28.6% and 36.3% decreases, respectively. Over the same period, demand in other energy use and power generation decreased by 45% and 48.2% respectively. Total demand dropped by 19.6%.

Conversely, the share of diesel (*gazole* in French) has steadily increased since the 1990s. Gas/diesel oil is the most used oil product in France, accounting for 60% of total oil products consumption (Figure 6.3). Motor gasoline represents 9%, kerosene-type jet fuel and naphtha 8.7% and 7.1%, respectively. The remainder is made up of liquefied petroleum gas (LPG), bitumen, petroleum coke, other kerosene, lubricants, white spirit, aviation gasoline and other non-specified oil products. In 2012, the share of new diesel vehicles out of total new registered cars was 73% compared to 35% in 2000. This

dieselisation is the result of both trends in car manufacturing and a favourable taxation of diesel versus gasoline. However, the trend seems to be changing, as the share of diesel vehicles sold in France has declined since 2012 from 73% to 62% in 2014 and is expected to be further impacted by the 2016 diesel scandals of the automotive industry with regard to test cycles for pollutants.

Figure 6.2 Oil demand (in terms of TPES) by consuming sector, 1973-2014



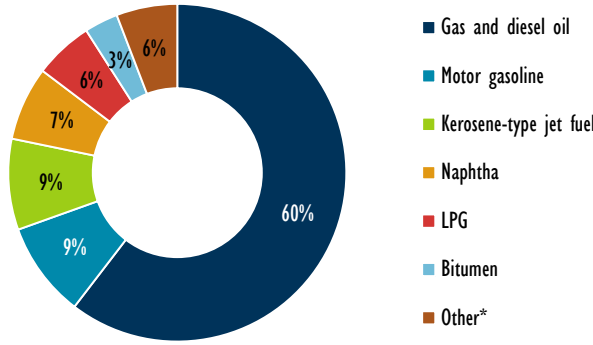
* *Other transformations* includes refineries and energy own-use.

** *Industry* includes non-energy use.

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

Source: IEA (2016b), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Figure 6.3 Oil consumption by product, 2014



**Other* includes fuel oil, petroleum coke, other kerosene, lubricants, white spirit, aviation gasoline, refinery gas, ethane, paraffin waxes and other non-specified oil products.

Source: IEA (2016a), *Oil Information 2016*, www.iea.org/statistics/.

OIL INFRASTRUCTURE

The French Mining Code (exploration) gives the state the right to manage mining, but the state may delegate the right to companies to explore and produce oil and gas, in line with Decree n°2006-648 of 2 June 2006 on Mineral Rights. Unconventional oil or gas exploration has not been allowed since 2012, as explained in the Chapter 5 on Natural Gas, fracking has been banned, despite France's endowment with shale reserves.

REFINING

The largest refinery operator in France is Total, with five refineries. The second-largest operator is Esso with two refineries. In 2016, France's 8 refineries have a combined capacity of 1.4 million barrels/day (mb/d). Because of structural problems (reduced competitiveness of the refineries in a European market with refinery overcapacity and lower demand, since 2009 four refineries have closed, reducing the total capacity from 12 refineries to 8 equal to 2 mb/d.

Total closed its 140 thousand barrels/day (kb/d) Dunkerque refinery in the north of France in 2010 and Petroplus shut its 80 kb/d Reichstett plant in 2011. Both Petroplus's Petite-Couronne refinery (150 kb/d) and LyondellBasel's Berre refinery (126 kb/d) were also shut down in 2013 and 2012, respectively. Net production of French refineries amounted to 58.7 Mt in 2015. Between 2005 and 2015, net production of French refineries overall decreased by 32.4%. Total's La Mède is being restructured into France's first bio-refinery and has ceased refining crude oil.

Refineries in France are fitted with catalytic reforming units to produce gasoline and hydro-desulphurisation units to meet specifications on the sulphur content of diesel fuel. These units account for 17% and 43% of total capacity, respectively.

STORAGE

France's global oil and oil products storage capacity totalled around 45.7 mcm of which nearly 60% dedicated to oil products (around 29 mcm) among which diesel represents 53%, gasoline 15% and jet fuel 8%.

Table 6.1 National oil products storage capacities

	Total volume (mcm)	Share of overall volume (%)
Refineries	14.4	31
Refineries annex depots	0.7	2
Caverns	9.2	20
Airports	0.3	1
Depots (*)	21.1	46
Total	45.7	100

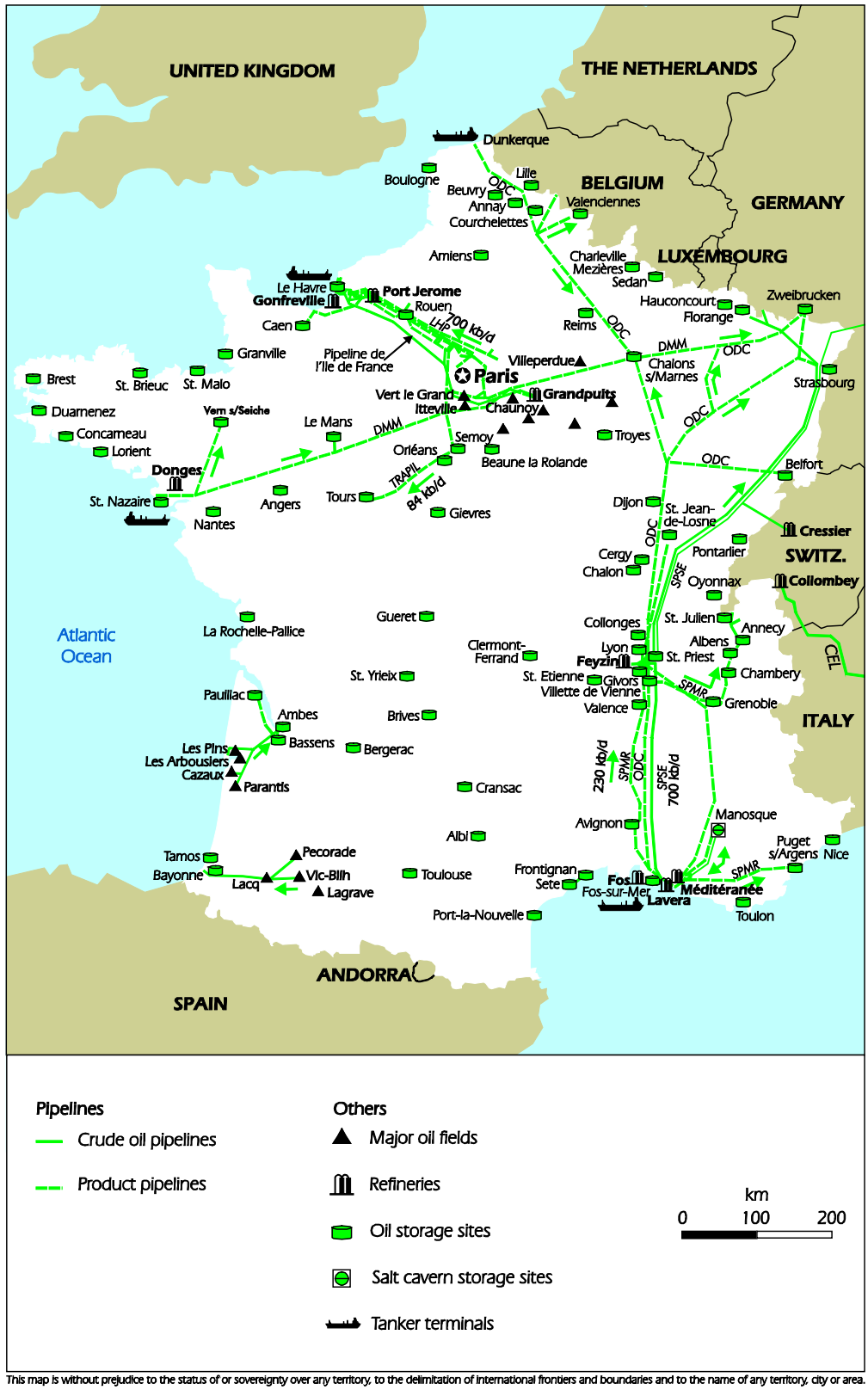
*Other oil and oil products storage depots of more than 400 cm (military facilities excluded).

Source: MEEM (2015), *Energy-Climate Panorama*, Paris.

PORTS AND PIPELINES

France's crude oil imports come through three major sea ports: Le Havre (42.5%), Marseilles (42.1%) and Saint-Nazaire (15.4%). France has three main crude oil pipelines: the South European pipeline (PSE), the Ile-de-France pipeline (PLIF) and the Antifer-Le Havre pipeline. PSE supplies refineries in Feyzin and Cressier (Switzerland) from the Marseilles port. PLIF supplies Grandpuits refinery in south-east of Paris, from the port of Le-Havre. PLIF can also be used as backup supply for the Normandy refinery. Antifer-Le Havre pipeline transports crude oil from the Port of Antifer to the CIM (*Compagnie Industrielle Maritime*) depot in Le Havre.

Figure 6.4 Map of oil infrastructure in France, 2014



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

OIL RETAIL MARKET STRUCTURE

The motor fuel market in France is highly competitive. Supermarkets and hypermarkets have a large market share (63% in 2014) and oil companies and independent suppliers account for 37%. The gasoline and diesel pump price in France is slightly lower than the European prices (but higher when taking into account taxation). The very thin retail margin reflects the competitiveness of the market.

The number of service stations has dropped since the 1980s (40 000). In 2014, their number amounted to about 11 000, down from 12 300 in 2009. The points of sale of the oil companies and independents amounted to around 6 000, whereas the number of service stations attached to supermarkets and hypermarkets has reached 5 000. The number of service stations with annual volumes of over 3 000 cubic metres (cm) has continued to increase. With the exception of Total, oil majors have been selling their service networks to independent companies (Delek for BP stations, Avia for Shell, DDC Energy France for Esso). Total and Esso have engaged in new commercial strategies of lower prices at the pump to stabilise their market against large retailing.

OIL SECURITY

France is well supplied from global oil markets with solid import infrastructure. However, in recent years, four out of 12 refineries have closed and the number of depots decreased from 300 to below 200 in 2016. There has also been a reduction in oil storage capacity (11 mcm in 2014), leading to larger concentrations of oil infrastructure with less redundancy. This rationalisation is due to the overall market conditions and changing economics common across the oil business in Europe. The government is monitoring the situation and concentration in the market. The reduction of the taxation gap between diesel and gasoline improves the situation for refineries.

EMERGENCY RESPONSE POLICY

France maintains emergency oil stocks to honour its commitments towards the European Union and the IEA. In 2016, France held 115 days of average daily net imports, well above the required level of 90 days. Emergency stocks are made up by industry stocks (39 days) and public stocks (76 days). Industry stocks are held by oil companies selling gasoline, gas oil, heating fuel oil, jet fuel and fuel oil. Obligated operators are divided into two categories depending on whether they possess the custom status of warehouse-keeper or not. There are commercial and industrial stocks.

Warehouse operators meet their stockholding obligation by delegating a share to the *Comité professionnel des stocks stratégiques pétroliers* (CPSSP). This “delegated” share of an operator is provided by the Committee against remuneration in proportion to volumes put to consumption by the operator. The other share called “own” share remains the responsibility of the obligated operator. The rate of the “delegated” share is at the option of the obligated operator, either 56% or 90% of its total obligation. Thus, according to the choice made, the “own” share of the operator is 44% or 10% of its total obligation. Companies that do not have the warehouse-keeper status must delegate 100% of their obligation to the CPSSP. In this case, remuneration due to CPSSP is paid through custom services. In order to maintain its strategic stocks share,

the CPSSP has recourse to ticketing and to the *Société anonyme de gestion des stocks de sécurité* (SAGESS) services for acquiring and maintaining physical stocks. SAGESS activity is financed through remuneration received by the CPSSP from the operators.

In 2014 agency stocks represented 15 Mt of crude oil and oil products, and 80% of total strategic stocks. The Directorate General for Energy and Climate (DGEC) requires that these stocks be spread on the territory in proportion with regional demand in order to better cope with disruptions. Storage facilities where strategic stocks can be held must be approved by an interdepartmental commission (CIDH) that bases its decisions on technical characteristics to assess depots ability to meet strategic needs.

The composition of strategic stocks is regulated. At least 50% of the obligation must be composed of oil products in line with specifications in force to meet demand as quickly as possible. This goes beyond IEA requirements (and also beyond the product requirements in Directive 2009/119/EC of the European Union).

EMERGENCY ACTION PLANS

The national Hydrocarbon Resources Plan (PRH) written in 2003 is the French emergency action plan. This document describes the National Emergency Structure Organisation (NESO) and provides a list of gradual measures to cope with major supply disruptions (including demand restraint measures). The PRH is a modular plan which can be triggered at national or local level by the Prime minister or prefects (of departments or of defence and security areas), respectively. On a daily basis, the DGEC monitors the proper functioning of the oil supply chain and deals directly with oil industry to face minor disruptions mainly by using agency and industry stock draws. PRH reconsideration is engaged.

DEMAND RESTRAINT MEASURES

France considers demand restraint as an extreme measure to be used in case of major supply disruptions. Demand restraint measures are listed in the National Hydrocarbon Resources Plan (PRH). This plan details criteria for each measure*: i)* responsibility level; *ii)* products concerned*; iii)* emergency level; *iv*) term range*; v)* scope of the measure; and *vi)* the constraint felt.

STOCK-DRAW MECHANISMS

The strategic stocks are exclusively in the hands of the DGEC. In case of an emergency, strategic stocks can be provided to the market by:

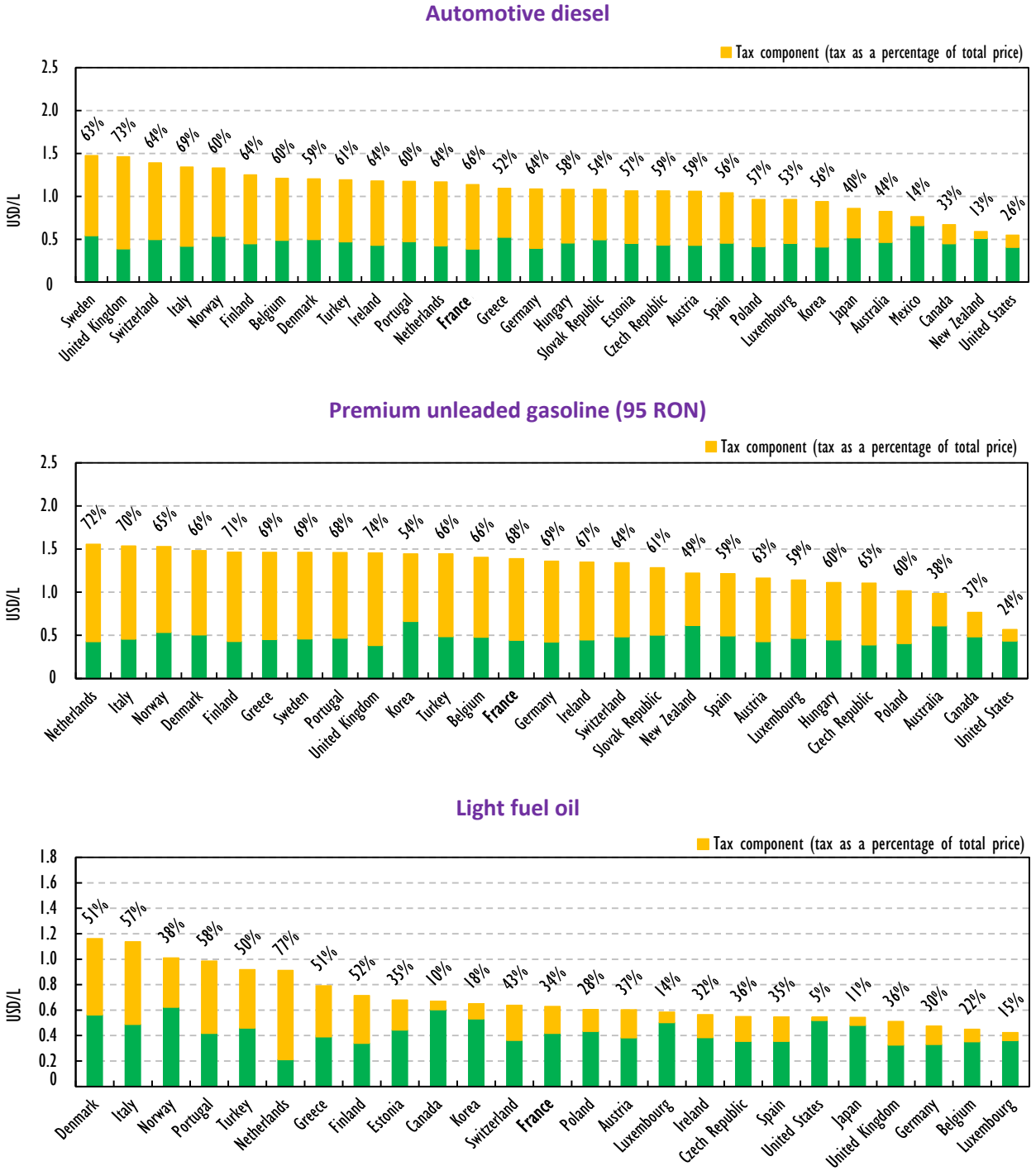
- injunction to swap, lend or sell agency stocks
- changing the stockholding obligation rate
- provisionally authorising operators to sell emergency stocks
- injunction to use agency ticket-purchasing options
- provisionally authorising operators to use stocks ticketed to the agency.

In 2011, strategic stocks have been used for the Libya crisis, as France contributed to the IEA collective action, and also in both December 2013 and during the summer 2016 to mitigate industrial action at refineries, ports and stations.

OIL PRICES AND TAXES

Gasoline and diesel prices in France are around the IEA median (Figure 6.5).

Figure 6.5 Fuel prices in IEA member countries, first quarter 2016



Note: Data not available for gasoline in Japan and light fuel oil in Australia, Hungary, New Zealand, the Slovak Republic and Sweden.

Source: IEA (2016b), *Energy Prices and Taxes 2016*, Q1, www.iea.org/statistics/.

The price of oil products, particularly at the pump, is set freely except in overseas territories. The retail prices for diesel and gasoline are determined by their various components: crude price, gross refining margin, gross retail margin, excise tax and value-added tax (VAT). As France is highly dependent on imports for oil products, the value of the euro against the US dollar is one of the important factors in determining pump prices.

In the Finance Law 2015, the excise rate for diesel has been further increased by EUR cents 2 per litre (on top of the increase of the carbon component, that affects both gasoline and diesel) to finance public investments in clean transport. This increase contributes to the rebalancing of taxation between gasoline and diesel.

The tax differential between gasoline and diesel has decreased from a little more than EUR cents 18 per litre in 2014 to EUR cents 15.5 per litre in 2015 and EUR cents 10 in 2017 (under the French Customs Code Article 265 (to be compared with the European average of EUR cents 11.5 per litre). The carbon trajectory towards 2030 set under the Energy Transition for Green Growth Act should eventually further reduce the tax differential.

France supports biofuel blending with tax incentives by means of the general tax on polluting activities (TGAP). In 2014, gasoline was taxed at 7% and diesel at 7.7%. The blending ratios have been expanded: for gasoline (E5, E10, E85) and for diesel (B8, B30). A large variety of biofuel products is available at the pumps in France.

ASSESSMENT

France operates a free market for primary oils and oil products and its strong diversity of supply – including domestic refining production and imports of finished products − offers benefits of supply security and access to fuels at the globally defined market price. The French government recently introduced a carbon element in the fossil fuel taxation and has also taken measures to reduce the differential between diesel and gasoline prices to EUR cents 10 in 2017. This progress addresses one of the key recommendations of the IEA in-depth review in 2009 to reduce distortions in the oil market.

France's total inland demand for petroleum products has been reduced slightly since 2009, totalling 75.7 Mt in 2014. France has relatively little (and slowly declining) indigenous crude oil production and relies on imports of crude oil for its refineries. There are currently no intentions in France to pursue the potential for shale as, since 2011, under French law, the use of hydraulic fracturing in exploration and exploitation has been banned. There is a strong diversity of supply for crude oil imports with only Saudi Arabia supplying over 20% of total demand.

Today, France has 8 refineries that processed 55 Mt. Since the last review there has been substantial change in the sector with the firm closure of four refineries and the conversion of another into a biorefinery in 2016. This situation is not uncommon across EU countries with free markets for oil. As a result, the market share of imported products has been increasing and now stands at 57%. As refineries have closed, in general, equivalent imports or storage infrastructure are being used in replacement – this is important as, even taking account of the energy and climate goals of the Energy Transition for Green Growth Act, petroleum products will be needed in the future to meet the transport sector's energy demand.

France's remaining refineries produce a surplus of gasoline. Diesel demand in France continues to considerably outstrip gasoline consumption. Despite some reduction in the rate of diesel cars purchased in the past two years in France, refineries are not set up to meet consumer demand and this imbalance is not uncommon across Europe.

Historically, France has had a lower excise duty on diesel than on gasoline. Together with a strong increase in road freight transport, taxation has contributed to the large diesel demand. Commendably, the French government introduced the carbon component in the tax on fossil fuels (consumer excise duty), with a gradually increasing carbon component in 2015-16 (from EUR 7 per tonne in 2014 to EUR 14.5 in 2015 and EUR 22 in 2016). Additional measures are being taken to reduce the tax differential with a final goal of reducing the duty differential to zero within five years.

RECOMMENDATIONS

The government of France should:

- ☐ *Pursue the proposed balancing of the excise duty on diesel and gasoline taxation in the medium term.*

References

IEA (2016a), *Oil Information 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016b), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

MEEM (Ministry of Environment, Energy and the Sea) (2015), *Energy-Climate Panorama*, Paris.

7. COAL

Key data (2015 estimated)

Production: Nil

Imports: 12.5 Mt with 12.4 Mt of hard coal and 0.1Mt of brown coal

Share of coal: 3.6% of TPES and 2.2% of electricity generation

Inland consumption (2014): 9.3 Mtoe (other transformation 34.3%, power generation 31.7%, industry 31.2%, residential 1.6%, commercial 1.2%)

SUPPLY AND DEMAND TRENDS

SUPPLY

France's coal production was stopped in 2004, after 250 years of exploitation. The country fully relies on imports. Compared to other International Energy Agency (IEA) member countries, France has the fourth-lowest share of coal in total primary energy supply (TPES) behind Switzerland, Luxembourg and Norway. Coal supply was 12.4 million tonnes (Mt) or 8.9 Mt of oil-equivalent (Mtoe) in 2015, 37.9% lower than in 2005 and 4.4% lower than the previous year. Coal has lost importance and now represents 3.6% of TPES and 2.2% of electricity generation.

Over the past decade to 2015, coal supply has contracted by an average of 4.7% per year, mainly because of declining coal-fired power generation. A total 3.3 gigawatts (GW) of coal-fired power plants were closed between the end of 2012 and the end of 2015. The total installed capacity of coal-fired power units was 5.1 GW in 2014, which is 19.5% lower than the previous year. Hard coal imports have declined by 33.8% from 19.9 Mt in 2005 to 12.4 Mt in 2015. In 2015, hard coal imports were sourced from Australia (30.9%), Russia (20.3%), South Africa (16.8%), the United States (12.7%), Colombia (12.3%) and others.

DEMAND

France's coal consumption in 2014 totalled 9.3 Mtoe, the lowest level since 1973. Since 2004, consumption has decreased by 33.2%. Around 34.3% of energy from coal is used in transformation, and 31.7% in power generation.

The role of coal in power generation is small and declining: in 2014, it provided 12.4 terawatt-hours (TWh) of electricity, representing 2.2% of total generation. In 2004, it had accounted for 4.8% of total generation with 27.2TWh.

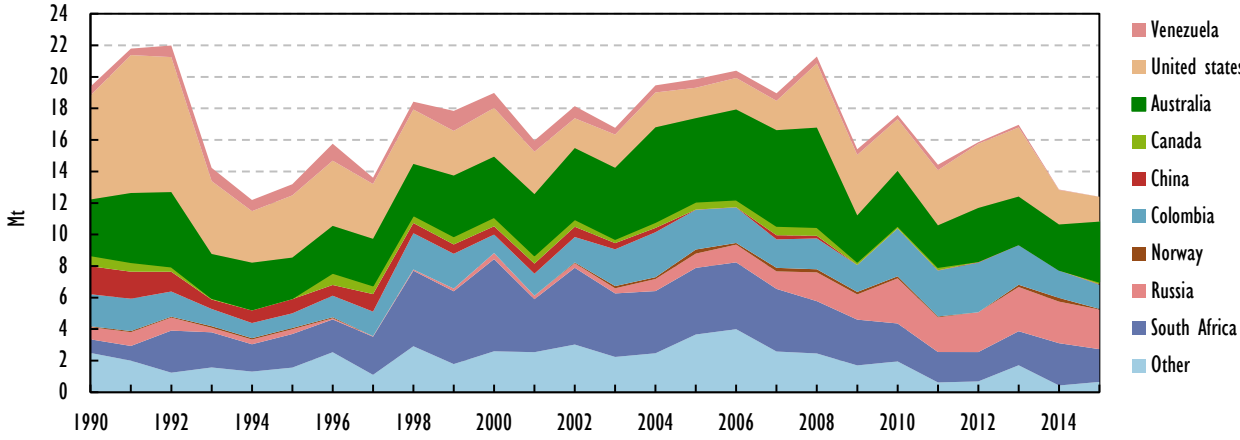
The industry sector accounted for 31.2% of total consumption in 2014, while the residential and commercial sectors accounted for 1.6% and 1.2%, respectively (Figure 7.2).

Over the ten years since 2004, overall demand of coal has fallen. Coal consumption in power generation and households decreased by 54.4% and 63.2%, respectively. Other

transformations and the Industry sectors showed slower decreases, with 14.1% and 11.9% respectively, over the same period. In contrast, demand in the commercial sector showed a 282.1% increase of its marginal share.

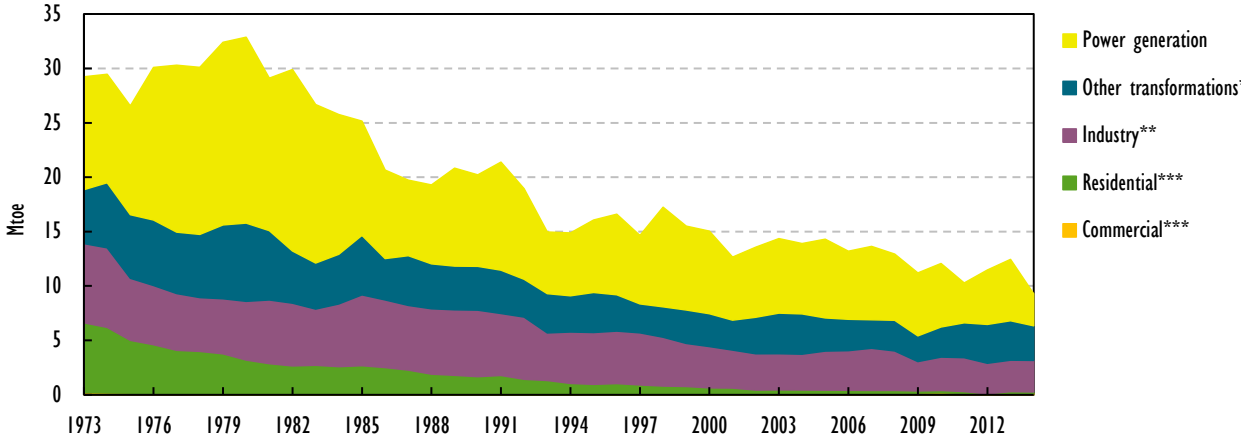
Coal consumption consists of 98.7% of hard coal and 1.3% of brown coal. The power and heat generation sector is the largest consumer, accounting for 84.9% of consumption, 11.2 Mt in 2014. Most of the remaining hard coal, 1.3 Mt, was consumed in the industry sector. Brown coal was used in industry.

Figure 7.1 Hard coal imports by country source, 1990-2015



Source: IEA (2016a), *Coal Information 2016*, www.iea.org/statistics/.

Figure 7.2 Coal demand by sector, 1973-2014



* *Other transformations* includes blast furnaces, coke ovens, other refining and energy own-use.

** *Industry* includes non-energy use.

*** Negligible (*Commercial* includes commercial and public services, agriculture, fishing and forestry).

Note: TPES by consuming sector.

Source: IEA (2016b), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris.

COAL POLICIES

Between 2012 and 2016, 15 coal-fired power plants for a total of 4 GW have been closed. This closure programme concerned those plants that do not comply with the emission standards laid out in the European environmental rules (Directive on Industrial Emissions, (IED, Directive 2010/75/EU, which entered into force in 2016 and the EU Large Combustion Plant Directive (EU LPCD). All old coal plants are closed in France, except four sites (Le Havre, Cordemais, Saint Avold, and Provence): two EDF plants and two Uniper plants, accounting for 3 GW together.

Investments in these units are focused on reducing pollution rather than on promoting energy efficiency. A retrofit of the two EDF power plants in Le Havre and Cordemais (with flue-gas desulphurisation and denitrification systems) is ongoing, in order to enhance technical and environmental performances and comply with the IED. More precisely, according to EDF, smoke denitrification of these plants will allow capturing 80% of nitrogen oxides, 90% of sulphur dioxide and 99% of fly ash.

In 2016, the government announced the introduction of a carbon floor price as a complement to the EU Emissions Trading Scheme at national level. The carbon price floor was under discussion in the Finance Law 2017 with a level of EUR 30/tonne of CO_2. The measure aims to amend the merit order to favour natural gas, however, it was not implemented.

ASSESSMENT

Coal production in France came to an end in 2004. All coal has been imported since. Coal imports are well diversified. In 2015 hard coal was sourced mainly from Australia (30.9%), Russia (20.3%), South Africa (16.8%), the United States (12.7%) and Colombia (12.3%). Coal stocks stood at about 3 months of consumption. In 2014, primary coal consumption (corrected for climatic variations) was 9.3 Mtoe, a noticeable decrease compared to an average consumption of around 12 Mtoe in 2009-13.

In 2015 coal represented 3.6% of the French primary energy mix. Coal plays practically no role in electricity generation (2.2%). It is used for power and heat generation in industry (steel sector) and in power generation. There is negligible residential use.

Between 2013 and 2016, 15 coal-fired power plants (3.3 GW in total) have been closed because they did not comply with emissions standards as stipulated in the European Directive on Industrial Emissions, which will enter into force in 2016. Total installed capacity of coal-fired plants stood at 5 119 MW at the end of 2014 (19.5% below the level in 2013). They generated 11 TWh of electricity in 2014 (58.2% down from 2013). The reduction of almost 60% of coal-fired electricity contributed substantially to the 40% reduction of CO_2 emissions of the electricity sector in 2014, compared to 2013.

Currently, only five coal-fired power plants are still in operation, all dating from the 1980s. Investments in these plants are needed so as to comply with the new emission standards. The investments concentrate on flue gas desulphurisation and denitrification systems, in order to capture 80% of nitrogen oxides, 90% of sulphur dioxide and 99% of fly ash. In line with EU rules, new coal-fired power plants can only be built when they are equipped with carbon capture and storage, “CCS ready”, as confirmed in the pluriannual energy programming (PPE) which covers the periods 2016-18 and 2019-23.

The share of coal use will fall sharply up to 2023, notably in industry, but also in power generation. It is unlikely that old plants will remain in place or new ones will be built. In 2016, the government announced a new carbon price floor to complement the low carbon price under the EU-ETS in Europe. The government intended to introduce a carbon price floor in the Finance Law 2017, at a level of EUR 30/tCO_2. In practise, this would reduce the use of coal in power generation. However, these plans have not been realised.

References

IEA (International Energy Agency), (2016a), *Coal Information 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016b), *Energy Balances of OECD Countries*, OECD/IEA, Paris, www.iea.org/statistics/.

8. ELECTRICITY

Key data (2015 estimated)

Total electricity generation: 563.2 TWh, -1.4% since 2005

Electricity generation mix: nuclear power 77.7%, hydro 9.7%, wind 3.8%, natural gas 3.5%, coal 2.2%, biofuels and waste 1.3%, solar 1.5%, oil 0.3%

Installed capacity (2014): 128.9 GW

Peak demand (2014): 82.5 GW

Electricity consumption (2014): 431.6 TWh (residential 34.6%, commercial, public services and agriculture 32.9%, industry 25.8%, transport 2.9%, energy 3.8%)

SUPPLY AND DEMAND

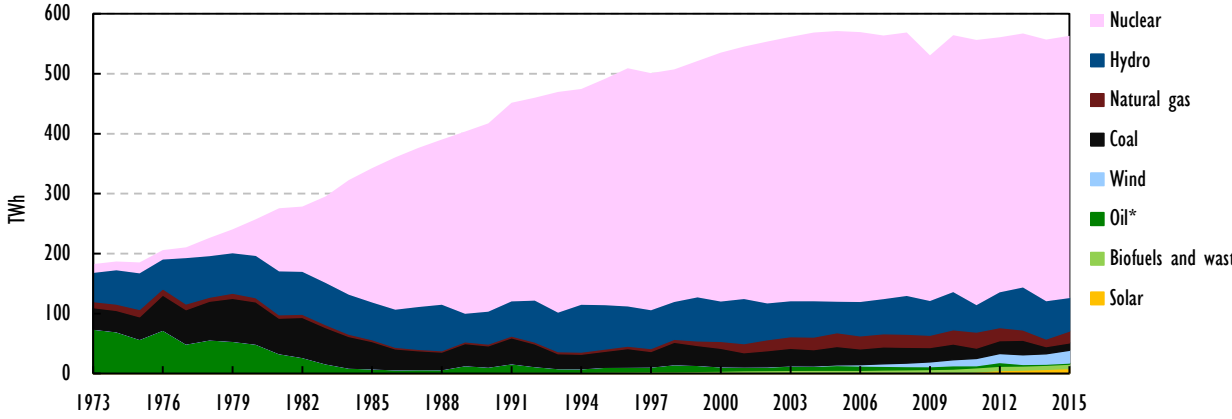
GENERATION

France's net electricity generation amounted to 563.2 terawatt-hours (TWh) in 2015, which is 1.4% lower than in 2005 and 1.1% higher than in 2004, but below the historic peak of 571.2 TWh in 2005. The electricity mix is dominated by nuclear power, accounting for 77.7% of the total in 2015. The average share of nuclear in total generation over the past decade was 77.5%. During 2005-15, generation from nuclear decreased at an annualised rate of 0.3%.

Hydro, the second-largest source, accounted for 9.7% of total generation in 2015 (or 54.9 TWh). Renewables, including hydro, represented 16.3% of electricity production in 2015, made up of hydro (9.7%), wind (3.8%), solar (1.5%) and biofuels and waste (1.3%). Renewables share in generation increased from 10.2% in 2005. On average, biofuels and waste grew at 3.7% per annum over the ten years to 2015, while solar and wind surged at 32.9% and 36.2% per annum, respectively, albeit with marginal shares. Hydropower generation has been volatile year-on-year. In 2015 it was 6.7% higher than in 2005, and grew by 0.6% per annum over the past decade to 2015.

Fossil fuels accounted for 6% of electricity generation in 2015, made up of natural gas (3.5%), coal (2.2%) and oil (0.3%). Because of tighter environmental requirements but also lower profitability, coal and oil are being progressively phased out. Electricity produced from oil fell by 76% from 2005 to 2015, while coal use was down by 59.7%, after closure of 10 coal units (3 gigawatts). Electricity generated from natural gas has decreased by 14.5% and some new gas-fired power plants are being mothballed. In general, fossil fuel-fired thermal plants have a supporting role in power generation, adjusting high or peak demand to complement nuclear and renewable energy sources.

Figure 8.1 Electricity generation in France by source, 1973-2015

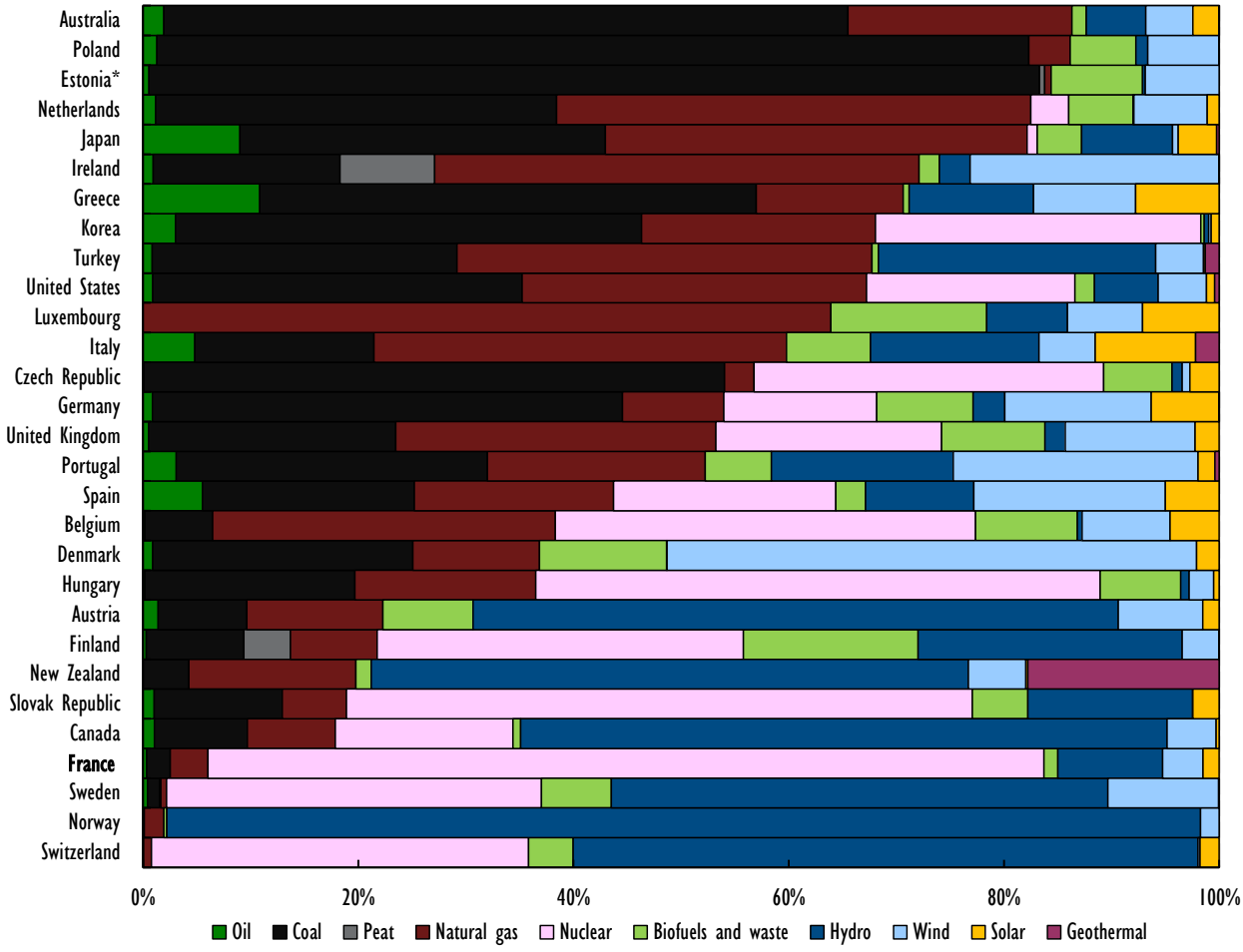


* Negligible.

Note: Data are estimated for 2015.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Figure 8.2 Electricity generation by source in IEA member countries, 2015



* Estonia's coal represents oil shale.

Note: Data are estimated.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

In comparison to other IEA member countries, France's share of fossil fuels in electricity generation was fourth-lowest in 2015 (Figure 8.2). Its nuclear share is the highest among IEA countries, followed by the Slovak Republic and Hungary.

For the first time in 2014, more electricity was produced from renewable sources (excluding hydro) than fossil fuels. Excluding hydro, generation stood at 36.9 terawatt-hours (TWh) in 2015 and more than half was from wind power, solar photovoltaics (PV) and biomass. Hydropower generation was 54.9 TWh in 2015, 12.6% lower than in 2014. Renewable energy sources covered 16.3% of total power generation in 2015. Wind power capacities have grown significantly since 2008, from 3.4 GW to 9 GW, and solar from 80 MW to 5.6 GW in 2014.

Table 8.1 Electricity generating capacity by source, 2010-14 (MW)

Year	2000	2002	2004	2006	2008	2010	2011	2012	2013	2014
Combustible fuel	26 071	27 902	27 898	25 672	25 648	28 824	27 792	27 764	25 576	24 411
Nuclear	63 183	63 273	63 363	63 260	63 260	63 130	63 130	63 130	63 130	63 130
Hydro	25 126	25 255	25 094	25 117	25 097	25 401	25 347	25 366	25 360	25 294
Wind	38	138	358	1 412	3 403	5 912	6 679	7 517	8 202	9 068
Geothermal	-	-	-	-	-	-	2	2	2	2
Solar	7	8	11	15	80	1 044	2 796	3 965	4 652	5 654
Tide	240	240	240	240	240	240	240	240	240	240
Other fuel sources	-	-	-	-	-	-	1 270	1 270	1 270	1 270
Total	**114 665**	**116 816**	**116 964**	**115 716**	**117 728**	**124 551**	**127 256**	**129 254**	**128 432**	**129 069**

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

DEMAND

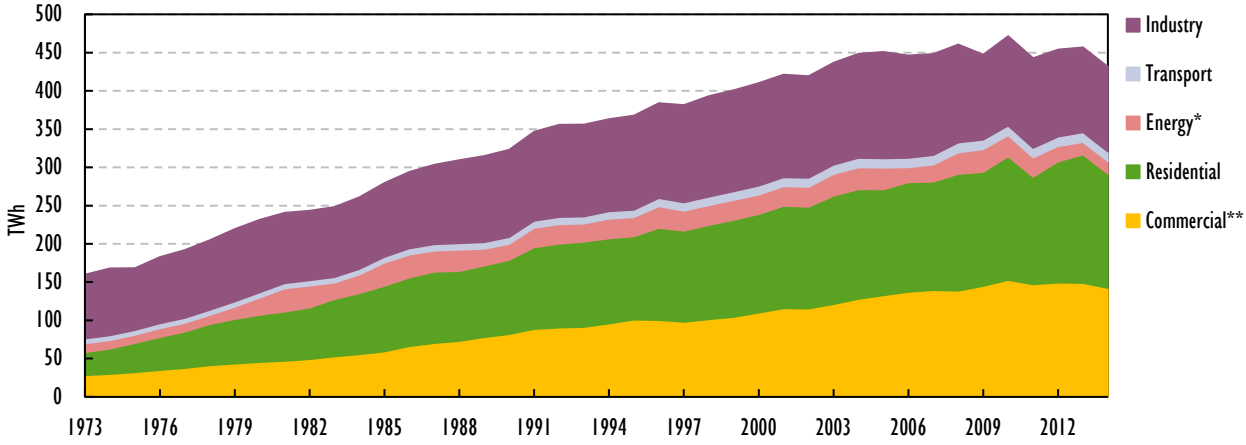
Electricity consumption in France in 2014 amounted to 431.6 TWh, 5.6% or 25.5 TWh below the previous year. This decrease was due mainly to the mild weather throughout the year, which was on average 0.5°C above the reference level. It also reflects the overall slow-down in economic activity and the lower use of electric heating, which has been falling for several years as a result of the implementation of the building code of the 2012 thermal regulation. Despite the decrease in electricity consumption, the annual peak demand has seen a steady rise in the past years (see Figure 8.4), reaching 100 GW in 2012. However, the growth of peak demand has now reversed (92 GW in 2013 and 82 GW in 2014) and follows the same pace as energy demand.

Residential (households) is the largest electricity-consuming sector, accounting for 34.6% of total demand. Commercial and public services (including agriculture) and the industry sector account for 32.9% and 25.8% of demand, respectively. The energy sector consumed 3.8% of total demand while transport consumed 2.9% in 2014.

Demand from households grew by 4.2% over the past ten years to 2014 while total demand decreased by 3.8%. Both the industry and energy sectors decreased their

consumption by 18.5% and 43%, respectively, during the same period. Transport's demand increased by 0.5% albeit being a marginal share of the total. Annual peak demand has been growing for several decades, but its growth rate is slowing down in recent years, ranging from 92.6 GW in 2013 to 82.5 GW in 2014 (Figure 8.4).

Figure 8.3 Electricity consumption by sector, 1973-2014

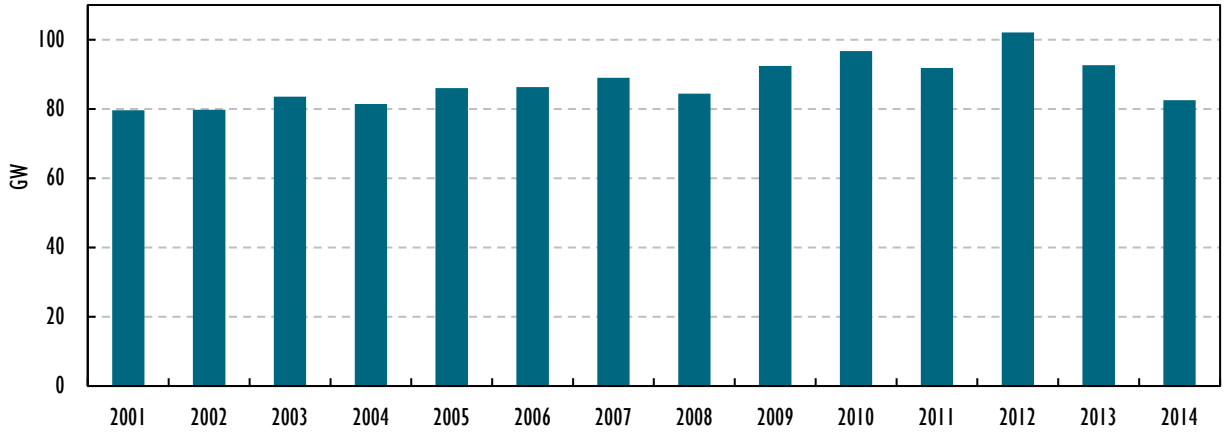


* *Energy* includes coal mining, oil and gas extraction, and refining.

** *Commercial* includes commercial and public services, agriculture, fishing and forestry.

Source: IEA (2016b), *Electricity Information 2016*, www.iea.org/statistics/.

Figure 8.4 Electricity peak demand, 2001-12



Source: RTE (2015a) *Annual Electricity Report 2014*.

IMPORTS AND EXPORTS

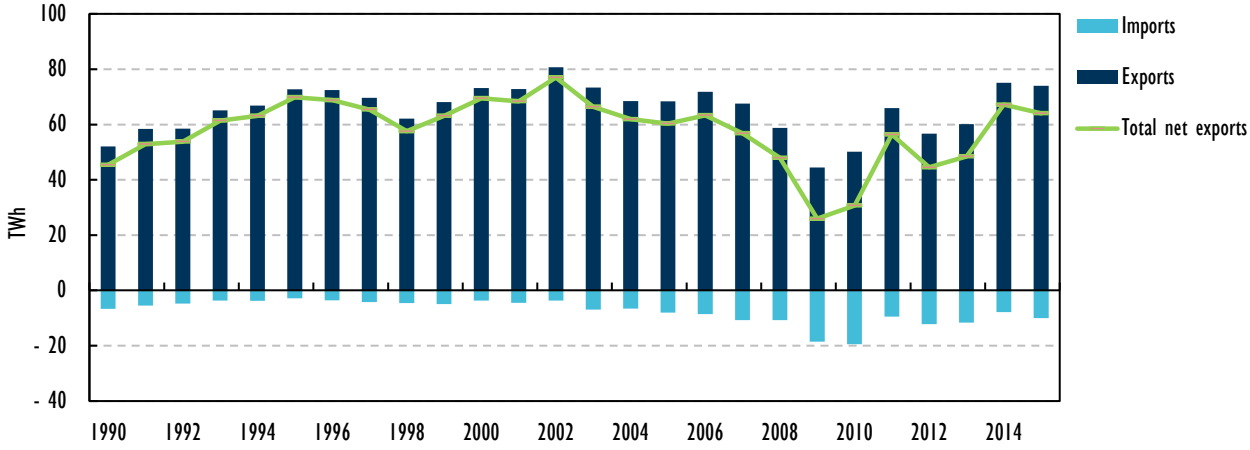
France holds a central position on the European grid and has many interconnections with neighbouring countries: the United Kingdom, Belgium, Germany, Italy, Spain and Switzerland. France is a net exporter of electricity, thanks to its high share of nuclear generation. It exported 75.1 TWh of electricity in 2014 (around 13% of total generation), the highest level since 2002 when France exported 80.7 TWh. Exports were directed to the United Kingdom (21.2%), Italy (20.7%), Germany (19.7%), Belgium (15%), Switzerland (13.8%), Spain (7.9%) and Luxembourg (1.5%).

Total imports amounted to 7.9 TWh in 2014 versus 11.7 TWh in 2013, but came back to their level in 2015, largely thanks to mild weather, low fossil fuel prices and higher availability of nuclear plants.

Electricity exchanges with Belgium were largely affected by the unavailability of Belgium's nuclear capacity. France's exports to Belgium increased to 11.2 TWh in 2014, 27.7% higher than in 2013. Exports to all neighbouring countries increased. France exports to Spain two-thirds of the time and imports from Spain only when generation of renewable energy in Spain is in excess and results in low prices.

On the other hand, imports from Germany are increasing, notably to cover France's winter consumption peaks and to export Germany's higher renewable energy production.

Figure 8.5 Net electricity imports to and exports from France, 1990-2015



Note: Data are estimated for 2015.

Source: IEA (2016b), *Electricity Information 2016*, www.iea.org/statistics/.

INSTITUTIONS

The **Ministry of Environment, Energy and the Sea** (*Ministère de l'environnement, de l'energie et de la mer, MEEM*) and its energy directorate have the lead responsibility for the formulation and implementation of energy and climate policies, including policies concerning the electricity market and security of electricity supply.

Established in 2000, the **Energy Regulatory Commission** (*Commission de régulation de l'énergie, CRE*) is the national regulatory authority in the energy sector, i.e. in gas and electricity markets. CRE is responsible for ensuring open access to all transmission and distribution networks for both electricity and gas. It approves transmission and distribution tariffs and annual network investment plans. In December 2015, CRE gained the competence to propose regulated tariffs in electricity, in line with the new methodology, which was previously a competence of the ministry. Already since 2014, CRE has been responsible for proposing the price of regulated access to nuclear power (ARENH, see section below on wholesale markets). In the area of renewable energy, CRE is in charge of assessing public service expenses in the context of the renewables support scheme and the organisation of renewable energy tenders. It has also a number of obligations under the European legislation in the field of energy (REMIT, Third Energy Package), including market monitoring, certification of the transmission system operator RTE (*Réseau de*

transport d'électricité) and compliance with unbundling and third-party access rules, approval of interconnection management rules, the examination of RTE's investment plan (ten-year network development plan) and European projects of common interest. The independence and impartiality of CRE are established under the provisions of Article L 133-6 of the French Code of Energy, but some competences are not yet fully independent (in terms of budget and resources). The CRE is governed by two independent authorities: the board of six commissioners who are appointed for a period of six years, non-renewable, and the Committee for dispute settlement and sanctions, consisting of four members. In 2015, CRE had 124 staff members, 127 in 2016 and it has been decided to increase the maximum number of full-time-equivalent (FTE) by 22 FTE in 2017. CRE's budget is submitted by MEEM and the Ministry of Finance to Parliament through the Finance Law. Resources have decreased in recent years: in 2015 CRE's budget was EUR 18.7 million, down from 19.9 million in 2009, despite its many new mandates under the Energy Transition for Green Growth Act, the NOME Act of 2010 and EU legislation.

INDUSTRY STRUCTURE

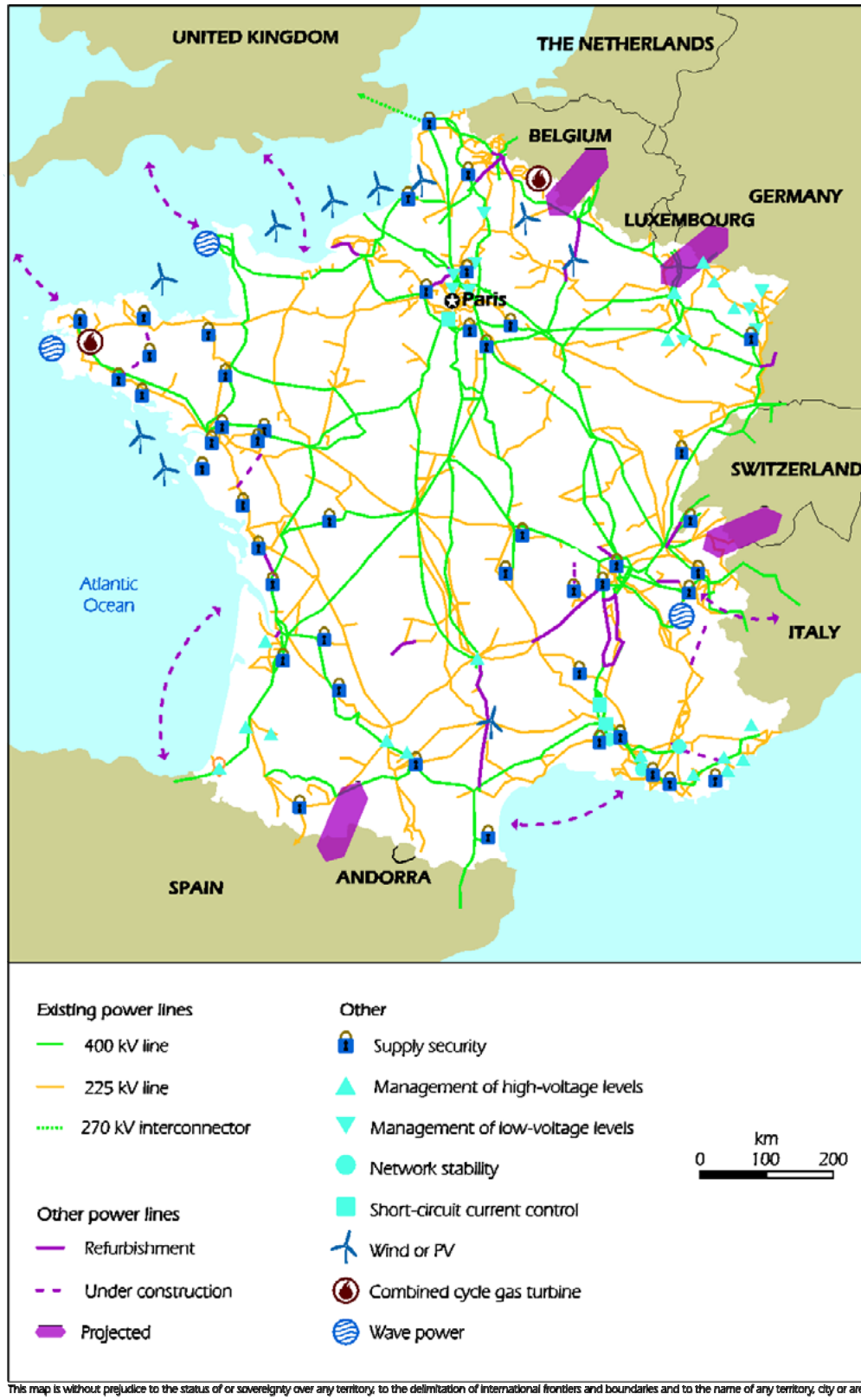
Électricité de France (EDF) is a key player in the French market, with a shareholding of French state and a largely vertically integrated structure. EDF operates all nuclear reactors in France and large parts of hydro generation. It has shareholdings in transmission (RTE) and distribution (Enedis), the latter holding 95% of mainland's concessions for electricity distribution and supplying final consumers. Next to EDF, at retail level, about 80 companies have a buy and resell authorization (*autorisation d'achat pour revente*), including 20 so-called alternative suppliers to end-consumers.

The state is a key investor in the French electricity industry, with shareholdings in EDF (84.5%) and in AREVA (87%). The government decided to split AREVA NP (nuclear plants) and AREVA NA (new Areva). EDF will take over AREVA NP activities and the government supports the recapitalisation of both companies (through the sale of shares in Engie). EDF is also about to sell a minority stake in RTE. In 2016, EDF took investment decisions to finance new reactors abroad (Hinkley Point C in the United Kingdom, Turkey's Sinop and Finland's Olkiluoto 3) and is faced with the decision about the lifetime extension of its fleet of reactors in France (the so-called *Grand Carénage*).

The Réseau de transport d'électricité *(RTE*) operates, maintains and develops the French high-voltage electricity transmission network, which is the largest in Europe. RTE is responsible for maintaining the power balance and operational security of the electricity system, on the basis of consumption and generation forecasts. RTE is a wholly owned subsidiary of the partially public-owned French generator *Électricité de France (EDF).* In 2012, RTE was certified by CRE as independent transmission operator (ITO), referred to in Article 9(8)(b) of the EU Electricity Directive. Under the compliance requirements of the ITO, RTE has adopted a transparency data platform, separated from EDF. Discussions are ongoing on the possible restructuring of RTE's ownership.

RTE operates a transmission network of 105 331 km of power lines of over 50 kilovolts (kV) on mainland France and 47 cross-border lines with neighbouring countries (the United Kingdom, Belgium, Germany, Luxembourg, Switzerland, Italy and Spain). RTE's customers are 54 electricity producers, 258 industrial customers, 32 electricity distributors and 135 traders and suppliers.

Figure 8.6 France's electricity transmission network



Since 1906, the local communities have acted as electricity distribution organising authorities (*Autorités organisatrices de la distribution d'énergie, AODEs*), and own the distribution networks, as regulated in the French Energy Code Article L. 322-4. Communities can give the right of operation to a concession holder. For 95% of mainland France or 35 million consumers, **Enedis** (formerly *Électricité Réseau Distribution France,* ERDF) is the concession holder of AODEs and operates 1.3 million km of distribution lines. Enedis is a wholly owned subsidiary of EDF. The remaining 5% of the national territory is served by so-called *entreprises locales de distribution (ELDs).* There are 150 ELDs or distribution system operators in France: six operate local networks in large cities (*Électricité de Strasbourg Réseaux* (*ESR), Gaz et Électricité de Grenoble, URM (ex Usine d'Électricité de Metz), SICAE de l'Oise, Géredis Deux-Sèvres and SRD (Sorégies))*, while the majority is very small and has fewer than 100 000 consumers. Since 2006, France has encouraged the regional amalgamation of territorial collectivities and authorities with a population of 1 million inhabitants and their distribution organisations towards larger department corporations (*syndicat départemental d'électricité*).

WHOLESALE MARKETS

MARKET STRUCTURE

The electricity wholesale (and retail) market remains highly concentrated. EDF owns and operates all of the 63 GW of French nuclear power capacity. Hydropower resources are allocated in concessions (Box 8.1). EDF operates 80% of all hydropower facilities (16 GW out of 25 GW), including all of pump storage hydro; the remainder of hydro is operated by ENGIE – through the *Société Hydroélectrique du Midi* (SHEM) and by the *Compagnie nationale du Rhône* (CNR), a 49% subsidiary of ENGIE.

While the generation and retail sectors are open to competition, in line with EU directives, actual competition on the generation side is limited to large consumers, as small consumers still have access to a regulated tariff, proposed by incumbent operators, besides so-called market offers proposed by all suppliers (including the incumbent). EDF operated 91.5% of installed capacity, ENGIE 5.1% and Uniper 2.6% (CRE, 2016). The Herfindahl-Hirschman index (HHI), a measure of market concentration, gives the French power market a high value. By owning all nuclear reactors, the historical national utility EDF has been able to dominate the French electricity market for a long time. In 2015, the HHI in production, including EDF, was 7318 versus 6346 in the final consumer market, indicating a very high concentration in both generation and supply (regulated tariffs have since then been phased out for large and medium-sized consumers). Production outside EDF was concentrated on only a few competitive players (CRE, 2016) and had a HHI of 3628.

With a view to promote competition in the French market and in response to a European Commission investigation, the New Market Organisation Act of 7 December 2010 *(Loi sur la nouvelle organisation du marché de l'électricité (NOME*), introduced regulated access to 25% of EDF's nuclear fleet or a maximum of 100 TWh per year (*Accès régulé à l'électricité nucléaire historique, ARENH*), which has been in place since July 2011 for every electricity supplier and should expire by 2025, if not renewed. Under the ARENH mechanism, all consumers in France can benefit from the competitively priced nuclear electricity, regardless of their supplier. EDF should provide alternative suppliers access to the electricity produced by EDF's nuclear plants "at cost".

Box 8.1 Hydropower concessions in France

Hydroelectricity covered 11.3% of electricity generation and 20% of installed capacity in 2014. As part of the 2020 objectives, France aims to increase pump hydro capacity by 3 GW. Hydropower is an important source of flexibility and a balancing power (15 GW out of 25 GW is flexible lake/reservoir and pump storage capacities); however, little new hydropower capacity has come online in the past decade.

All hydropower rights for facilities above 4.5 MW are allocated through concessions by the departmental prefecture for capacities below 100 MW and by the Council of State upon proposal by MEEM for facilities above 100 MW for a typical duration of 40 years. They are subject to renewal and can be valid for a maximum of 75 years. There are around 400 concessions; 80% of the total capacity (and all of pump storage) is operated by EDF, the remainder by ENGIE through the *Société Hydroélectrique du Midi (SHEM)* and by the *Compagnie Nationale du Rhône (CNR)*, a 49% subsidiary of ENGIE.

In 2006, France modified its legislation, following an infringement procedure by the European Commission in 2004 and the subsequent ruling by the European Court of Justice, in order to avoid that incumbent concession holders are granted preference in the renewals. After the end of a concession (the process starts 5 years before the end), a call for tender is launched by the state to determine the next concessionaire, on the basis of the applicant's contribution to energy, the environment and the royalties. In 2010, the government announced tenders for 2 800 MW or 20% of the total capacity with a regrouping of the hydro plants in 10 valleys. However, the tendering process came to a halt and concessions of many hydropower facilities in the Alps and the Pyrenees are still pending. In fact, the Energy Code allows, for concessions which are not yet renewed, the facility to be operated by the historical concessionaire, which does not have to pay concession fees. In October 2013 the French Parliament issued the Battistel report which called for a review of the hydropower market opening. The European Commission sent a letter of notice to France in October 2015 for failing to liberalise its hydropower market and called for the acceleration of the actions. Hydropower is a key asset in a power system with increasing shares of variable renewable sources as it ensures power system flexibility. Between 2020 and 2060 most concessions will expire.

The Energy Transition for Green Growth Act includes a new regulatory framework for hydropower concessions. Existing concessions can be extended, along the following principles: *i*) concession contracts can be bundled (Barycentre method) and consolidated within large valleys to optimise operations (some concessions can therefore run beyond 75 years, others are renewed before their normal expiration date), *ii)* existing concessions can be exceptionally extended (under the same concessionaire) to address the need for works to increase capacity, *iii)* semi-public hydroelectricity companies can be established with public entities (which can retain control if they wish) and a private partner selected by tender, and *iv)* a new revenue-based royalty regime will apply to all new, renewed or extended concessions. A decree setting out the new concession groups and the new concession expiry dates is expected to be published as part of the implementation of the Act in 2016.

The ARENH price has been fixed at EUR 42 per MWh in 2012 and the CRE has revised the methodology in 2016, as the fixed tariff is hardly used by industrial consumers. In the past years wholesale prices in France and Europe were below the level of ARENH (Figure 8.7).

In its 2015 report, the French Competition Authority (*Autorité de la concurrence*) called upon the government to decide as soon as possible on the phase-out or extension of ARENH beyond 2025 (*Autorité de la concurrence, 2015*). The Authority concludes that ARENH has not met its objectives. The future of ARENH has significant implications on the state of competition in the French market, the amortisation cost of the nuclear energy infrastructure and the end of regulated tariffs, which are calculated on the basis of the ARENH price.

MARKET COUPLING

The integration of the French electricity market with the regional electricity markets in Europe has continued. After the market coupling of Central Western electricity markets, North Western Europe (February 2014) and South Western Europe (May 2014) were coupled, and Italy and Slovenia followed (February 2015). The process cumulated in May 2015 in the coupling of the two regions (South Western Europe and North Western Europe), managed by the grid operators and power exchanges from the relevant member states, with a view to manage cross-border electricity flows in an optimal way and to smooth out price differences across the European Union.

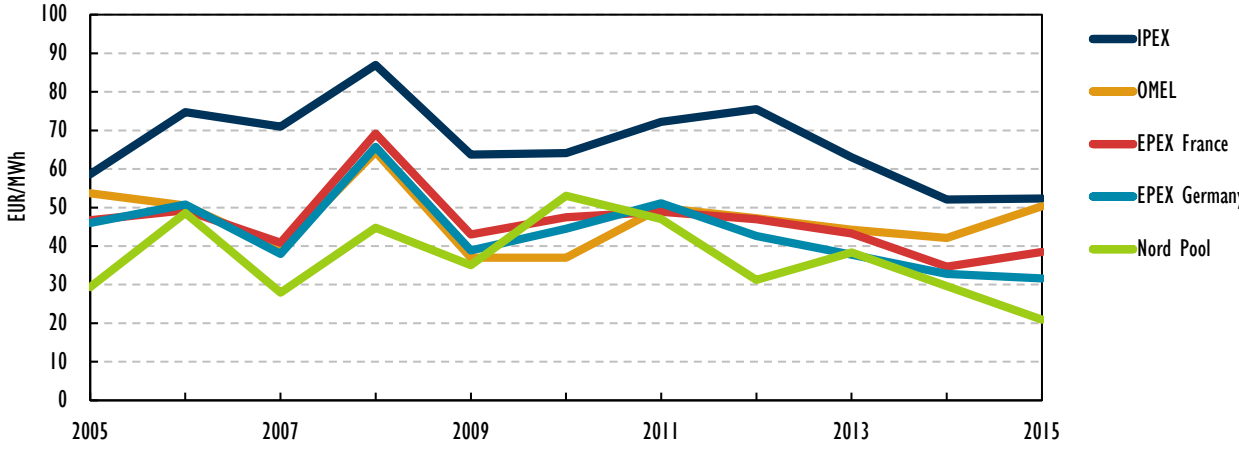
In May 2015, a new flow-based method for market coupling was introduced in Central West Europe (including France) to better account for renewable power flows in integrated cross-border electricity networks. The cross-border capacity between Germany-France and Belgium-France has increased in 2016 following flow-based market coupling in 2015. Equally, the integration of France with neighbouring intraday markets has increased (with Italy) over the past five years. In fact, wholesale electricity prices have largely converged in Europe in recent years.

WHOLESALE MARKET PRICE TRENDS

Because of declining demand and plummeting fossil fuel prices, average spot prices in France have been declining since 2008. They dropped below EUR 30 per MWh in 2014 before recovering again to an average value of around EUR 40 per MWh by the end of 2015. In addition, high availability of nuclear power and the inflow of renewable electricity put additional downward pressure on prices. France had low wholesale electricity prices at the EPEX France, which were above the lowest prices in Europe depicted at Nord Pool and the German EPEX (Figure 8.7).

Total annual amount of electricity (including brokered contracts) traded on the exchanges has increased significantly during 2009-15; the futures market had the largest volume, while the intraday market is still relatively small. The bulk of the energy trade, however, takes place over the counter, reaching similar volumes as the futures market of around 800 TWh (CRE, 2016).

Figure 8.7 Comparison of annual wholesale electricity prices on European exchanges, 2005-15



Source: Gestore dei Mercati Energetici SpA.

France has undertaken three important reforms of its electricity market which aim at:

- Ensuring security of supply by complementing the "energy-only" market with a capacity market (as of 1 January 2017) in the form of a decentralised capacity mechanism (capacity obligation).
- Better rewarding demand-side flexibility of industrial/household users (including aggregators) by enabling demand-side capacities to participate in every electricity market.
- Better integrating renewable energy in the electricity grids and markets by exposing renewable energy generators to short-term market signals, with the transition from feed-in tariffs to feed-in premiums, capacity auctions and by fostering participation in voltage and frequency control services (see Chapter 9 on Renewable Energy).

The French capacity market

France adopted a capacity market with a view to:

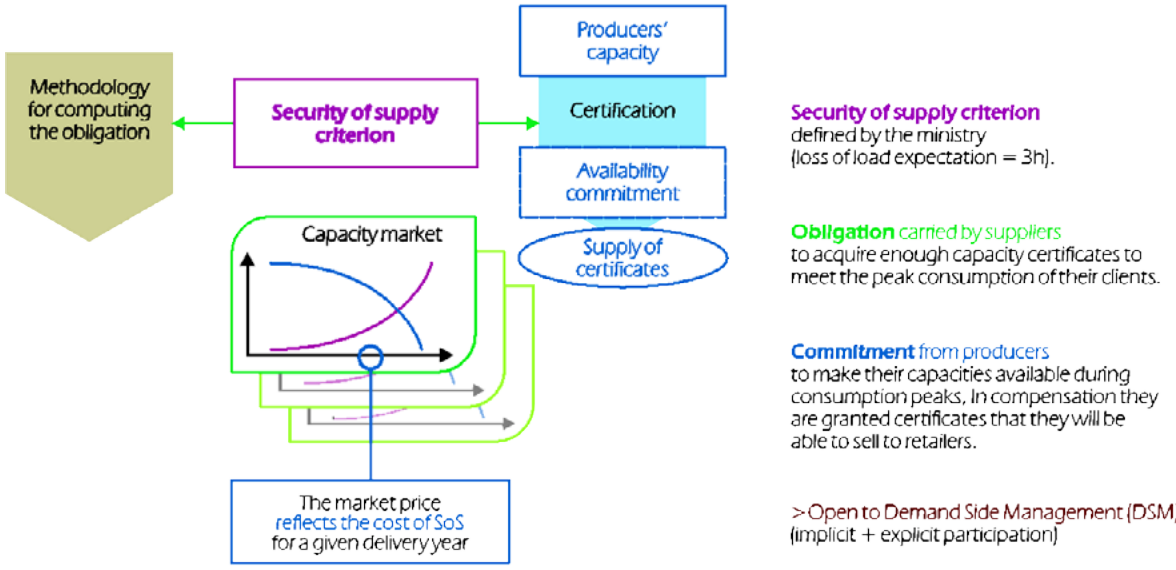
- Ensure incentives for medium- to long-term investment and operation of the capacity necessary to ensure security of supply amid low wholesale prices (average price of EUR 40 per MWh remains below levelised costs for new generation units and even below the operating and maintenance costs for conventional thermal units).
- Help reverse the decline in demand response capacity in France (demand response capacity fell from around 6 GW in 2000 to 2.8 GW in 2014).

The French capacity market (see Figure 8.8) places an obligation on suppliers to hold a number of "capacity certificates" to match their customers' peak consumption. They can acquire these certificates by having their own generation or demand-side response capacity certified, or by acquiring them from other generation or demand-side response operators. If a threat to security of supply is identified, the mechanism will provide remuneration for available capacity (demand-side response or generation) in addition to the sale of electricity generated, which will contribute to the necessary investment. The capacity market starts on 1 January 2017.

Given the high concentration of the French market for generation and supply to final consumers, the introduction of a capacity mechanism has therefore certain risks when it comes to competition. On 29 April 2015, the European Commission launched a state aid sector inquiry into national capacity mechanisms. It has given its clearance to the French capacity market to ensure its does not represent a potential barrier to new entrants or distortion to the EU internal energy market. On 8 November 2016, the European Commission approved the capacity market and requested France to:

- Progressively allow explicit participation of cross-border capacities (explicit cross-border participation in the mechanism will be operational on 1 January 2019).
- Introduce a dedicated framework (within the capacity mechanism) for new capacities, in order to give them more visibility on the price of capacity, and thus facilitate investment decisions (in practice those capacities will have the possibility to conclude seven-year CFDs on capacity [instead of one year], provided they are competitive).
- Revise some of the rules of the capacity mechanism to prevent all forms of market abuse (capacity retention, price-scissors effect) and increase transparency.

Figure 8.8 The functioning of the French capacity market



Source: Adapted from RTE (2015b), *Electricity Supply-Demand Balance in France (Bilan Prévisionel)*, Paris.

From demand-side management (DSM) to demand response (DR)[1]

France saw an early DSM development with time-of-use tariffs being offered by EDF, differentiating night and day tariff hours since 1982. DSM has come down from 6 GW to 2 GW over the past decades. Demand response (DR) in the electricity market is expected to unfold as future reforms will allow operators to participate in all electricity markets (day-ahead market, balancing market, reserves, ancillary services, interruptible capacity

1. Demand-side management (DSM) programmes have been developed and coordinated by utilities, often supervised by regulators, seeking to minimise the operating cost base used to determine regulated tariffs for end-users. Demand response differs from DSM in that it is the product of voluntary and independent decentralised decision-making by suppliers and customers. For further information see IEA (2011), *Empowering Customer Choice in Electricity Markets*, OECD/IEA, Paris.

as well as in the capacity market). This provides a competitive environment between conventional producers/suppliers and system operators, especially third-party aggregators. EDF's Enedis has just started the roll-out of its Linky smart meter, which will allow more DR through dynamic tariffs, in addition. Structural changes in the electricity markets have thus been carried out to allow the explicit participation of distribution operators:

- Regarding **ancillary services**, a pilot project was launched to allow DR resources to provide frequency containment reserves (FCR) and automatic frequency restoration reserves (aFRR). Since July 2014, distribution operators are now able to sell FCR and aFRR to generators and to set their own price for this service. Currently, 60 MW of DR capacities are contracted by RTE in 2015.
- Regarding the **procurement of reserves**, RTE has been able to contract with DR operators manual frequency restoration reserves (mFRR) and restoration reserves (RR) since 2008. The share of DR in the procurement of reserves has been steadily growing. Currently, 400 MW of mFRR and RR are contracted by RTE with DR operators. Since 2012, a specific call for tender is organised and targets DR resources. The aim of this call for tender is to secure the availability of DR resources for a one year period. This call for tender dedicated to DR represents 1.8 GW.
- Regarding the **balancing market**, DR has increased over time from the sole participation of industrial customers (since the creation of the balancing market in 2003) to the participation of all aggregated DR resources (since 2007). The activation of DR resources in the balancing market has grown from 10 000 MWh in 2003 to more than 20 000 MWh in 2013, however, a small share of a market of 563 TWh.
- Complementary products are offered on short-term markets (balancing). RTE is entitled to conclude one-year interruptible contracts with consumption sites connected to the transmission network with instant interruptibility profiles. These interruptibility contracts represent 600 MW of additional reserves.
- Regarding the **wholesale market**, since 2003 DR has been valued directly and indirectly in the day-ahead and balancing markets alongside generation. Law 2013-312 of 15 April 2013 "*visant à préparer la transition vers un système énergétique sobre et portant diverses dispositions sur la tarification de l'eau et sur les éoliennes*" (the Law aims at preparing the transition towards a self-restrained energy system with various measures regarding water tariffs and wind turbines) introduced the so-called "*NEBEF mechanism*" with a view to address several issues:
  - **Competition:** NEBEF addresses the competitive position of independent aggregators versus suppliers, by giving them access to the consumer base of every supplier (DSR operators can activate DSR without the supplier's consent).
  - **Markets:** the NEBEF mechanism allows independent aggregators to bid directly on the day-ahead and balancing markets, and thus allows "curtailed energy" to be sold as "energy".
  - **Financing:** the NEBEF mechanism regulates the financial interface between suppliers and independent aggregators in case they cannot/do not want to agree on financial settlements.
  - **Aggregation:** NEBEF addresses all technical barriers to aggregation of consumption sites.

RETAIL MARKET

International experience of IEA member countries (IEA, 2011) suggests that the key elements of a transparent and competitive retail market include the following aspects:

- Increasing customer exposure to real-time pricing, with protection of vulnerable consumers addressed 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 to take full advantage of the choices available.
- 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 retail markets and distribution networks are at the forefront of the challenges emerging with the energy transformation. Experience in IEA jurisdictions has shown that there are several means to build transparent and competitive retail markets. At EU level, the discussion about the future electricity market design is currently focusing on a number of actions to foster the integration of renewable energy in the electricity wholesale and retail markets while ensuring the economic and energy systems' integrity.

The report will now analyse the state of play in the French retail market with regard to those principles.

MARKET STRUCTURE

In 2016, the French retail market represented 36.9 million consumption sites (including 27.8 million households) and an annual consumption of 431 TWh (CRE, 2016).

Since July 2007, the retail market has been entirely opened to competition: every consumer can choose a market offer from a so-called historic supplier or any other supplier. Only the historic supplier – EDF and the so-called local distribution companies (*entreprises locales de distribution (ELDs)*, which include municipalities, *Electricité de Strasbourg, Gaz Électricité de Grenoble*, UEM, and others) – can offer regulated tariffs to consumers located on their territory. Historic suppliers can also provide a market offer,

which means that market offers co-exist with regulated prices (ENGIE can make market offers in the electricity segment. EDF can make market offers in the gas segment.)

In 2016, there were more than twenty alternative suppliers active in France: Alpiq, Alterna, Axpo, Direct Énergie, Edenkia, Enalp, Enel France, Enercoop, Energem, Enevos, Energie Libres, Electricité de Savoie, ENGIE, Energies du Santerre, GEG Source d'énergies, Hydronext, Hydroption, Iberdrola, Lampiris, Lucia, Planète Oui, Proxelia, Selia, Total, Uniper, and Vattenfall.

The five largest retailers are EDF, ENGIE, Uniper, Alpiq and Direct Énergie.

REGULATED TARIFFS

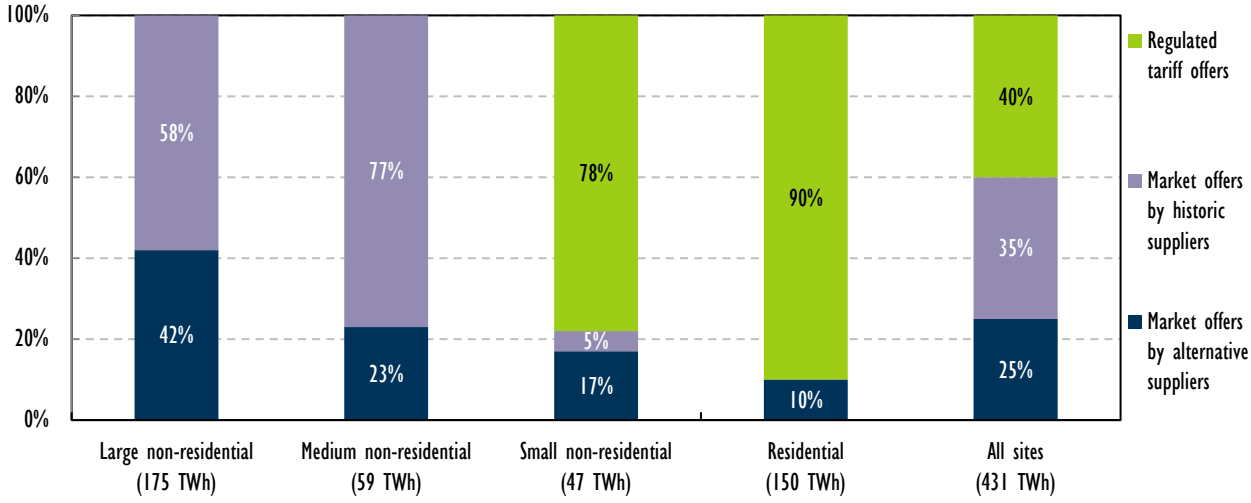
The opening of the electricity market to competition has advanced in the non-residential sector. Regulated tariffs were phased out for large and medium-sized non-residential customers (green and yellow tariffs bands). Following the EU competition case (state aid) France had to phase out these regulated tariffs, which were fixed by the government by end of 2015. Tariffs were abolished on 1 January 2016 for:

- large professional customers connected to the transmission grid (green bands)
- consumption sites with subscriptions of over 36 kVA (yellow bands).

Residential customers and professionals using less than 36 kVA (blue bands) remain eligible to regulated tariffs, the level of which is now proposed by the regulator CRE.

When the regulated tariffs for large consumers were abolished, some consumers did not take up the market offer by 1 January 2016. The government forced the historic supplier to terminate the contracts of those unresponsive consumers by providing a "transitional" offer until 30 June 2016, with a 5% top-up over the regulated tariff. As consumers still did not switch, the government ordered the CRE to assign consumers to new suppliers through competitive auctions for 1 July 2016 and to increase the top-up of 30%.

Figure 8.9. Market share of alternative and historic suppliers (31 March 2016)



Source: CRE (Commission de Régulation de l'Énergie) (2016), *Observatory of Wholesale Electricity and Gas Marketes (Observatoire des Marchés de Gros de l'Electricité et du Gaz)*, Q1 2016.

Despite the theoretical market opening of 100%, 90% of residential consumers and 78% of small non-residential ones remained on regulated tariffs offered by the historic supplier as of 31 March 2016. Only 10% of the households have chosen alternative suppliers. Conversely, 58% of large non-residential consumers had market offers from the historic supplier (versus 42% by alternative suppliers).

In total, the share of regulated tariffs in the market has come down to 40% after their phase-out for large consumers (Figure 8.9).

Supplier switching remains low and is limited to about 2% of non-residential consumers, around 1% of households and 8% of large consumers in 2016 (CRE, 2016).

The principle of reversibility allows household consumers to change from regulated prices to market offers and vice-versa, without restriction.

Under the NOME Law, a new calculation method for regulated tariffs was introduced on the basis of accumulated costs. Regulated tariffs are calculated by CRE as the sum of the cost of nuclear (ARENH purchase cost), the additional cost of alternative market offers, distribution and transmission charges, and EDF's marketing costs. This aims to make a gradual transition towards transparent pricing and the phase-out of regulated prices, and to stimulate the entry of alternative suppliers, while mitigating the price increase in the transition to market prices. When market prices are above the nuclear costs, alternative suppliers can purchase nuclear electricity from EDF at cost (ARENH price of EUR 42 per MWh) and thus compete with EDF. However, with decreasing wholesale prices (Figure 8.7) below the nuclear cost, most suppliers no longer purchase from EDF but from the wholesale market and charge mark-ups to final consumers.

The French government has not yet set out plans on how to abolish regulated household tariffs. However, regulated tariffs are calculated on the basis of the ARENH price and are therefore tied to its duration. ARENH is set as a temporary measure under French law and should expire by 31 December 2025.

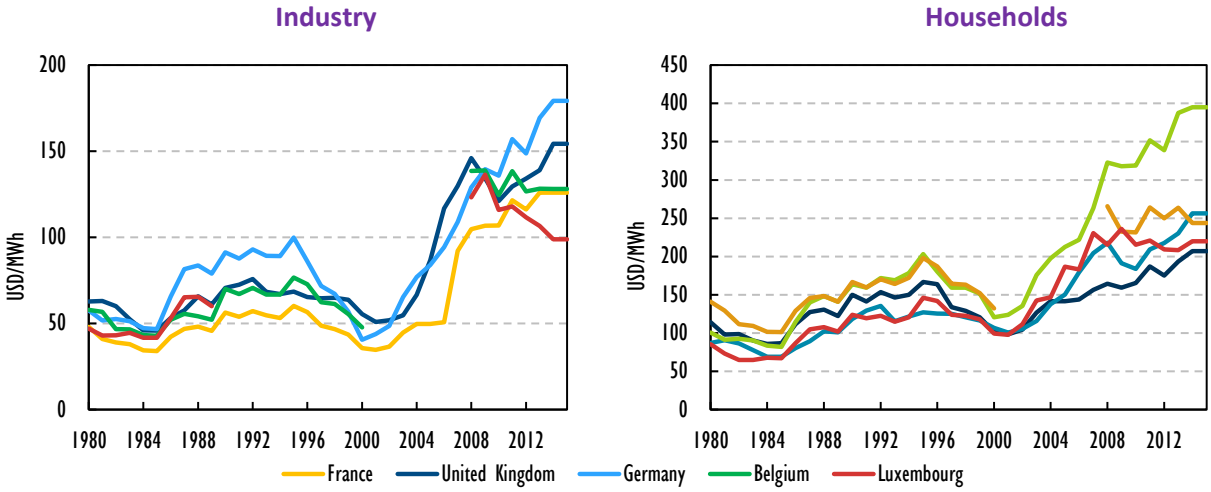
PRICE TRENDS

Final electricity prices have remained fairly stable over the last five years, with some increase for industry and decrease for households, but not comparable to the major increase in industry prices which occurred during 2005-10 (Figure 8.10).

By international comparison, France has electricity prices for households and industry around the IEA median, thanks to nuclear and hydro-based electricity generation.

However, electricity prices are heavily taxed; the energy cost component is rather low and transmission/distribution charges (*Tarif d'utilisation des réseaux publics d'électricité, TURPE*) are added. The tax component is 34% for households and 22% for industry customers (Figure 8.11) as in France, because electricity prices carry a number of public service charges.

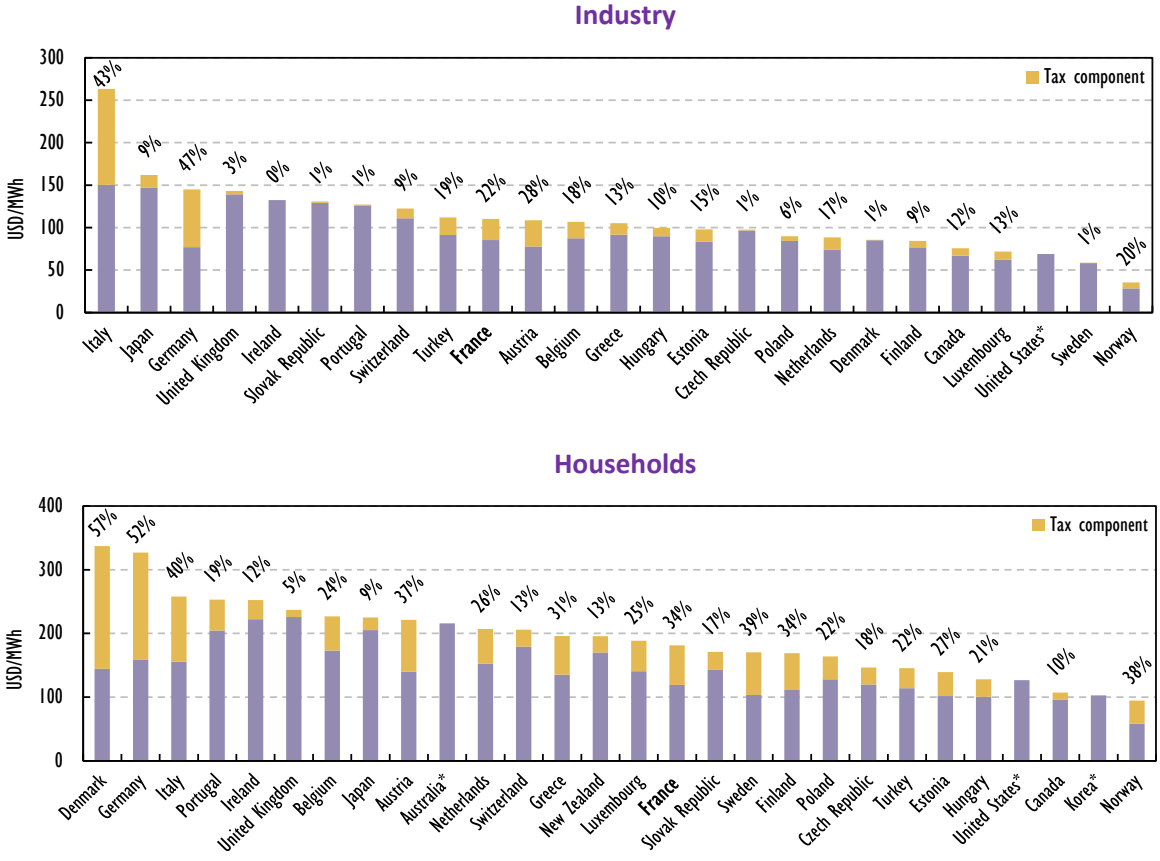
Figure 8.10 Electricity prices in France and in other selected IEA member countries, 1980-2015



Note: Data for Belgium for industry and households are not available for 2001-07; data for Luxembourg for industry are not available for 1990-2007.

Source: IEA (2016c), *Energy Prices and Taxes 2015*, www.iea.org/statistics/.

Figure 8.11 Electricity prices in IEA member countries, 2015



* Tax information not available.

Note: Data not available for Australia (industry), Korea (industry), New Zealand (industry) and Spain (industry and households).

Source: IEA (2016c), *Energy Prices and Taxes 2015*, www.iea.org/statistics/.

In 2015 there were four types of taxes charged to final electricity consumption in addition to the value-added tax (VAT):

- the contribution to the public electricity service (*contribution au service public de l'électricité, CSPE*) which is used to finance the costs of the public electricity service including renewable energy support, additional production costs in non-interconnected areas (Corsica and the French DOMs), costs resulting from the special "staple commodity" (*produit de première nécessité*) price rate for people suffering from fuel poverty, as well as the budget of the national energy mediator
- the domestic tax on final electricity consumption (*taxe intérieure sur la consommation finale d'électricité, TCFE*)
- the municipal tax on final electricity consumption (*taxe communale sur la consommation finale d'électricité*)
- the département tax on final electricity consumption (*taxe départementale sur la consommation finale d'électricité)*.

A reform of the electricity taxation was implemented at the end of 2015. The government reformed the CSPE under the revised Finance Law 2015. Public service expenses are now included in the state budget, and thus under Parliamentary control. The new CSPE committee monitors the evolution of public service expenses and gives an opinion on the pluriannual energy programming (PPE). In 2016, the CSPE budget in support of renewable energy is allocated to a dedicated energy transition item, while other general public services are contained in a new public mission budget of the state. The CSPE is merged with the excise tax on electricity (*taxe intérieure sur les consommations finales d'électricité, TICFE*) and, from 2017 onwards, with the carbon component of EUR 30.5 per tCO_2.

CONSUMER ENGAGEMENT AND SMART GRIDS

Most of the current regulated prices and contracts contain some dynamic price element, including price levels of peak/off-peak hours or peak demand blue days/red days. Today, an obstacle to the further development of more dynamic price offers is the technical barriers imposed by old meters. Much later than other EU countries, France has taken the decision to roll out smart meters to all consumers by 2021. Endis is deploying the Linky smart meter to all households.

Investment in innovation has been an issue for the historic supplier EDF which held the lion's share of the electricity market volume and networks. This has been a barrier to investment in new smarter applications, including smart meters and electric vehicles. In addition, Enedis currently holds most of the distribution concessions. However, many concession contracts will have to be renewed in the coming years. Around 82% of the contracts will need to be renewed during 2018-28. This may present an opportunity for new distribution companies or municipalities to enter the business, as seen in other IEA countries, notably in Germany, where cities and municipalities bought back the distribution concessions from the utilities.

As the historic suppliers offer regulated tariffs to households and small consumers, France does not have regulation regarding the electricity supplier of last resort; EDF is the *de-facto* supplier of last resort, as households have the right to access to electricity. However, when the phase-out of regulated tariffs for households are undertaken, the

government will need to define a last-resort supplier who would ensure supply to final consumers in case of a financial or technical failure of the current supplier.

France has an energy ombudsman to settle disputes and provide consumer information. However, consumers in France are not well informed about their choice of market offers, as both regulated prices and market offers coexist, and about how they can switch supplier. Consumer information is not made available on a systematic basis, notably with regard to the principle of reversibility of switching decisions and prices. In a market with largely regulated tariffs, price comparison tools or private/public switching campaigns have not been developed. The experience from the phase-out of regulated tariffs for large consumers shows how difficult it is to activate inert and unresponsive consumers.

To accompany the eventual phase-out of regulated tariffs, it may be desirable to have protection measures in place for vulnerable consumers. Under French law, persons are in energy poverty when they have difficulties in ensuring the necessary energy supply to satisfy their basic needs because of the inadequacy of their incomes or their living conditions. Special social tariffs exist for 8% of the households and are linked to several income criteria (tax statements). This does not allow targeting those persons who do need support, because of inefficient file comparison between social/fiscal files and suppliers' databases. The system also lacks equity as some gas consumers benefit from electricity social tariff (TPN) and gas social tariff (TSS), whereas others only benefit from TPN. The amount thus varies from 1 to 3. The government has presented plans to introduce energy vouchers so as to gradually phase out social tariffs financed through the electricity and gas taxes. The CSPE is also paid for the social tariffs offered by the historic supplier EDF to certain consumer groups. Social tariffs are envisaged to be phased out and replaced by energy vouchers under the Energy Transition for Green Growth Act of July 2015.

SECURITY OF ELECTRICITY SUPPLY

LEGAL FRAMEWORK

The Ministry of Environment, Energy and the Sea (MEEM) has the overall responsibility for the security of electricity supply with three key instruments: *i)* reliability margins based on a national adequacy assessment (generation and networks) by RTE. The security of supply criterion for France is defined as the expected loss of load of maximum 3 hours or 30 hours every 10 years; *ii)* pluriannual energy programming (PPE); and *iii)* the capacity market.

On 27 October 2016, the pluriannual energy programming (PPE) was adopted (Décret n° 2016-1442) and covers the periods 2016-23 and includes all investments required for security of supply (oil, gas, electricity), including import capacities.

Under the Energy Code, the transmission system operator RTE has the task of ensuring the security of the electric power system, thus requiring the grid at all times to deliver electricity from producers to consumers. To this end, each year RTE presents a forward-looking 10-year network development plan and carries out a medium-term assessment of the future supply-demand adequacy (RTE, 2016a) as well as an annual winter and summer adequacy outlook (RTE, 2016b). These exercises feed into the European assessments by ENTSOE. France will implement a national market-wide capacity

mechanism where capacity obligations are traded between electricity capacity providers (e.g. generators or demand side operators) and electricity suppliers. Capacity providers offer capacity when demand is highest, for example during extreme winter conditions. In return for their available electricity capacity they receive certificates. Suppliers need to purchase certificates from capacity providers in order to cover the peak demand of their customers. These certificates can either be traded bilaterally between providers and suppliers or through regularly organised public auctions. The capacity market is going to start on 1 January 2017.

POWER SYSTEM ADEQUACY

The French electricity mix has a low diversity and high baseload thanks to the dominance of nuclear (78%) and hydro (10%) in the mix. Despite having a largely decarbonised power generation, there are a number of challenges related to power system adequacy, such as the ageing nuclear fleet with requirements for shut-downs during more frequent maintenance and safety upgrades, lower water availability in hydro basins in dry years, reduced flexibility from thermal plants following the closure of oil and coal-fired power plants, and decreasing peak-demand response capacity in recent years. These impacts are only partially offset by increasing shares of variable renewable electricity.

On the demand side, France has seen a large decline in electricity (industrial) demand, with the relocation of industry and the impact of energy efficiency and the economic slowdown. Forecasts expect a flat electricity-demand curve in the coming decade with a maximum of 1% increase per year. (The share of nuclear in the electricity mix would actually increase if electricity consumption declined in the coming years, which would not be in line with the target of the government.)

The main risk for security of supply is the thermo-sensitivity of the demand and the peak load during cold snaps. In winter periods electricity consumption is very sensitive to temperature (+2.4 GW/°C) owing to the high penetration of electric heating. Peak load demand has increased 2.5 times faster than the average demand during the last 10 years. Peak demand hit the 100 GW for the first time in 2012. Growth in peak demand has however declined since. With the deployment of electric vehicles, peak demand is expected to rise again to 100 GW in the period to 2020, but consumption from electric heaters could find itself replaced by electric vehicles.

Peak demand-response capacity has actually been reduced by more than 50% in the past decade. Demand-response capacity fell from 6 GW in 2000 to 2.8 GW in 2014, as regulated, dynamic tariffs are being gradually phased-out. Therefore, the draft PPE stipulates that demand response should be in the order of 5 GW up to 2018 and 6 GW for 2023.

The availability of French generation is usually good, with large baseload and only a low portion of variable electricity from renewable energy sources in the mix. Nuclear and hydro need stable water basin levels. In recent years, however, France experiences increasing water scarcity amid the rise in temperatures and recurring heat waves. At the same time, the share of backup plants from fossil-fuel capacities has decreased in recent years. Around 10 coal units (or 3.3 GW) were phased out during 2012-16. In 2016, EDF announced plans to shut down its entire fuel oil-fired power fleet by 2018, which corresponds to a total capacity of 5.2 GW. While the construction of new gas-fired power plants (combined cycle gas turbines, CCGTs) continued, current market conditions

lead to limited availability. There are only two main thermal plants under construction or planned during the next years are the CCGTs of Bouchain (2016) and Landivisiau (2018).

Traditionally, the French power system has been characterised by a structural overcapacity following the nuclear programme which saw the construction of a large fleet of 58 nuclear reactors during the 1970-80s (the oldest reactor is Fessenheim, built in 1978). France has enjoyed an "overabundance" of electricity supply, due to the combined effects of sluggish demand and low growth of renewable energy. However, as explained in Chapter 10 on Nuclear Energy, the French nuclear power plant fleet is ageing, as the plants were built in the same timeframe and are approaching 30 years average age. In the longer term, the ageing nuclear fleet presents an enormous financial and organisational challenge for the main owner and operator EDF and the French government, as well as for the electricity market in terms of securing the electricity supplies at competitive prices. Project delays in Flamanville could compromise the possibility to replace Fessenheim with the new European pressurised water reactor (EPR). The closure date of Fessenheim has been decided in 2016 and should take place in 2018 (the plant will reach 40 years in 2019) and EDF has been offered a compensation payment of EUR 400 million.

In addition, there are systemic risks linked to the fact that most plants have the same design and if the design fails, then a range of reactors could have to close for inspections. This situation has actually occurred in the winter 2016-17 (see the assessment of the short-term adequacy in Box 8.2). It remains uncertain which plants are expected to be extended or shut down. Under French nuclear safety regulations, the authorisation for extending a plant's lifetime is granted by the French Nuclear Safety Authority (ASN) for a period of 10 years only following a review of the safety of the entire capacity level with the same nuclear design (palier). By end of 2018/early 2019, ASN is expected to give a general notice on the possibility to extend the lifetime of a share of the reactors by another 10 years; however, final safety approvals need to be given plant by plant.

Under the Energy Transition for Green Growth Act of 2015, the government set out ambitions to decrease the share of nuclear in electricity generation to 50% by 2025 and increase the share of renewable energy to 40% in the power mix by 2030. This means that within 10 years, all conditions the same, France has to replace the remainder (78% - 50% = 28%) by renewable energies (assuming that the hydro potential has been reached and that new CCGTs are not economic), which also shall increase to 40% by 2030. The closure of Fessenheim alone will not reduce the share of nuclear to 50% by 2025.

Most of the new capacities are renewable energy sources, mainly wind power and solar PV. Wind power growth had slowed because of regulatory uncertainty and an unfavourable economic climate but is showing signs of recovery. Concerning PV, robust global expansion has driven production costs down considerably in recent years: significant efforts have been made to reduce the cost of solar panels, and the focus now is on increasing productivity by targeting costs associated with installation, civil engineering and inverters and other equipment. A large share of new solar photovoltaic projects is being developed through tenders organised by the regulator CRE. The objectives of installed capacity for renewable energy sources are defined in the PPI (*programmation pluriannuelle de l'investissement)* and have been included in the PPE (*programmation pluriannuelle de l'énergie*) for the period 2016-23. The PPE gives visibility concerning the development of renewables, which, as a no-regret measure, will continue to be strongly supported and will contribute to achieve the reduction of the share of nuclear energy in the electricity mix to 50% by 2025.

With regard to the closure of the Fessenheim nuclear power plant, the objective of the PPE is to repeal the authorisation to exploit the plant by 2016. Only the next PPE will include a forecast with regard to nuclear energy, based on the ASN review in 2018.

In addition, supplies to France from neighbouring countries during peaks may be compromised by the situation in Belgium (extended unavailability of a portion of the Belgian nuclear fleet increase), lower imports from the Netherlands/Germany to Belgium), and the general retirement of old plants in the region or their placement in strategic reserves (in Germany and Austria). France already imports from Germany in winter peak periods.

The 2015 RTE adequacy outlook (RTE, 2015b) alerted to reduced margins at peak load in the winters towards 2020, because of growing uncertainties linked to the large amount of nuclear plants under maintenance and possible decommissioning of coal/oil/gas power plants and growing concern about security of supply at times of peak demand. RTE does not guarantee that it is able to fulfill the security-of-supply standard (loss of load expectation <= 3 hours) in all scenarios. Increasing flexibility is also needed to cope with *i)* intermittent renewable energies, and *ii)* rising peak demand, while the real value of flexibility is not yet fully recognised. Therefore, the government decided to introduce a capacity mechanism by ministerial decree in January 2015, as described above. The 2015 report illustrated the decreasing capacity margins during all winters up to 2019-20, as demand peaks increase (though at lower growth rates) while peak generation decreases every year and baseload coal or gas-fired power plants were closed in 2013-15. The 2015 report takes also into account generation adequacy in neighbouring countries' interconnections and assesses various risk scenarios up to 2020. A regional generation adequacy assessment, based on a shared methodology among TSOs was presented in the framework of the Pentalateral Energy Forum in March 2015.

Import capacity is necessary for France to maintain its security of supply. Without interconnections, which contribute about 10 GW over the coming years, France would not be able to maintain its balance during peak hours, as can be seen in Table 8.2.

Table 8.2 Security of supply adequacy assessment (baseline scenario) with and without interconnections

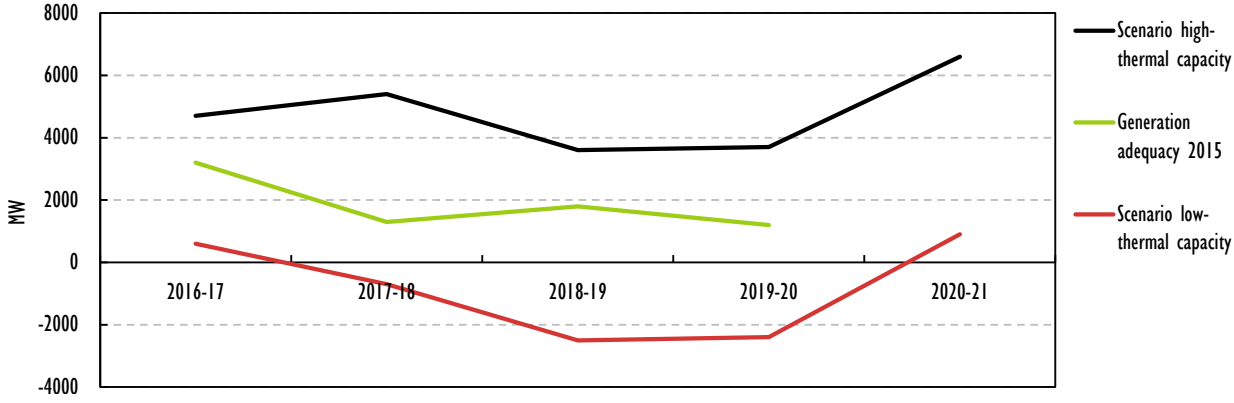
	Winter 2015/16	Winter 2016/17	Winter 2017/18	Winter 2018/19	Winter 2019/20
With interconnections					
Expected energy not served	1.4 GWh	3.7 GWh	7.6 GWh	6.7 GWh	7.0 GWh
Loss of load expected	0h60	0h15	2h00	1h45	2h00
Capacity margin or deficit	4 800 MW	3 200 MW	1 300 MW	1 800 MW	1 200 MW
Without interconnections					
Expected energy not served	53.8 GWh	85.1 GWh	458.9 GWh	128.8 GWh	133.2 GWh
Loss of load expected	14h	20h	34h	28h	30h
Capacity deficit	-4 600 MW	-5 400 MW	-7 200 MW	-6 600 MW	-6 700 MW

Source: RTE (2015b), *Electricity Supply-Demand Balance in France (Bilan Prévisionel)*, Paris.

The expansion of interconnection capacity in the years ahead (notably with Spain and Italy), along with the availability of capacities in foreign countries (where declining demand can create margins), explains why this contribution is so high. The analysis of shortfall risk in a "stand-alone" situation is shown in Table 8.2, in the Baseline Scenario, and illustrates that France without interconnection would lack capacity.

RTE's latest generation adequacy report in 2016 illustrates that the capacity margins become negative when more thermal power plants are being closed down.

Figure 8.12 Winter capacity margins 2015 versus 2016



Source: RTE (Réseau de Transport d'Électricité) (2016a), *Supply-Demand Balance in France (Bilan Prévisionnel)*, Paris, www.rte-france.com/sites/default/files/bp2016_complet_vf.pdf. Network adequacy.

NETWORK ADEQUACY

Transmission networks and interconnections

The physical integration of the electricity market is progressing with the commercial opening of the new interconnection with Spain in October 2015. A total of up to 10 GW of new underground cables is planned between France and Spain in the Gulf of Biscay/Bordeaux (2023), to Ireland (Celtic, 2025), the United Kingdom (FAB, 2022; ElecLink, 2017; IFA2, 2020) and Italy (Savoy-Piemonte, 2019).

Today, France is facing congestion on the electricity interconnection capacity with Italy. RTE envisages major reinforcements of the electricity grid in the coming ten years (see Figure 8.6), notably towards Italy and the United Kingdom.

RTE invested around EUR 1 500 million per year during 2009-15 to strengthen network adequacy in France. Future investments focus on the reinforcement of the electricity grid in the south of France, which has been structurally weak, notably in connection to the electricity cross-border flows to and from Spain and Italy, which remain highly congested.

Distribution networks

With a view to strengthen the distribution network against extreme climatic conditions, the extreme weather plan of Enedis was validated by the public authorities in 2006; it includes a EUR 2.3 billion investment over 10 years to reduce the vulnerability of the network to extreme climatic conditions. This involves:

- reconstructing some high-voltage lines in rural areas
- burying fragile lines or those situated in wooded areas
- renewing urban cables that may have been weakened during high summer temperatures
- securing electricity supply to sites that may be used as refuges for populations in cases of extreme weather conditions
- limiting flood damage.

The final objective for the extreme weather plan is to ensure that 90% of customers are reconnected in fewer than five days, as was the case during the storms in 1999 and 2009. The PPE covers all investments, including network investment. At the same time, the territorial and regional authorities have to adopt energy and climate plans which will include investments in renewable energies and energy efficiency. At the moment, the PPE does neither reflect those territorial and regional investment plans nor their impact on the transmission investment plan by RTE.

Box 8.2 Security of electricity supply in the winter 2016-17

In the winter 2016-17, France is experiencing electricity supply constraints mainly due to unprecedented unavailability of nuclear generation. In case of a temperature much colder than average, ensuring security of supply in the coming winter could be challenging. The French nuclear safety authority (ASN) required the extension of the planned maintenance period and the additional brief shutdown of several nuclear reactors in the winter to test for possible safety issues (involving excessive level of carbon in the steel of the steam generators).

RTE considers that the development of renewable energies, import capacity, demand response and energy efficiency will enable to compensate the decrease of nuclear generation. In 2016, total installed capacity in France reached 126 GW, two times the installed nuclear capacity (63 GW). Hydro capacity in France is 25 GW but the level of water in the reservoirs is at its lowest over the last 10 years. Wind capacity is 10.3 GW and its statistical average of load factor in winter is 30%. Solar PV capacity reaches 6.2 GW, but this capacity is not generating during the evening peak that takes place at 19h00 in winter. Conventional capacity (gas, coal and oil) reaches 22.5 GW in 2016. The availability is good as only one coal unit is currently under long term maintenance work until 9 January 2017.

However, electricity import capacity has been lower than expected, with a tight situation in the United Kingdom and Belgium (where nuclear reactors Doel 3 and Tihange 1 are shutdown). French nuclear safety authority ASN confirmed that 7 reactors will come back on line before the end of 2016. The situation in Belgium is considered to be less challenging in the winter 2016-17. The Belgian TSO arranged for some 750 MW of strategic reserves, which can be activated for economic and security reasons, and relies on the possibility to increase interconnection capacity from 3 500 MW to 4 500 MW and has brought online one nuclear plant of 1 000 MW, following maintenance work.

On 8 November 2016, RTE published its adequacy analysis for the winter 2016-17 (RTE, 2016b). Peak demand is expected for January 2017. If temperatures fall 3°C below the average, RTE may have to gradually implement emergency measures.

Box 8.2 Security of electricity supply in the winter 2016-17 (continued)

The first step would be interrupting 21 energy-intensive industrial sites and volunteers to reduce the power demand by 1.5 GW. RTE could then reduce voltage by 5% or 4 GW of load, without interrupting supply. In the case of an extreme imbalance between consumption and production, RTE could finally perform load-shedding through 'programmed and momentary outages' in a rotational basis of less than two hours per consumer while preserving supply to sensitive loads and priority customers, such as hospitals and important industries.

The Minister for Environment, Energy and Marine Affairs, Segolène Royal announced the launch of a national campaign on the behaviors and tools to reduce electricity consumption in winter. RTE has a citizen alert system in place to allow consumer participation in alleviating supply tightness during peak periods (éCO2mix). It broadcast alerts via smartphones, tablet computers, and the RTE website with the aim to encourage consumers to reduce their consumption by deferring the usage of appliances to off-peak hours, lowering the room temperature by 1°-2°C before leaving home and turning off lights in empty rooms.

ASSESSMENT

France holds the second-highest installed capacity for nuclear (63 GW) and nuclear generation among IEA member countries (after the United States). It has the world's highest share of nuclear in its electricity mix (78%). France is Europe's leading electricity exporter to neighbouring countries, with the exception of Germany, from which France imports.

Domestic electricity demand is declining, notably because of decreasing industrial activity and energy efficiency gains. However, peak demand has been on the rise. The French electricity market is characterised by an intense peak demand, notably during winters; electricity consumption is very sensitive to temperature (+2.4 GW/°C). Because of the high penetration of electric heating, peak load demand increased 2.5 times faster than the average demand during the last 10 years. However, the growth of the peak load is now decreasing and is more in line with the growth of the average demand.

Since the last in-depth review in 2009, the government has taken several steps to deal with three main challenges: *i)* phase out regulated tariffs (for large and medium-sized consumers), reform regulated tariffs (for small consumers) to ensure their contestability, and tackle EDF's near-monopoly (84.5% state-owned), *ii)* ensure that electricity security covers the winter peak demand through the introduction of a capacity market and demand-response management (DRM) and *iii)* continue to increase electricity market integration and interconnections of France with the rest of the Union, notably Spain.

Despite having a target of reducing the share of nuclear in the power mix from 78% to 50% by 2025, the government has not been able so far to set out pathways and scenarios for the future of nuclear energy in France, pending decisions with regard to the closure or lifetime extension from the French Nuclear Safety Authority. The financing of the *Grand Carénage* is currently not secured, as the ARENH mechanism does not provide the necessary revenues to EDF, since wholesale electricity prices have been largely below the ARENH price in recent years. This fact adds to significant uncertainty for the French electricity sector and the energy transition. Without creating more competition and thereby enlarging the investment base for both nuclear and renewable energy, the

government may face substantial financing issues. The government should evaluate the cost and benefits of nuclear power and renewable energy within the forthcoming investment plans and assess the potential impact on security of electricity supply in France and in the neighbouring countries (which are almost all closing down nuclear capacity).

WHOLESALE ELECTRICITY MARKET

The French wholesale electricity market remains highly concentrated, as nuclear and hydropower assets are owned by incumbent EDF. Regulated access to EDF's nuclear fleet is allowed to 25% or 100 TWh through the new ARENH mechanism. On the other hand, France is participating in the market integration process with other European countries in a more and more integrated European electricity market.

Since the last IEA in-depth review in 2009, in response to the European Commission investigation, the government introduced the regulated tariff for access to historic nuclear energy (ARENH) under the NOME Law. The IEA welcomes this, as it partly improves access for alternative suppliers; however its implementation can be adjusted. The quantity of ARENH supplied in 2015 has largely decreased as spot market prices are below the ARENH fixed tariff (EUR 42 per MWh).

In the context of low wholesale prices, some actors feared that ARENH prices may have adverse effects on the market ("arenhisation of prices"), developing from a ceiling price to a floor price. However, wholesale prices are now significantly below the ARENH which is not a floor but still provides protection to all suppliers in case of a rise in prices. New suppliers are obliged to get guarantees, to pay in advance and to maintain the level of purchase (monotony clause) which could hamper fair competition and thus lead to out-of-market decisions.

The Energy Transition for Green Growth Act has a number of opportunities to open the market to new competitors. Next to hydropower and renewable energy, the role of demand aggregators will be important in delivering services and, as a consequence, in introducing competition in the retail market. As for generation, new capacities and the decrease of nuclear share could imply new market players. The review team encourages the government to swiftly create an open market place in France with a view to make the energy transition a success.

As part of the Energy Transition for Green Growth Act, the government has announced it will renew the hydropower concessions. The vast majority of France's hydro plants (80%) are run by EDF, the remaining 20% by subsidiaries of ENGIE. The lack of access to the hydro capacities reinforces the dominant position of the incumbent, providing an advantage in terms of reserves and ancillary services, but also in the forthcoming capacity market and the renewable energy market. However, the Act does not provide for the full opening of the existing concessions; instead it creates the possibility to prolong the existing concessions through exemptions for refurbishment work and for the set-up of public-private partnerships. The IEA believes that the renewal of hydropower concessions would need to encompass all hydropower plants, and should make investment/refurbishment needs part of the concession contract, with a view to improve competition on the wholesale market and foster security of supply to cover peak demand in France.

With regard to security of electricity supply, the 2014 generation adequacy assessment by RTE identified a deficit of capacity, notably in the winter 2017/18, due to nuclear capacity maintenance and the closure of fossil fuel-fired power plants. The assessment for the period 2015-20 reveals a positive margin on the baseline scenario, taking also into account the expected closure of the Fessenheim power plant while at the same time the new EPR nuclear reactor of Flamanville (2018-19) and two new CCGTs, and the contribution of imports from other countries.

The new capacity mechanism aims to deal with winter peak load and to improve security of supply. Registration of capacities has started in 2015 (with delivery starting on 1 January 2017). Both generation (old and new) and demand-side market players can participate as providers. Its aim is to ensure that the security of supply is met, because the risk of losing load expectation for 3 hours equals 30 hours every 10 years in France, as defined by the TSO and approved by the government. France has opted for a "decentralised" capacity mechanism.

The implementation of the capacity mechanism is a learning process for all actors, with a number of open questions on how capacity reserves held abroad, and thus interconnection capacity, can be taken into account and how the level of the estimated peak capacity will need to evolve over time. EDF is likely to be a dominant actor on the new capacity market, so it will be important to remain vigilant that fair competition conditions be applied for alternative suppliers.

After an inquiry in 2016, the European Commission has required France to introduce significant changes of the model chosen (capacity market) in order to ensure that the mechanism is inclusive of capacities located across the borders and does not put in a disadvantage new entrants.

For the coming years, an important role for demand response is expected in order to meet peak demand, provide flexibility, and deal with increasing renewable targets. This role is expected to be based on market mechanisms (explicit DR) instead of being based on tariffs (implicit DR), so that consumers benefit from lower electricity prices. Pilot projects are being carried out to test the response of demand. In the short term, and in addition to DR, the integration of renewable energy sources must be encouraged through the different markets (day-ahead, balancing, ancillary services). In this regard, developments at European level on the new energy market design will be taken into account by France.

ELECTRICITY TRANSMISSION AND DISTRIBUTION NETWORKS

Implementing the EU Third Internal Energy Package, France has opted for the ITO model (independent transmission operator) which means that RTE owns and operates the assets as the sole TSO in France, while it remains part of the vertically integrated company (EDF), with special rules to guarantee its independence.

At the distribution level, 95% of the network is operated by EDF's ERDF distribution system operator, recently rebranded Enedis. Local distribution companies (around 150) are responsible for public service electricity distribution over approximately 5% of mainland France, and have different network rules. The main rules are set at the national level by secondary legislation and decisions of the regulator.

Since the last in-depth review in 2009, the energy regulatory authority CRE has further developed its competences. CRE approves the transmission network investment plan

and sets the access and transportation tariffs for both transmission and distribution networks. The responsibility for regularly reviewing the regulated tariffs has been transferred to CRE as of December 2015. CRE has no explicit competence on promoting competition, but can ask the competition authority to rule on a case-by-case basis.

To date, CRE is financed out of the state budget but resources have been declining sharply since 2009 (in line with the EU requirements to reduce France's public deficit). This situation has been a challenge to the independent management of a growing number of tasks, including market surveillance under EU REMIT and the assessment of public expenses, including renewables support. The government has decided to increase the regulator CRE's resources of in 2016 and 2017. The IEA recommends enhancing CRE's autonomy from the state budget and applying a more fee-based system.

The electricity networks will have to play a crucial role in the French energy transition. Today, there are several agents involved in the network development process at different levels. RTE contributes to the Ten-Year Network Development Plan (TYNDP) at a European level and prepares a yearly plan for the following 10 years at a national level, which is reviewed by CRE (and its annual investments are approved by CRE). The plan must take into account:

- The scenario assessments of generation adequacy prepared by RTE.
- The pluriannual energy planning (PPE) prepared by the government (the first PPE was adopted on 27 October 2016). This ensures that the orientations defined by the government to achieve the goals of the Energy Transition for Green Growth Act are taken into account in the network development process.
- The regional plans for the connection of renewable energy to the grid, which are prepared by RTE in co-ordination with the DSOs and the regional authorities.

In any scenario, the increase of network investment will impact network access tariffs to be paid by final consumers. The CRE will need to ensure that the network planning process is cost-effective, well integrated and forward-looking. The PPE is a welcome step in the right direction.

France has 47 interconnections with the United Kingdom, Belgium, Germany, Luxembourg, Switzerland, Italy and Spain, with a total of 12 GW (import) and 16 GW (export) interconnection capacity. There are several new subsea cables to Spain, the United Kingdom, and Ireland being planned, as projects of common interest under the new EU Trans-European Network framework. Exports amounted to total revenues of around EUR 3 billion per year for 91.3 TWh versus imports of 29.6 TWh in 2015 (RTE, 2015a). France will increase the interconnection capacity in the period 2015-20 (2015 for Spain, 2020 for Italy and the United Kingdom). As a result, the total amount of winter imports, quite important to avoid the risks of generation adequacy miscalculations, are expected to reach 11.4 GW at the end of 2020.

Environmental procedures and permit granting or authorisations still take many years. There is a need to further streamline permitting and environmental assessment procedures. The government should publish the manual on the permit-granting process for project promoters that are required under the Trans-European Network regulation. It will allow supporting different electricity projects of common interest and increase the level of interconnections beyond 2020.

RETAIL ELECTRICITY MARKET

The French electricity retail market has a large industrial customer base (42% of total consumption), alongside medium-sized non-residential (14%), small non-residential (10%), and residential consumers (35%). Competition has improved in the non-residential sectors (mainly for the large industrial sector) and regulated tariffs were abolished in 2016 for large and medium-sized consumers (power supply capacity above 36 kVA).

The retail market is still highly concentrated and the number of consumers willing to switch supplier were only around 0.4% in 2008 and 1% in 2015 in the residential segment, but progress has nevertheless been achieved since the last in-depth review. Today, competition is emerging in the large industry and tertiary sectors where regulated prices were phased out in 2016. However, the switching process and the uptake of market offers have been slow and the government had to force switching by open tenders and compulsory assignment of suppliers. The household segment remains under regulated tariffs and is dominated by the historic supplier. However, some market offers are emerging, with ENGIE, ENI, Total (Lampiris) and Direct Énergie which are now entering the market and offer lower tariffs.

The calculation of regulated tariff levels has become more transparent. Historically based on the accounting costs of the integrated operator, tariffs now reflect the costs incurred by an "average" supplier, taking the ARENH price and wholesale market prices into account. ARENH was designed as a temporary measure and should be phased out in 2025, which implicitly means the end of regulated tariffs. However, the government has not set a date for their phase-out. The IEA encourages the competition authority and the regulator to adopt strong competition measures, increase consumers' involvement in activeness of market offers, which are most of the time below regulated tariffs, and further support market opening before considering the phase-out of regulated tariffs also for household consumers.

The French government plans to replace the so-called social tariffs for electricity and gas by an energy voucher (*chèque énergie*), which can be used for all energies or energy efficiency investments (e.g. insulation, energy-efficient appliance, efficient heating systems). This and the government's Better Living programme that focuses on the renovation of low-income households' housing would be good steps for targeting energy poverty. The work of the energy ombudsman is growing with an extended mission beyond electricity and gas, and an increasing number of consumer/supplier mediation cases. It is very important for the education of consumers and market players. At the same time, the government has embarked on a reform of the tax on electricity consumption, notably the CSPE. Public service expenses (including energy vouchers) will now be financed out of the state budget and be placed under Parliamentary control. The CSPE has been merged with the excise tax on electricity (*taxe intérieure sur les consommations finales d'électricité, TICFE*). From 2017 onwards, public service expenses will be increasingly financed by the new carbon component in the fossil fuel taxation and not only by electricity consumers.

The government has not set a date for the phase-out of regulated tariffs for households. It therefore needs to tackle the retail market opening in a more comprehensive way, balancing consumer protection and competition. This is possible if the government adopts a roadmap for an electricity market design of the energy transition. Consumers need to be better informed about their opportunities for switching to market offers and

the reversibility option. Price comparison tools and switching campaigns can be useful in this regard. The government, the regulator or the energy ombudsman should encourage regular switching campaigns, such as those carried out in Germany or the Netherlands.

However, existing measures are not sufficient to foster competition, despite progress made in obliging EDF to provide consumption data to alternative suppliers. Data quality provided by the incumbent supplier still needs to be improved. The number of consumers switching supplier remains very low. The challenges are complex: preserving the privacy of consumers, while ensuring market players and operators have open access to anonymous end-use information and data on prices, costs, consumption and investments in energy and energy efficiency for all classes of consumers. Ensuring that consumers have free access to their own data, effective comparative information, and that data security and privacy are all managed by independent data providers as important components of retail market regulation. The review of the actual performance of retail energy billing, meter reading and accurate charging of consumption is crucial.

Today, distribution network concessions are largely held by Enedis. In the near future, between 2018 and 2028, the distribution concessions with Enedis will be renewed in a number of cities and regions. DSO regulation, codes and rules for access to the various regional small distribution networks and to the large Enedis network would benefit to all actors and enhance access for independent retailers and open competition. The roll-out of one smart-meter technology (Enedis's Linky smart meter) by 2021 may take too long and could become a technology lock-in, as global metering devices are innovative and improve fast. This can create a barrier for switching and consumer choice.

Given the transformation of the demand-side and retail markets in the future with a growing use of solar PV and distributed generation as well as smart meters, there is an opportunity for improving consumers' engagement and facilitating retail market competition. The European Union is discussing the future electricity market design which includes measures to foster independent DSOs that can support data management, smart metering and support the market as neutral facilitator. France should examine these opportunities and adapt its retail market in step with its energy transition.

RECOMMENDATIONS

The government of France should:

- *Promote competition by opening up concessions for hydropower facilities under the Energy Transition for Green Growth Act, and by remaining vigilant that fair competition is applied in the capacity mechanism for alternative and foreign suppliers.*
- *Take measures to ensure that the costs of the energy transition are minimised and allocated fairly and equitably across customer categories; and complete the revision of the energy-climate taxation.*
- *Promote a co-ordinated approach to energy planning at different levels, ensuring consistency and efficiency of network plans with the pluriannual energy programming and in the regional renewable energy plans. Continue to support cross-border electricity interconnection projects, notably by streamlining the permitting process.*

- *Continue to strengthen the competences, independence and budgetary autonomy of the energy regulator, of the competition and consumer protection authorities so as to promote competition and the inclusiveness of the energy sector's consultative bodies.*
- *Adapt the electricity market design in step with the energy transition and encourage further reforms in the retail market by:*
  - *Increasing access to and transparency of consumer and energy market data to all market players while ensuring privacy of consumer data.*
  - *Enhancing competition, supplier switching and considering the phase-out of regulated tariffs for residential consumers.*
  - *Using opportunities from the renewal of distribution concessions and the forthcoming EU market design to review the structure and access regulation of the distribution systems; and to create harmonised rules for all distributors in mainland France.*
  - *Making full use of smart metering and smart grid capabilities, including electric vehicles, in order to accommodate the share of variable renewable electricity and demand-side response; and to enhance flexibility of the power system.*

References

Autorité de la Concurrence (2015), *Evaluation report of the ARENH Mechanism*, Paris. www.autoritedelaconcurrence.fr/doc/rapport_arenh.pdf.

CRE (Commission de Régulation de l'Énergie) (2016), *Observatory of Wholesale Electricity and Gas Marketes (Observatoire des Marchés de Gros de l'Electricité et du Gaz),* Q1 2016. www.cre.fr/marches/observatoire-et-indicateurs-des-marches#section2.

Court of Auditors (2015), Cour des comptes, *Opening of the Electricity Market to Competition: an Unfinished Site*, *L'ouverture du Marché de l'Électricité à la Concurrence : une Construction Inaboutie*, February, Paris.

IEA (International Energy Agency) (2016a), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016b), *Electricity Information 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016c), *Energy Prices and Taxes*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2011), *Empowering Customer Choice in Electricity Markets*, OECD/IEA, Paris.

RTE (Réseau de Transport d'Électricité) (2016a), *Supply-Demand Balance in France* (*Bilan Prévisionnel),* Paris, www.rte-france.com/sites/default/files/bp2016_complet_vf.pdf.

RTE (2016b), *Analysis of the Adequacy of Supply and Demand of Electricity : the Winter 2016-17 under Vigilance (Analyse équilibre offre/demande d'électricité : un hiver 2016-2017 sous forte vigilance*), www.rte-france.com/fr/actualite/analyse-equilibre-offredemande-d-electricite-un-hiver-2016-2017-sous-forte-vigilance.

RTE (2015a) *Annual Electricity Report 2014*, Paris, www.rte-france.com/sites/default/files/bilan_electrique_2014_en.pdf.

RTE (2015b), *Electricity Supply-Demand Balance in France (Bilan Prévisionel),* Paris.

9. RENEWABLE ENERGY

Key data (2015 estimated)

Total supply: 22.6 Mtoe (9.2% of TPES) and 91.8 TWh (16.3% of electricity generation), IEA average: 10% of TPES and 23.5% of electricity generation

Biofuels and waste: 15.1 Mtoe (6.1% of TPES) and 7.3 TWh (1.3% of electricity generation)

Hydro: 4.7 Mtoe (1.9% of TPES) and 54.9 TWh (9.7% of electricity generation)

Wind: 1.8 Mtoe (0.7% of TPES) and 21.2 TWh (3.8% of electricity generation)

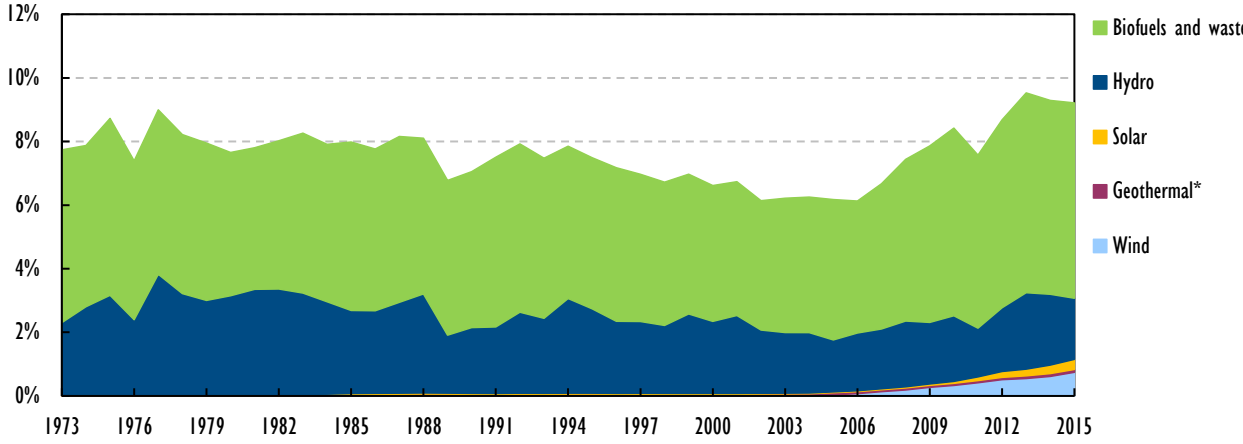
Solar: 0.8 Mtoe (0.3% of TPES) and 8.4 TWh (1.5% of electricity generation)

Geothermal: 0.2 Mtoe (0.1% of TPES), no electricity generation.

SUPPLY AND DEMAND

Renewable energy plays a small but growing role in France's energy mix as total primary energy supply (TPES) from renewable sources has increased by 35.4% over the past decade to 2015, from 16.7 million tonnes of oil-equivalent (Mtoe) to 22.6 Mtoe or 9.2% of France's total primary energy supply (TPES) in 2015. Biofuels and waste are the main renewable sources with 15.1 Mtoe or 6.1% of TPES in 2015. Hydropower represented 4.7 Mtoe or 1.9% of TPES followed by wind power (1.8 Mtoe or 0.7% of TPES), solar power (0.8 Mtoe or 0.3% of TPES) and marginal amounts of geothermal energy (0.2 Mtoe or 0.1%) (Figure 9.1).

Figure 9.1 Renewable energy as a percentage of TPES, 1973-2015



* Negligible.

Note: Data are estimated for 2015.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/,

Over the last ten years, biofuels and waste grew at a 2.4% annualised rate and slightly increased their share in TPES from 4.4% to 6.1%. Solar grew from a negligible level at an annualised rate of 27.8% to a small share of 0.3% in TPES, while wind energy increased to 0.7% at an annualised growth rate of 36.2%, depicting the fastest technology growth.

Installed renewable electricity generation capacity surged from 26 639 megawatts (MW) to 41 858 MW over the decade 2004 to 2014 (Table 9.1). Hydropower has remained the dominant source in renewable power but its capacity has remained stable, showing a small 0.8% increase. Solar power grew to 5 654 MW from negligible levels in 2004. During the same period, wind power surged in capacity from 358 MW to 9 068 MW. Wind capacity advanced at 38.2% per annum or by a factor of 25 over ten years to 9 068 MW in 2014. However, exploitation of offshore wind has not started.

Table 9.1 Renewable electricity generating capacity, 2000-14 (MW)

Technology	2000	2002	2004	2006	2008	2010	2011	2012	2013	2014
Hydro	25 126	25 255	25 094	25 117	25 097	25 401	25 347	25 366	25 360	25 294
Pumped storage*	1 857	1 857	1 801	1 801	1 808	1 808	1 808	1 808	1 808	1 728
Solar PV	7	8	11	15	80	1 044	2 796	3 965	4 652	5 654
Wind	38	138	358	1 412	3 403	5 912	6 679	7 517	8 202	9 068
Waste	432	545	661	729	819	807	852	900	861	900
Tide	240	240	240	240	240	240	240	240	240	240
Biofuels	216	256	275	303	378	524	514	551	605	700
Geothermal	-	-	-	-	-	-	2	2	2	2
Total capacity	**26 059**	**26 442**	**26 639**	**27 816**	**30 017**	**33 928**	**36 430**	**38 541**	**39 922**	**41 858**
Solar collectors surface (1 000 m^2)	513	493	527	744	1 139	1 447	1 595	1 810	1 975	2 162
Capacity of solar collectors (MW_{th})**	359	345	369	521	797	1 013	1 117	1 267	1 383	1 513

* Only includes capacity in pure pump storage plants, not capacity in conventional hydropower plants that also have pump storage capacity.

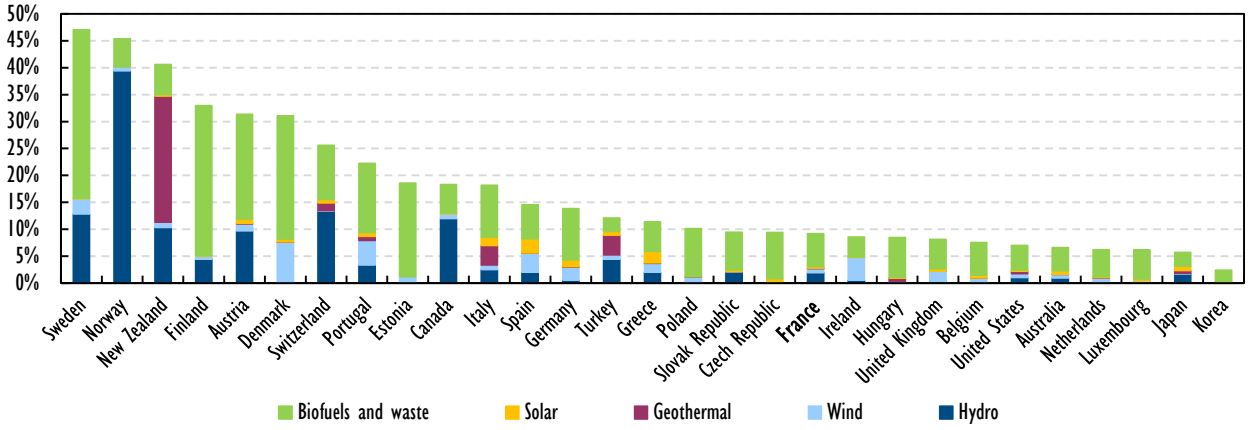
** Converted at 0.7 kW_{th}/m^2 of solar collector area, as estimated by the IEA Solar Heating & Cooling Programme.

Source: IEA (2016b), *Renewables Information*, www.iea.org/statistics/.

Electricity generated from renewable sources amounted to 91.8 terawatt-hours (TWh) in 2015, or 16.3% of total generation (Figure 9.3). During the last 10 years, it has increased by 58.3%, from 58 TWh in 2005. Renewable electricity generation comprises hydro (54.9 TWh or 9.7%), wind (21.2 TWh or 3.8%), biofuels and waste (7.3 TWh or 1.3%) and solar (8.4 TWh or 1.5%).

By international comparison, France is slightly below the IEA median when looking at the share of renewables in TPES. It is the eleventh-lowest among 29 IEA member countries, behind the Czech Republic and followed by Ireland (see Figure 9.2). Its share of biofuels and waste is the fifteenth-highest, while the share of hydro is fourteenth-highest.

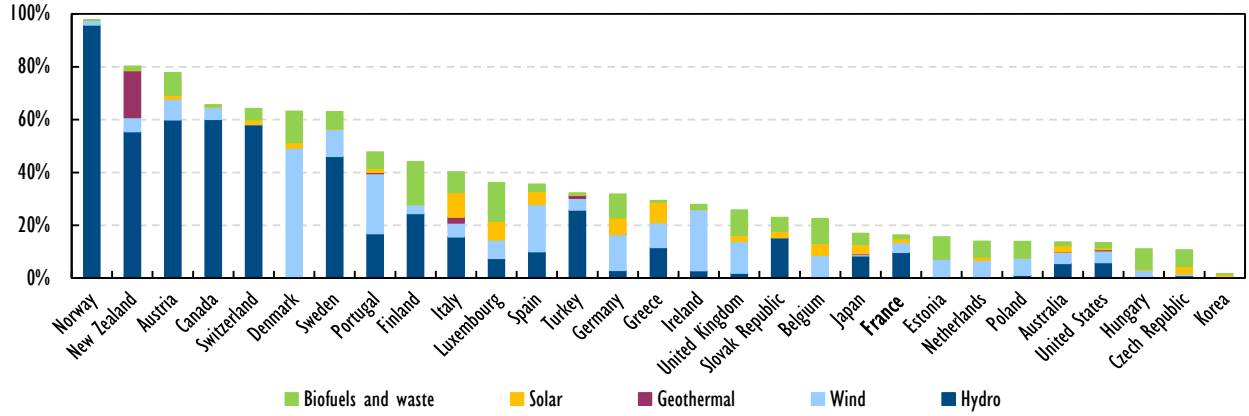
Figure 9.2 Renewable energy as a percentage of TPES in France and in IEA member countries, 2015



Note: Data are estimated.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Figure 9.3 Electricity generation from renewable sources as a percentage of all generation in France and in IEA member countries, 2015



Note: Data are estimated.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

INSTITUTIONS

France's **Ministry of Environment, Energy and the Sea** (*Ministère de l'environnement, de l'énergie et de la mer, MEEM*) and its Directorate-General for Energy and Climate (DGEC) are responsible for policies in the area of renewable energies, including hydropower concessions. The **Regional Directorate for Environment, Planning and Housing (DREAL)** supports MEEM as executive state agency at the level of the prefecture. The six Basin Authorities (*Agences de l'Eau*) are responsible for environmental protection of the water sources but do not have regulatory powers.

The **Ministry of Economy and Finance** oversees the energy taxation under the French Finance Act, including the contribution to the electricity public service (CSPE) which supports renewable energies.

A public agency under the joint authority of the French Ministry for Environment, Energy and the Sea and the Ministry for Higher Education and Research, **the Environment and**

Energy Management Agency (ADEME) supports project developers, citizens and policy makers with analysis, information and financial support (notably the renewable heat fund and waste fund), including on research, development and demonstration of energy technologies.

The **Regulatory Commission of Energy (CRE)** oversees the French electricity and gas markets and ensures the right of access to all electricity and gas transmission and distribution networks from suppliers to customers. In the area of renewable energy, CRE administers the public service contributions, which are used to cover renewables support. It organises the call for tenders in co-operation with the electricity network operators and the renewable energy generators.

POLICIES AND MEASURES

PROGRESS TO 2020

France has an obligation to reach a share of 23% renewable energy in gross final energy consumption[1] by 2020 pursuant to EU Directive 2009/28/EU, with a sector split of 27% share of renewables in electricity, 33% in heating and cooling and 10.5% in transport[2] as detailed in its National Renewable Energy Action Plan (NREAP) of 2010. The overall 23% target has also been enshrined in the Energy Transition for Green Growth Act of 2015 (*Loi relative à la transition énergétique pour la croissance verte, LTECV*).

Progress so far shows a positive trend with total renewable energy in gross final consumption growing from 9% in 2009 to 14.6% in 2014, slightly below the interim target for 2014 of 16% of gross final consumption. Looking at consumption, by 2014, France had reached a share of renewable energy of 18.3% in electricity, 17.8% in heat and 7.8% in transport. By 2014, progress towards the targets was unevenly distributed among technologies. France has overshot its targets for solar PV, as the technology costs have come down significantly (the 2016 solar PV tenders resulted in bid prices between EUR 80/MWh and EUR 70/MWh). To date, wind power is not on track, and the plan to install large-scale wind capacity offshore has yet to materialise. Biomass has seen strong additions in the heating and transport sectors, thanks to the improvement of thermal performances of buildings and improved use of biomass in co-generation. In heating and cooling, France was far from the proposed 2020 targets. This lag in relation to heating and cooling is due in part to the fact that 2014 was the hottest recorded year in decades. In France, there is a strong correlation between the severity of the winter and the share of biomass in final consumption (and domestic biomass consumption is not corrected for climate variations in line with Eurostat).

Future growth is expected to come from wind in electricity and solid biomass in heat, as well as biofuels and electric vehicles in the transport sector (MEDDE, 2014; NREAP, 2010). The objectives for each renewable technology have been revised in April 2016 in the context of the Energy Transition for Green Growth Act and the pluriannual investment plan (PPI), taking into account the real development of installed capacities since the elaboration of the NREAP.

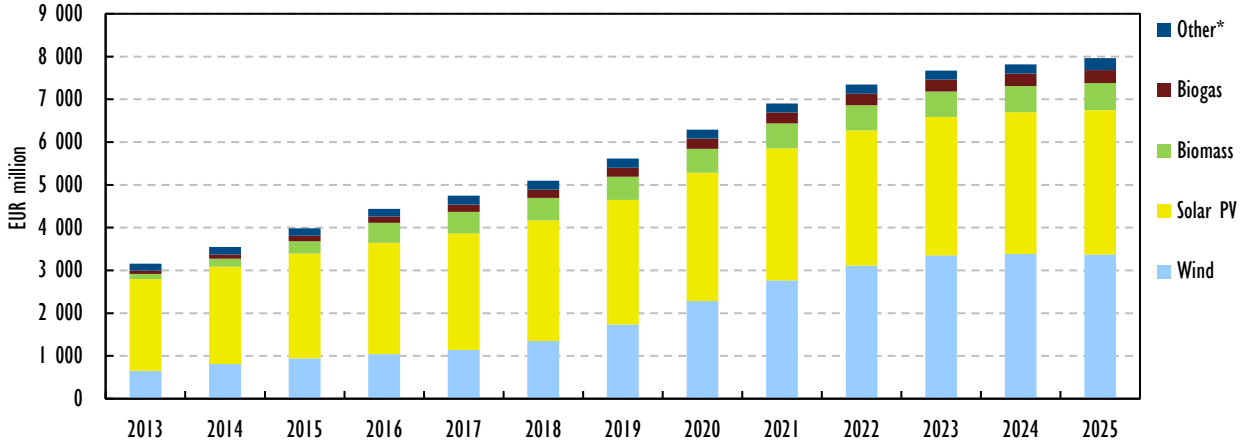
1. Gross final energy consumption is the sum of final energy consumption (as defined by the IEA and Eurostat), network losses plus electricity and/or heat consumed by the energy sector for the production of electricity and/or heat.

2. This includes also the objective of deploying 450 000 electric vehicles by 2015 and 2 million electric vehicles in 2020.

Renewable electricity

Up to 2016, renewable electricity has been supported by means of a feed-in-tariff paid by the electricity consumers through a tax on final electricity consumption, the so-called contribution to electricity public service (*contribution au service public de l'électricité, CSPE*). With its proceeds, the public mission bank (*Caisse des Dépôts et Consignations, CdC*) compensated EDF and local distribution companies that had an obligation to buy renewable electricity at a regulated price (feed-in tariff) from renewable energy producers. Around 64% of CSPE contributed to the support of renewable electricity; 7.5% of CSPE supported combined heat and power generation and the remainder was allocated to the price equalisation in overseas territories and the so-called "social tariffs". In 2015, the cost of the CSPE amounted to EUR 19.5 per MWh or 12% of the electricity bill of an average household. The CSPE costs were only levied on electricity consumers, and not on other fossil fuel sources (petrol, diesel or gas).

Figure 9.4 Contribution to electricity public services 2003-15 (2016-25 includes the projected increase)



* *Other* includes geothermal, hydro and municipal waste incineration.

Source: CRE.

As of 2010, CSPE contributions had to cover rising costs, mainly due to overshooting solar PV support through feed-in-tariffs (FIT), as illustrated in Figure 9.4. Before 2010, CSPE revenues failed to increase at the same pace as the costs of the support scheme (the CSPE was capped at an annual electricity price increase of maximum EUR 3 per MWh), resulting in the accumulation of a EUR 6 billion debt for EDF.

The renewable energy component in the CSPE increased from EUR 580 million in 2009 to over EUR 3.2 billion in 2013 and EDF accumulated a deficit. In 2010, an automatic increase of the unit contribution was introduced so as to progressively catch up with expenses and to fully reimburse the debt by 2018. Forecasts by the regulator CRE had indicated that the CSPE renewable energy component would reach a level of EUR 8 billion in 2025.

The government introduced cuts in the subsidies, some of them retroactive, to avoid further overshooting of the deployment targets, notably for solar PV, as technology costs were coming down rapidly, and could avoid an even higher deficit, which other countries have experienced, for instance Spain or Portugal.

REFORM AND 2030 TARGETS

The Energy Transition for Green Growth Act sets ambitious targets for renewable energy: France now commits to reaching a share of 32% in the energy mix by 2030 at national level. Renewable energy sources will need to represent 40% of electricity generation, 38% of heat consumption, 15% in the transport sector and 10% of gas consumption.

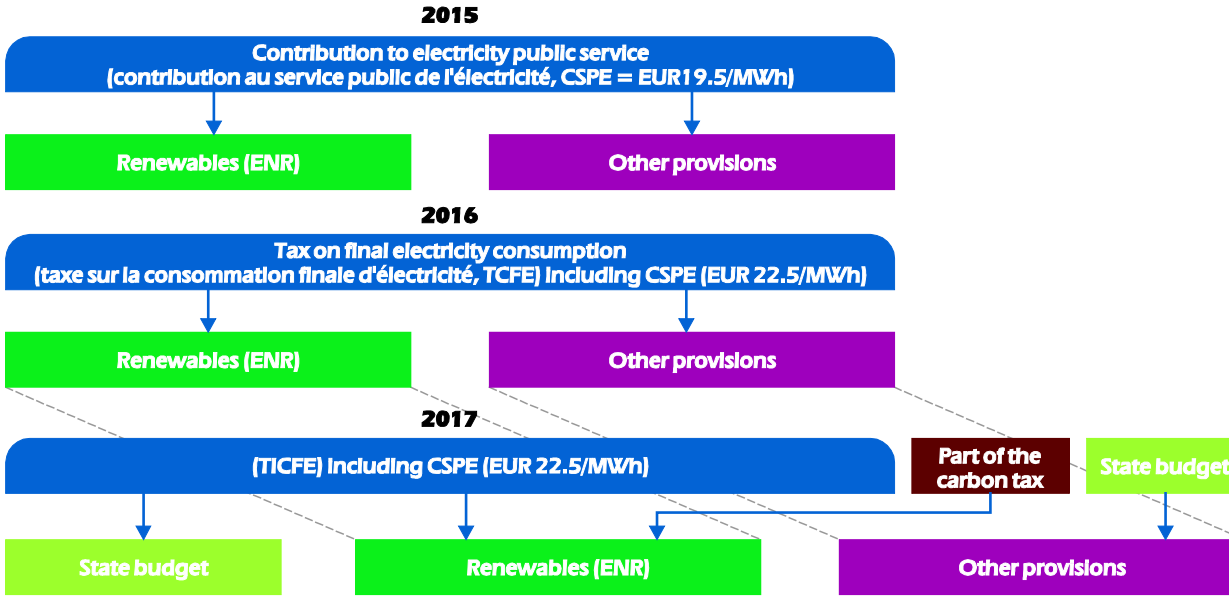
The Act also required the reform of the CSPE, which needed to be aligned to EU state aid guidelines and new cost curves for technology development. In 2015, the government set in motion the reform of the support scheme for 1 January 2016 onwards.

The government reformed the CSPE under the revised Finance Law 2015. Public service expenses are now included in the state budget. The new CSPE committee is charged to monitor the evolution of public service expenses, including pluriannual programming. In 2016, the CSPE budget in support of renewable energy is allocated to a dedicated energy transition item, while other general public services are covered by a new public mission budget of the state. Social tariffs are to be phased out and replaced by energy vouchers. A more robust energy taxation framework will be created in 2017 (see Figure 9.5). The CSPE renewables support contribution will be merged with the excise tax on electricity (*taxe intérieure sur la consommation finale d'électricité, TICFE*) and, which enlarge the tax base and bring the support under Parliamentary control. In line with EU guidelines on state aid for environmental protection and energy 2014-20, the Energy Transition for Green Growth Act amended the French Energy Code (Article 104) and required that the reform of support policies for renewable electricity promote direct marketing with feed-in premium along the following elements:

- Since 1 January 2016, large-scale and mature renewable electricity technologies need to be tendered (direct marketing) with a feed-in premium to complement the market price (complement de remuneration). Tenders are organised for new large-scale biomass (above 300 kW), biogas (above 500 kW), solar PV (above 500 kW) and offshore wind. For new onshore wind and all small-scale facilities, the FIT continues to apply, sometimes through tenders (solar PV). According to the EU state aid guidelines (EEAG), some technologies are exempted from tenders and benefit from direct feed-in premium (energy from waste and geothermal energy).
- Simplification of permit procedures through administrative deadlines which require the permitting and connection of renewable power facilities of up to 18 months for large-scale facilities and 2 months for facilities of less than 3 kW, with penalties for non-compliance. For wind, hydro and biogas facilities, a streamlined permitting procedure (single permit) should become the default.
- Financial participation (shareholdings) of local communities and municipalities in private companies investing in renewable energy generation projects.
- Simplification of the tender procedure in order to reduce the timing of the procedure and to facilitate its application.

A transitory arrangement is in place for facilities that applied for the FIT before the Energy Transition for Green Growth Act was passed and that can deploy their facilities within 18 months. Existing facilities can also choose to switch to the market premium (from FIT), but they can only return to FIT within three years.

Figure 9.5 Reform of the financing of renewable energy (ENR)



The expansion of renewable energy technologies is managed through the pluriannual programming of investments (*programmation pluriannuelle des investissements, PPI*). The 2009 PPI was revised and a new one presented in April 2016 which establishes deployment targets up to 2023 with interim targets for 2018. Taking stock of the delays in the deployment of wind power, especially offshore (where France has lost ground), and the more rapid than expected cost reduction of solar photovoltaics, the PPI slightly postpones the target for wind but increases that for solar, from 5 400 MW in 2018 to 10 200 MW in 2020 and to 20 200 MW by 2023. In comparison, in 2008, France had a target of 6 GW offshore wind and 19 MW onshore wind for the year 2020.

Table 9.2 Expansion plans for cumulative renewable energy installed capacity by technology (in GW)

Technology/timeframe	2018	2023
Wind onshore	15	min: 21.8 and max: 26
Wind offshore	0.5*	3*
Marine		0.1 plus additional 0.2-2
Solar PV	10.2	min: 18.2 and max: 20.2
Hydro**	25.3 or 61 TWh generation	min: 25.8 (63 TWh) and max: 26.05 (64 TWh)
Biomass	0.54	min: 0.79 and max: 1.04
Methanisation	0.137	min: 0.237 and max: 0.3

* Plus additional 0.5 to 6 GW depending on financing and experience.

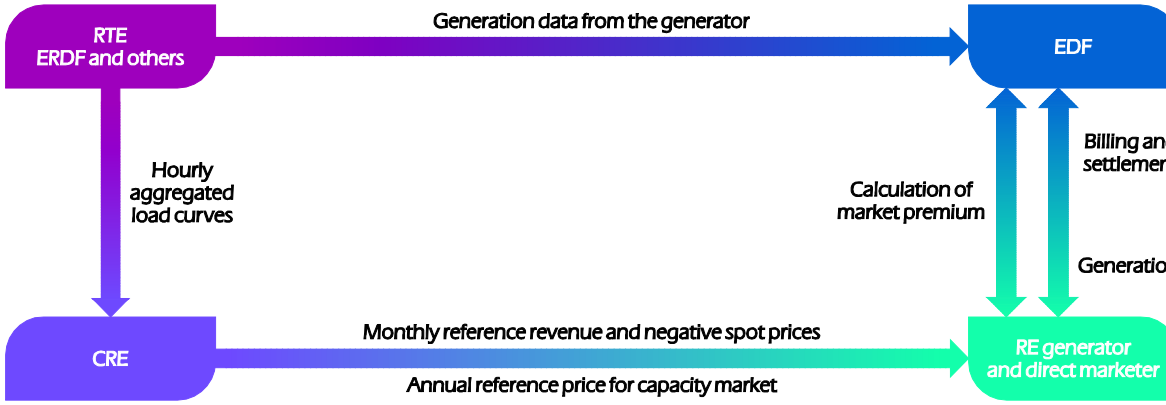
** Hydro is recorded in electricity generation (TWh).

Notes: In addition to PPI targets, pump hydro storage projects shall be started in the period up to 2023 to achieve expansion of 1 to 2 GW during 2025-30. Marine energy includes floating wind generator farms and river-based tidal-stream generators.

The PPI was published ahead of the new pluriannual programming for the energy sector (*progammation pluriannualle de l'énergie, PPE*), developed under the Energy Transition for Green Growth Act as the main governance tool to evaluate and control target progress. The first PPE was adopted as law on 27 October 2016, which reflects the targets of the PPI.

France has changed its support mechanism. In May 2016, two implementing regulations (Decrees 2016-682 and 2016-691) were adopted to detail the reforms. Regulation 2016-682 establishes the new mechanism of feed-in premium (*complément de rémunération)*, while Decree 2016-691 contains the list of renewable energy facilities eligible for the market premium.

Figure 9.6 The new renewable support scheme (direct marketing with market premium) in France



For small-scale renewable energy technologies, additional technology-specific decrees will be published which will set out the contract lengths and reference values for each technology, as submitted to the regulator CRE *ex-ante* (see Figure 9.6). Decreasing reference values might be allowed, depending on the speed of development of each technology. The Decree also includes the possibility to introduce a cap above which additional megawatt-hours would not benefit from the premium and only get the market value. The monthly (or annual) market premium, depending on the technology, is calculated as the difference between the reference value of the technology and the average revenues of all installations of the same technology from the French energy and capacity markets, augmented by a management premium covering the cost of direct access to these markets (*ex post*). As a result, this "sliding" premium allows producers to receive market signals and those producers proving able to better meet the market needs earn higher total revenues. A simplified overview of the management of the new market premium is shown in Figure 9.6.

Renewable heat

Historically, France has placed strong emphasis on the heat sector, as a means to improve energy efficiency and foster energy security in the aftermaths of the oil crises of the 1970s. The share of total heat in final energy consumption was about 50% in 2014, much more than electricity. The 2020 objectives of the French government in the area of renewable heat are ambitious (33% of gross final consumption by 2020). However, the growth of biogas, solar thermal, geothermal, but also biomass, has been slower than expected.

Table 9.3 Overview of the investments of the Heat Fund (2009-14)

Key figures	Number of projects	Eligible investments (EUR million)	Subsidies (EUR million)	RES (toe/y)	Subsidies (EUR/toe over 20 years)
Wood BCIAT	147	867	4	808	20.6
Wood except BCIAT	762	1295	327	523	31
Geothermal	394	499	106	115	46
Biogas	51	200	31	68	22.9
Solar	1590	154	73	7	521
Heat networks	668	1565	506	248	102
Waste heat recovery	32	46	14	21	33.3
Cross-cutting actions			110		
TOTAL	**3644**	**4626**	**1501**	**1790**	**41.9**

Notes: BCIAT = Biomasse Chaleur Industrie Agriculture Tertiaire; toe/y = tonne of oil-equivalent/year.

Source: ADEME.

Several instruments are in place to support renewable heat. The 2012 Thermal Regulation (2012 TR) requires all new one-family homes to make use of some form of renewable energy (it is most often heat with bioenergy, solar water heating or heat pumps, but can also be electricity from photovoltaics).

The income tax credit for sustainable development (CIDD), and as of 2015 the income tax credit for the energy transition (CITE), promote the purchase of equipment using renewable or recovered energy through a 30% rebate from capital cost and a 5.5% VAT rate (in both new and existing dwellings). Since 2009, the zero-rate eco-loan (*écoprêt à taux zéro*) has supported thermal renovation in houses, including in some using renewable heat.

The combination of the 2012 Thermal Regulations and tax incentives has supported the strong development of heat pumps. France is the largest heat pump market in Europe, followed by Italy and Poland (EPHA, 2016). In 2012, heat pumps accounted for 12% of 11.9 Mtoe of renewable heat.

The Fonds Chaleur (Heat Fund) allocates EUR 220 million per year to heat projects. The Fund is managed through ADEME with a national call for projects (*Biomasse Chaleur Industrie Agriculture Tertiaire, BCIAT*) and regional grants and call for projects. Over the period 2009-15, around 1.79 Mtoe renewable heat production per year was supported at an average public cost of around EUR 40 per toe over 20 years, with a total budget of EUR 1.5 billion for the period. The government intends to double the Heat Fund in 2017.

The total annual cost of renewable heat incentives is estimated to amount to about EUR 500 million (Heat Fund, CITE, and VAT rate).

Renewable energy in district heating and cooling

The Energy Transition for Green Growth Act has the ambition to increase fivefold the amount of renewable heat distributed by district heating and cooling (DHC) networks by 2030. The PPE sets an interim target by 2023, which means a share of DHC produced from renewables or recovered energy of between 55% and 60%, and a supply of DHC to 4 million dwelling-equivalents. In 2014, there were 518 district heating (17 district cooling) networks, with a share of DHC produced from renewables or recovered energy around 40%, and a supply of DHC to 2.3 million dwelling-equivalents. To achieve its target, the government will need to increase the density of existing networks, build extensions and new networks.

In addition to the incentives for renewable heat listed above, for networks that supply heat mainly produced from renewable or recovered energy (at least 50%), a reduced VAT rate (5.5 %) is applicable, and a local procedure (*procédure de classement*) can make it mandatory, where possible, to connect new buildings and existing buildings undergoing significant refurbishment works to the network. The government also aims to improve information on DHC networks through better project co-ordination of new urban areas or major urban change, by mapping existing DHC under the Energy, Air and Climate Schemes and carrying out a cost-benefit analysis for recovering waste heat.

Renewable energy in transport

The government encourages the production and sale of biofuels through mandatory blending targets, which were raised over time. During 2008-15, the share of blending increased from 5.75% in 2008 to 7.7% for diesel and 7% for petrol in 2014 and 2015. To meet the targets, the production and sale of biofuels is supported through incentives under the general tax on polluting activities (TGAP), which penalises operators who market a proportion of biofuels below the target, through partial relief from the domestic tax on the consumption of energy products to cover the cost involved in manufacturing biofuels (produced by approved facilities) rather than fossil fuels.

Permitting procedures

High administrative complexity has been one of the main barriers to the deployment of wind power. The time lapse between the permit application and the construction for onshore wind was three times longer than in Germany in 2013. There has been a long line of projects, particularly for wind, waiting to be connected to the grid. A project can take 7 to 10 years to be deployed. This delay is due essentially to complaints and judicial proceedings, amid the lack of local acceptance of the projects.

According to the national progress reports in 2013 and 2015, public acceptance of biomass and wind power projects remains a seemingly controversial issue: a high number of projects are being challenged after permits have been delivered, with litigation cases resulting in additional delays and further uncertainty.

Given the territorial structure, a project in France requires several permits at various government levels, which also gives more opportunities for many levels of consultations, appeals and reviews. Barriers also include the radar regulation (weather or military), overlaps between regional wind power schemes and wind turbine development zones, and the classification of wind mills as environmentally protected facilities.

In 2015, the government introduced a clear improvement with the single permit (bundling of procedures and authorisations) in regions with significant wind power potential. It suppressed the wind turbine development zones and supported the negotiations with the radar authorities concerned. The Energy Transition for Green Growth Act shortened the time for appeals for all projects outside the single licence procedure.

Furthermore, to remove the main barrier of public contestation and lack of social acceptance, the Energy Transition for Green Growth Act has improved the procedure for the participation of local communities and land-owners for financing of renewable projects.

ASSESSMENT

France has witnessed a steady growth of the renewable share in gross final energy consumption. However, it is not on track to achieve its target of 23% by 2020. With a share of 14.6% in 2014, the growth in the next six years (2015-20) will need to be twice the rates achieved over the last nine years (2005-14). The National Action Plan of 2010 to support renewable energy generation set intermediate targets towards the 2020 objectives. These objectives were revised in April 2016 to take into account the real development of each technology since 2010 and the barriers identified. Targets have been reached for solar PV and biomass, which both account for more than 36% of the growth of the renewable energy share since 2005. But there is a gap to be filled for hydro, wind power and heat. Future growth is expected to come from wind power and solar PV, and also from renewable heat, which all have seen a favourable growth in recent years.

Hydropower, today the second-largest source of renewable electricity, cannot be expected to contribute more than the current level because of physical limitation and environmental requirements. The legal framework of the Transition Act did not encourage the renewal of concessions through competitive tenders.

Onshore wind has reached about 10 GW but offshore wind deployment has not started, despite ambitious plans of the French government. The slow growth of renewable energy deployment, notably wind energy, is the result of non-economic barriers more than economic ones, including the various administrative and judiciary procedures for having a permit cleared of any claim (7 years on average for wind mills), coupled with a lack of social acceptance for wind and biomass. The single permit should improve permitting for onshore/offshore wind parks. The accumulation of regulations, successive changes, and the need to address additional constraints imposed by urbanisation, safety or environmental considerations, result in lengthy procedures for the commissioning of installations and the connection works to the grid. The measures taken by the Transition Act addressed these issues and will remove an important part of the barriers to renewables development.

Development of renewable energy generation is fostered by support schemes established by the French authorities. Some are common for both electricity and heat generation, such as reduced VAT, tax credit, and co-funding of research and development (via grants, reimbursable subsidies, or venture capital). Buildings regulations promote renewable heat or electricity generation. Others are specific to the field considered. To support ambitious goals for heat generation and biogas,

France set up the Heat Fund, endowed with a EUR 1.3 billion budget for 2009-14. The future budget should reflect 2020 objectives; the government aims to double it by 2017.

In addition, the government has adopted action plans for the deployment of some green energy technologies, including biogas production, solar PV, offshore wind (tenders and technology roadmap), ocean energy (National Committee for Ocean Energy and Marine Current Power), and biomass.

For electricity generation, the purchase of the renewable output is guaranteed at fixed prices through feed-in tariffs for 10 to 20 years for wind onshore, small hydro, small biogas and solar (below 100 kWp), through a purchase obligation by the national operator EDF and local utilities, regardless of the supply-demand balance on the market. Open counter tariffs were adjusted on several occasions by decrees to better match decreasing levelised costs of technologies over time. Bigger capacities (solar above 100 kWp, wind offshore and biomass) are delivered through tenders. The energy regulator advises the government on the level of the feed-in tariff and on reference values for the feed-in premium.

Until 2015, the FIT budget was raised entirely through the CSPE (contribution to electricity public services), collected by incumbent EDF from the final electricity consumers. The overall public expenditure in support of renewable energy generation has increased significantly since the last review in 2009, as illustrated by the drastic rise in EDF's CSPE debt, as contributions remained rather flat. In 2015, the government acted on time to avoid the financial collapse of the system and reduced the burden to final electricity consumers. The Energy Transition for Green Growth Act set in motion several reforms to improve support mechanisms with a view to boost the share of renewable energies to 30% by 2030. In 2016, the government brought the CSPE under the state budget and parliamentary control and, in 2017, it plans to merge the renewable energy contribution with the current excise tax on electricity (*taxe intérieure sur la consommation finale d'électricité, TICFE*) and the new Energy and Climate Contribution (or carbon tax), which will be EUR 30.5 per tonne of CO_2.This is a commendable progress that should allow to broaden the tax base, improve the financing and transparency of the support, its budgetary control by Parliament and also strengthen the financial viability of the scheme.

In 2016, the government presented its reformed renewable support scheme, which will promote the integration of renewable energy in the power system, in line with the EU guidelines of 2014, the CSPE reform and the requirements of the Transition Act. Feed-in premiums can ensure that electricity from renewable energy is integrated into the market by responding to market signals and dynamics. Technology reference values should better reflect benchmarked costs and support the technology development towards the integration of intermittent renewable energy into the market and the grid.

The rapid cost reduction of the less controversial photovoltaic technology offers an opportunity to tip the balance between technologies, which the government pragmatically exploits to compensate for the difficulties in deploying wind power. However, this could be insufficient to achieve the country's European binding commitment to reach 23% of renewables in gross final energy consumption by 2020, and put it on a path to rebalancing nuclear power and renewable electricity by 2025, as the law requires, without increasing fossil fuel consumption and associated emissions. The new solar targets will require installing about 2 000 MW capacity per year. However, this

may not suffice, and neighbouring countries have proven able – at a time when costs were much higher – to install PV at a much more rapid pace. Other renewable sources will thus play an important role in the achievement of the 2020 target.

Additional energy system costs have to be considered with the expected rise of energy generated from renewable sources. For historical reasons, the French grid was developed for centralised generation by nuclear plants generating baseload power. It will need to be adapted to decentralised production sources and designed to address the variability of renewable energy sources. However, baseload generation itself required flexibility to respond to the variations of demand, so that significant pumped-storage hydropower capacities were built alongside the nuclear power plants: they can also accommodate variable generation. For its part, the TSO indicates that up to 2030, there is no need for major transformation of the transmission system to integrate growing shares of variable renewables. While the targets are set at national level, investment needs will have to be discussed and agreed at regional level between local authorities and the electricity TSO and DSOs.

Towards 2020 and 2030, France has set ambitious targets, notably for renewable heat and biomass. The current combination of measures, ranging from the Heat Fund to tax incentives and building regulation, has stimulated a number of technologies and should be continued on the basis of a renewed National Renewable Energy Action Plan for 2030, including a dedicated heat strategy with targets and milestones for delivery.

RECOMMENDATIONS

The government of France should:

- *Implement the reformed renewable electricity support scheme in line with the pluriannual energy programming to ensure it reflects market signals and benchmarked technology costs, while addressing the need for transparency, long-term predictability and certainty to gain investors' confidence.*
- *Continue to broaden the tax base for the financing of renewable energy support with a view to minimise the burden of the energy transition while sharing the cost across all energy consumer groups.*
- *Continue to simplify the administrative procedures and shorten the lead times for obtaining the necessary permits; prepare the siting of wind parks and their connection to and integration in the electricity network, without prejudice to environmental requirements in permits/authorisations.*
- *Set out a clear strategy and a detailed implementation plan for achieving the ambitious renewable heat targets, notably through the pluriannual energy programming, with instruments and budgets to address a range of barriers and improve the valorisation of biomass.*

References

EPHA (European Heat Pump Association) (2016), *France – First heat pump market in Europe, Keys to Success*,

www.ehpa.org/fileadmin/red/_EHPA_Archive_Forum/8th_Heat_Pump_Forum_2015/Presentations/Thierry_Nille.pdf.

IEA (International Energy Agency) (2016a), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016b), *Renewables Information 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

MEEM (*Ministère de l'Environnement, de l'Énergie et de la Mer*) (2014), *Energy Balances* 2015 (*Bilan de l'Énergie 2015)*, Paris, www.developpement-durable.gouv.fr/IMG/pdf/l_energie_bilan_2015.pdf.

NERA Economic Consulting (2015), *The Future of Hydroelectricity in France: What does the New Energy Transition Law Mean for the Long-Delayed Renewal of Concessions,* by Jeanne Lubek and Stéphane Wakeford, 12 November, www.nera.com/content/dam/nera/publications/2015/PUB_France_Hydro_Future_A4_1115.

MEEDE (*Ministère de l'Écologie, Environnement et Development Durable*) (2010), *National Renewable Energy Action Plan*, Paris.

10. NUCLEAR ENERGY

Key data (2015 estimated)

Number of reactors: 58 reactors operated by EDF, one under construction

Installed capacity: 65.9/63.2 GW_e (brutto/netto)

Electricity generation: 433.66 TWh nuclear

Share of nuclear: 46.4% of TPES and 77.7% of electricity generation

OVERVIEW

In 2015, France's installed nuclear power capacity was netto 63.2 GW_e and consisted of 58 commercial reactors operated by *Électricité de France (EDF).* Nuclear accounted for 77.7% or 433.66 terawatt-hour (TWh) of France's electricity generation in 2015. Compared to other IEA member countries, France has the highest share of nuclear both in total primary energy supply (TPES) and electricity generation. Since the last nuclear unit was connected to the grid at the end of the 1990s, the share of nuclear generation has been stable over time, contributing to the overall low carbon footprint of the French power sector, together with hydropower which accounted for 10% of the electricity generated in 2015.

The nuclear power sector is entering a new phase. The average age of the nuclear fleet climbed to thirty years recently. As the original design lifetime of the operating plants is forty years, questions about the lifetime extension and/or replacement by new plants are at the top of the nuclear agenda, at industry, safety authority and government levels. The underlying issues are multiple and interconnected, embracing technical and safety matters, economics, security and reliability of supply, environmental aspects, and politics. Important investment decisions need to be taken to cover the necessary upgrading programmes for long-term operation (LTO) and safety requirements following the Fukushima Daiichi accident. The Nuclear Safety Authority (ASN) determined, after Fukushima, that the French reactors were safe for continued operation, but that their resistance to extreme situations needed to be improved. EDF has estimated the cost of the full lifetime extension programme, the so-called "*Grand Carénage*", to amount to EUR 47.5 billion for the period 2014-25, including the post-Fukushima safety upgrades of around EUR 10 billion. Much larger investments would be necessary for the renewal of the fleet, because of the substantial construction costs. In addition, financial provisions need to be accumulated over the design lifetime of the reactors to secure the funding of the legacy, decommissioning and waste management, including geological disposal. The decisions on lifetime extension and LTO will impact those cost and financial provisions.

The French nuclear industry is in the midst of the reorganisation of AREVA and the take-over of its reactor business by EDF. It is faced with construction delays and

substantial cost overruns of the European pressurised water reactors (EPRs) in Olkiluoto (in Finland) and Flamanville, and with the investment decision made for Hinkley Point in the United Kingdom.

In the light of an ageing nuclear fleet, the Energy Transition for Green Growth Act (*Loi relative à la transition énergétique pour la croissance verte, LTECV*) set a target of maximum 50% nuclear contribution to the electricity mix in 2025, with a cap at the current 63.2 GW_e of netto installed capacity. The cap means that two operating units would be shut down when the EPR under construction in Flamanville comes on line, in accordance with the French President's decision to close the two reactors of Fessenheim.

The target results in several challenges for the French energy sector. The Energy Transition of Green Growth Act's target of 50% and the ageing fleet will have an influence on the security and reliability of supply, on the cost of electricity, on the nuclear industrial policy, and it could also impact environmental objectives if nuclear is, at least temporarily, replaced by gas-fired power plants.

On the basis of specific assumptions of future electricity demand and exports, the French Court of Auditors (CdC, 2015) estimated that the 50% nuclear electricity target in 2025 would translate into the shutdown of up to 20 units out of the 58 in operation today. A large number of the reactors reaching their design lifetime in the next 5 to 10 years would not undergo upgrading programmes and, instead, would be shut down when reaching 40 years of operation, even if such lifetime extension after upgrades would be authorised on safety grounds. From an economic point of view, investing in major lifetime extension programmes makes sense only if LTO is possible for an extended period of time after the refurbishment (10 to 20 years). Beyond the economic dimension of the decision, there are impacts on the security/reliability of supply and the greenhouse gas emission goals. Achieving a 50% share by 2025 through the addition of alternative low-carbon sources within less than ten years will have an impact on the security and reliability of supply, the cost of electricity, and the French nuclear industry. In light of evolving electricity markets, actual uncertainties will need to be addressed in the future pluriannual energy programming (PPE) of the government.

INSTITUTIONAL FRAMEWORK

ADMINISTRATIVE AUTHORITIES

Different ministries have responsibilities for nuclear issues in France. The **Ministry of Environment, Energy and the Sea (MEEM)** has the main responsibility. The **Ministry of Foreign Affairs** and the **Secretariat General for European Affairs** are responsible for official international affairs aspects. The **Ministry for Research** and the **Ministry for Defence** have their specific responsibilities.

In 2008, the ***Conseil de politique nucléaire (CPN)*** was established, chaired by the President of France, reflecting the continued strategic importance of nuclear energy for France and ensuring an overall co-ordination role.

SAFETY AUTHORITY

The **Nuclear Safety Authority** *(Autorité de sûreté nucléaire, ASN)* was established as an independent administrative authority by the so called TSN Law (*Loi relative à la transparence et à la sécurité en matière nucléaire*) of June 2006. This law ensures the full

independence of ASN from the ministries, fosters transparency by installing a High Committee for the purpose and gives a legal framework to the Local Information Committees (*Commissions locales d'information,* CLI). The ASN is responsible to control all civil nuclear activities in France and contributes to the information of the public. In particular the ASN is charged to provide the construction and operation licences for nuclear power plants (NPPs) and installations of the fuel cycle. It is mandated to perform inspections and is allowed to take necessary measures (up to the shutdown of a plant), at any time, in case a safety problem appears.

In France as in most other European countries, licences are not provided for the full duration of the plant lifetime. Every ten years, the plant owner is required to submit a safety file on which the ASN will make its evaluation and give the authorisation for continued operation for the next decade.

PUBLIC AGENCIES AND ORGANISATIONS

The ***Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA)*** is the main public nuclear research organisation in France. It also has responsibilities for representing France in international relations, in particular at the International Atomic Energy Agency (IAEA).

The ***Institut de Radioprotection et de Sûreté Nucléaire (IRSN)*** was created in 2001 to be the public technical expert body for radiation protection and nuclear safety. It serves as the Technical Safety Organisation (TSO) in support to ASN, and provides much technical support internationally.

The ***Agence nationale pour la gestion des déchets (ANDRA)*** was created in 1991, but saw its mandate reinforced by the Law of 2006 on the management of nuclear waste. It is a public body with an industrial responsibility, under the MEEM, in charge of the long-term management of all nuclear waste produced in France.

INDUSTRIAL ACTORS

The French state holds majority stakes in the country's nuclear and electricity industry. EDF is the largest electricity producer in France (also the main player worldwide with a total of 135 GW_e installed capacity), with a 85.3% public stake. All NPPs in France are operated by EDF which is also its own architect-engineer and has developed a strong expertise in building nuclear power stations. (Second in France in terms of electricity generation, ENGIE operates the seven nuclear plants in Belgium.)

Majority state-owned AREVA is the designer/supplier of the French pressurised water reactor (PWR) nuclear plants (at the origin under a licence from Westinghouse) and the main industrial actor in the nuclear fuel cycle, from mining of uranium, conversion and enrichment, to reprocessing. Until recently, the first activity was handled by AREVA NP (formerly Framatome), and the second by AREVA NC (formerly Cogema). The state holds majority shares in AREVA through the French Alternative Energies and Atomic Energy Commission (54.37%), the *Banque publique d'investissement* (3.32%), and the *Agence des participations de l'État* (28.83%).

AREVA is effecting a strategic refocusing on its nuclear fuel cycle business, with projects to withdraw from certain activities and divest assets outside the scope of the

fuel cycle, in particular activities linked to renewables, propulsion and research reactors (its third branch AREVA TA, formerly Technicatome). These remain, until such time as divestments occur, within the scope of AREVA SA.

AREVA is reorganising into two main activities, with New AREVA (NA) and AREVA NP (nuclear plants). New AREVA includes all of the fuel cycle activities and related central departments. New AREVA, refocused on the production and recycling of nuclear materials and waste management, will develop its activities in mining, uranium chemistry (conversion and enrichment), used fuel recycling, logistics, dismantling and fuel cycle engineering. The alignment of interests within the nuclear sector in France decided by the government also involves the takeover of AREVA NP by EDF. AREVA NP covers the Nuclear Steam Supply System (NSSS – primary side of NPPs) design, supply, construction, maintenance and modernisation activities, as well as fuel design and fabrication.

An agreement in principle has been concluded with EDF on the sale price of AREVA NP at EUR 2.5 billion, pending the approval of the French competition authority and under the EU merger control rules. The French state made the commitment to support the recapitalisation of AREVA SA (EUR 4.5 billion) and EDF (EUR 3 billion). The European Commission approved on 10 January 2017 French state's contribution to the financing of the AREVA group's restructuring under EU rules on state aid. The Commission concluded that the restructuring plan of AREVA and its future focus on the nuclear fuel cycle can restore the undertaking's long-term viability and allow AREVA to operate without constant injections of public funds. The Commission requires that the sale makes a sufficient, real contribution to the costs of its restructuring and approved a bridging loan by the government of EUR 3.3 billion until the sale is completed. The approval of the state aid is subject to the effective divestment of the nuclear business and the positive result of tests, performed at the request of the ASN, on the Flamanville III nuclear reactor vessel, which is supplied by Areva.

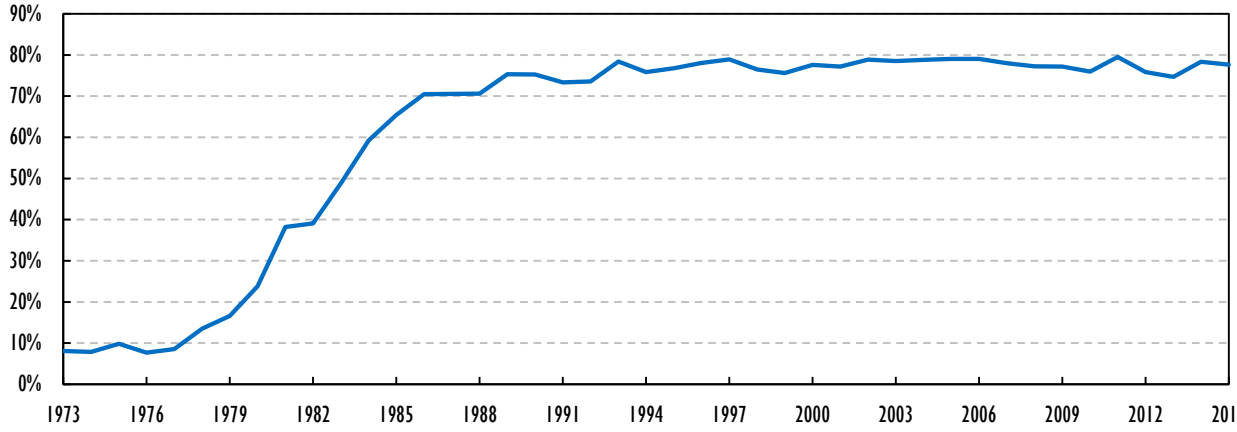
HISTORICAL BACKGROUND

Out of a total of 129 GW_e netto generating installed capacity in 2015, nearly half (63.2 GW_e) was nuclear, producing 77.7% of the consumed electricity. This share of nuclear-generated electricity has been rather stable since 1985, when most of the 34 units of 900 megawatts-electric (MW_e) units were in operation (see Figure 10.1). This is to be compared with the maximum historic peak demand of around 100 GW_e capacity.

Frances's unique position with regard to nuclear electricity is the result of the French government decision in 1974 to opt for nuclear energy as the main element of security of supply, nuclear fuel being considered as quasi domestic because of the diversity of supply sources and the ability to store years of nuclear fuel reserves.

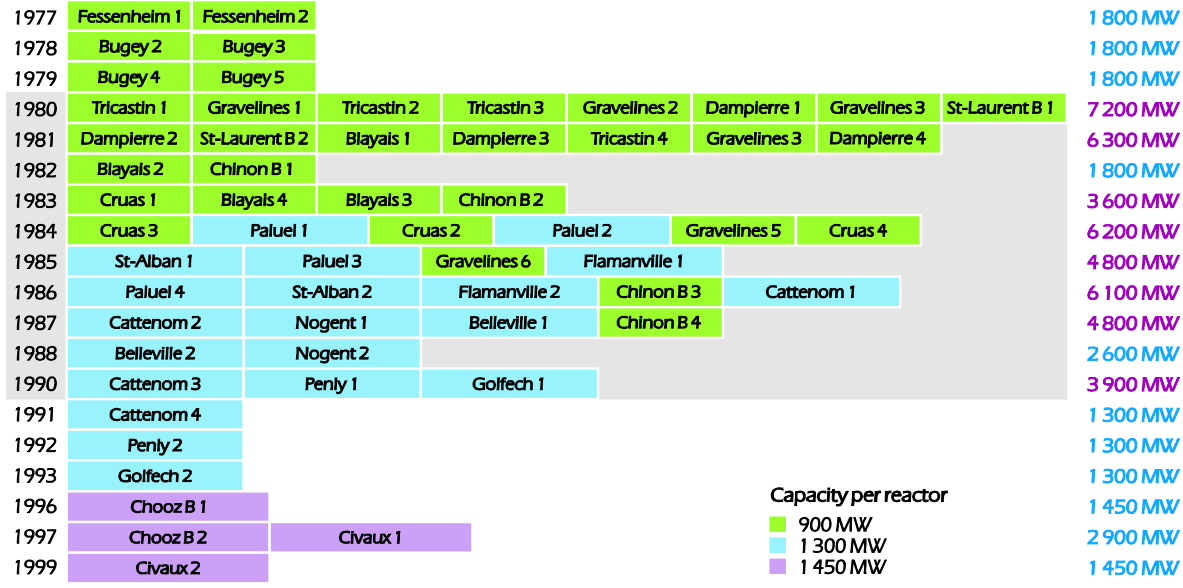
Within the following ten years, most of the 34 units of "900 MW_e" were commissioned, followed by 20 units of "1 300 MW_e" in the following decade. The last four units of "1 450 MW_e" came all on line at the turn of the millennium (Figure 10.2). This was only possible due to a strongly developed and well organised industrial sector (integrating the supplier of technology, the supply chain, the owner-operator also acting as architect-engineer, the fuel cycle industry, an efficient nuclear licensing process, combined with very active research programmes).

Figure 10.1 Share of nuclear power in electricity generation in France, 1973-2015



Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/ .

Figure 10.2 History of commissioning PWRs in France, 1977-99



Source: RTE (Réseau de Transport d'Électricité) (2016a), *Supply-Demand Outlook* (*Bilan Prévisionnel*), Paris.

Harmonisation and standardisation allowed economies of scale at the time of both design and construction, as well as for operation and maintenance, while at the same time introducing a risk of common mode problem or failure, which could require the simultaneous shutdown of a number of plants if a failure were to be detected.

The nuclear sector in France allowed the country to be a net exporter of electricity for many years, with a net export of 75.1 TWh in 2015, contributing to the overall stability and reliability of supply in the wider region. The French nuclear sector has been a key player on the worldwide nuclear technology export market, both in the reactors and fuel cycle activities.

In 2005, a law established guidelines for energy policy and security, where the role of nuclear energy was central, leading to the decision to build a first Gen III EPR (resulting from the mix of French and German technologies) as a FOAK (first-of-a-kind), opening

the path for further commercial deployment as of 2015, both for the domestic and export markets.

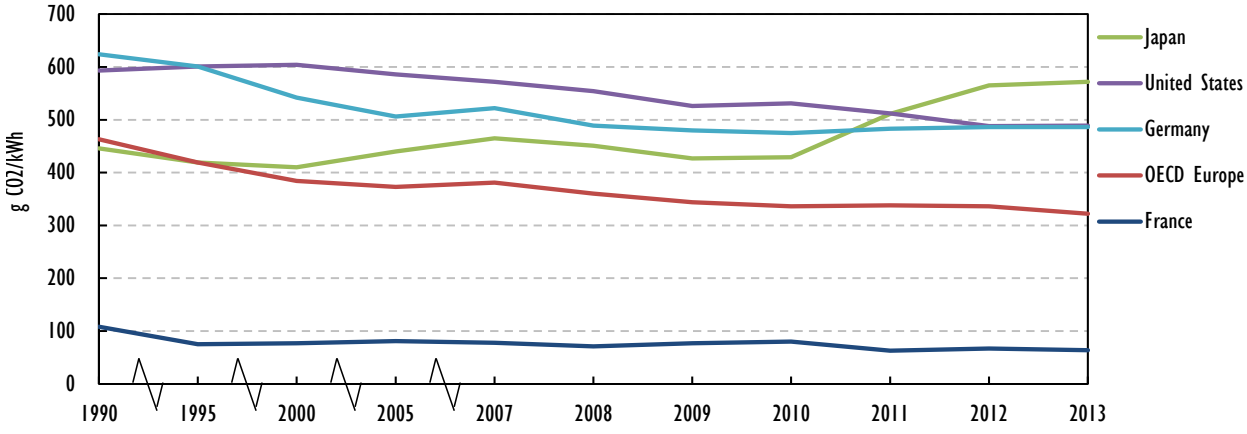
In 2008, the *Conseil de politique nucléaire (CPN)* was established, chaired by the President, reflecting the continued strategic importance of nuclear energy and international development. CPN tasked the CEA to develop a comprehensive partnership with the Chinese authorities on all aspects of the civil nuclear power sector, including safety. The *Agence France Nucléaire International (AFNI)* was created in 2008 under CEA to provide a vehicle for international cooperation and assistance.

Following the wide "national debate on the energy transition" launched in 2012, the *Office Parlementaire d'Évaluation des Choix Scientifiques et Technologiques* (OPECST) issued a report in September 2013 recognising the risk in terms of security of supply and power prices shocks of pursuing a speedy reduction of the nuclear contribution to the electricity supply with insufficient replacement by energy efficiency and other low carbon sources.

The Energy Transition for Green Growth Act (*Loi relative à la transition énergétique pour la croissance verte, LTECV*) was passed at the National Assembly in 2015, setting a limit of 50% for the nuclear contribution to electricity generation in 2025 and a cap of 63.2 GW_e nuclear installed capacity from now on and over time (corresponding to the installed capacity in 2014 with the 58 units in operation, which means that two operating units would be shut down, at the latest when the EPR under construction in Flamanville comes on line – expected end of 2018, in line with the decision of the French president to close the two reactors of Fessenheim). The Act also set a target of 32% of renewables in the energy mix in 2030, which can be translated into 40% in the power sector.

And, last but not least, the French power sector has been for a long time and still is extremely low-carbon with contribution of the high share of nuclear (combined with hydropower) in the mix (see Figure 10.3).

Figure 10.3 Historic CO_2 emissions per kWh among IEA member countries



Source: IEA (2016b), *CO_2 Emissions from Fuel Combustion* (database), www.iea.org/statistics/.

ECONOMIC ASPECTS OF NUCLEAR ELECTRICITY IN FRANCE

LONG-TERM OPERATION (*GRAND CARÉNAGE*)

To fulfil the objectives of the Energy Transition for Green Growth Act, it is estimated that 17 to 20 nuclear units of 900 MW_e would no longer be required by 2025 and are likely to be closed, as confirmed by the 2016 report of the *Cour des Comptes*, assuming a flat evolution of the demand and exports of electricity. Beyond the pure "electricity supply" issue associated with this decision, there is another central question related to the global industrial and economic aspects, in particular for EDF and the nuclear industry, but also for the final electricity consumer. Future electricity supply/demand scenarios involve uncertainty and should be assessed and updated to determine the future outlook for the nuclear fleet. The government will assess these fundamentals of the outlook in the pluriannual energy programming (PPE).

Out of the 34 units of 900 MW_e, 32 will reach their design lifetime (40 years of operation) between 2017 and 2025 (see Figure 10.2). EDF has made an evaluation of the cost of refurbishment necessary to allow lifetime extension (also called long-term operation) beyond these 40 years. This refurbishment has been called the "*Grand Carénage*". In France, the authorisation for operation, delivered strictly on safety grounds by the Nuclear Safety Authority, is given for periods of 10 years after the so-called "*révision décennale*". The cost estimated by EDF to go for long-term operation for at least ten more years, from 40 to 50 years, but with the prospect of an extension for the next ten-year period also, up to 60 years, is EUR 47.5 billion, to be spent over the period 2014-25. This includes the costs of both refurbishment and the safety upgrades to keep the safety levels at the highest standards, in particular by implementing the post-Fukushima safety measures. In 2016, the report of the *Cour des Comptes* estimated the cost for long-term operation at EUR 100 billion (CdC, 2016), but for the period 2014-30, and including EUR 25 billion for regular maintenance costs, not included in the EDF figures of EUR 47.5 billion which run to 2025. All these cost estimates are above LTO investment made in other IEA jurisdictions (i.e. the United States, Belgium).

The strict application of the objective of "50% nuclear in 2025" of the Energy Transition for Green Growth Act would make this lifetime extension, refurbishment and safety upgrade programmes not economically viable for 17 to 20 plants. This would be a definitive decision since the upgrades would have to be implemented before reaching the 40 years to obtain the authorisation to go beyond.

Existing nuclear plants are producing affordable electricity, even considering the refurbishment costs for long-term operation. Refurbishment for LTO needs to be evaluated against the levelised cost of electricity (LCOE) of other low-carbon sources for a lifetime of 20 years. A refurbishment cost of up to EUR 1 billion per unit (or EUR 35/MWh levelised cost of electricity[1] for an additional 20 years compares to the cost of a nuclear new Generation III build (EUR 115/MWh levelised cost of electricity) (IEA/NEA, 2015). However, over the past few years, the cost of renewable energy technologies has also come down quickly and is expected to continue to decrease further.

1. The calculation for a 1 000 MW_e plant integrates the refurbishment capital cost of EUR 850 million (corresponding to EDF estimates), at a discount rate of 10% (highest value), O&M (operation and maintenance) and fuel cycle cost (including waste management and decommissioning provision) of EUR 4/MWh.

NEW BUILDS

Two European Pressurised Water Reactors (EPRs) are under construction in Europe: in Finland (Olkiluoto 3) and in France (Flamanville 3). Two others are being built in China. The design is the result of the combination of the French Framatome and German KWU Siemens expertise. The origin of the common design was the wish, in the 1990s, to have one common and harmonised design for the European market. The final product of AREVA complies with the highest safety levels and, in particular, the principle of no radioactive releases beyond the fence of the site in case of core meltdown.

Contrary to construction on schedule in China, important delays and large cost overruns are impacting both EPRs construction in Finland and France. It is one of the reasons of the serious financial difficulties encountered by AREVA in the recent years, which have resulted in the decision to have EDF taking over the "reactor business" of AREVA, leaving it with the fuel cycle business. The details of this process and the respective cross-share are expected to be in place for the end of 2016. EDF will therefore become the French reactor technology leader, including for the export market. Beyond the interests of both industrial groups, this move has strong political support, showing the importance the country puts on its nuclear energy and industrial policy. The liabilities of the Olkiluoto EPR project will nevertheless stay with AREVA as a turnkey project.

After Flamanville, the first EPR plant to be built under the EDF flag should be the Hinckley Point C unit in the United Kingdom, to be owned by EDF Energy together with a Chinese stakeholder. EDF took the final investment decision (FID) in August 2016, which will rely on diverse domestic and foreign sources, in a difficult financial environment for the company. The EDF investment decision taken in the fall of 2016 for Hinckley Point relied on the previous UK government offer for a Contract for Difference mechanism, with a strike price at GBP 92 per MWh. This mechanism, applicable to nuclear as well as to wind power (but with a higher strike price), as part of the UK low-carbon energy policy, has been reviewed and accepted by the European Commission as not contradicting European State Aid rules.

The UK government has reviewed the project in 2016, without changing the conditions of the investment, and decided to strengthen the provisions for the state to have a golden share with a view to foster national security.

With experience gained from the EPRs in Finland, France and China, EDF and AREVA are revisiting the EPR design, making it simpler and more cost effective, cheaper and easier to build and operate/maintain, while keeping the highest levels of safety. This new design is called EPR NM (EPR New Model). In March 2016, AREVA, EDF and the CEA announced the creation of the *Plateforme France Nucléaire* (*PFN*) to devise a shared medium- and long-term vision for the French nuclear industry, providing consolidated inputs to the CPN. Its initial agenda will focus on a review of technological options for the EPR design and associated regulatory aspects, on the future of reprocessing, on deep geological repository (CIGEO), on decommissioning technologies, and on research and development for Generation IV reactors. When it comes to the French export policy on nuclear reactor technology beyond the EPR, mainly towards countries embarking upon nuclear programmes, the CPN called on AREVA, EDF and GDF SUEZ (now ENGIE) in 2011 to strengthen collaboration on the Atmea 1 100 MW_e, a Generation III design developed under a 2006 joint venture between AREVA and Mitsubishi Heavy Industries (MHI). Similarly, work has also started to look into the technical, legal and economic aspects of small reactor designs (100 to 300 MW_e).

FINANCING CHALLENGES

The construction (overnight) cost of the nuclear power programme in France was estimated at FF 400 billion in 1993 currency. Half has been self-financed by EDF, 42% by commercial loans and 8% was invested by the state. In early 2009, EDF estimated that its operating reactors were providing electricity at a cost of EUR 46 /MWh. The NOME Law of 2010 (for the new organisation of the electricity market) introduced the ARENH floor price at EUR 40/MWh in 2011 to provide a stable remuneration in return for access to EDF's nuclear-generated electricity for other market participants as an element to foster market competition. The ARENH price calculation integrated the anticipated investment costs for the refurbishment of the existing fleet for long-term operation. The ARENH price was in line with the *Cour des Comptes* (CdC, 2012) estimated range of EUR 33 to 50 (2010 value) per MWh, depending on the calculation method, noting that the costs could be increased by EUR 3/MWh for higher back-end costs. In a revised report in 2014, the CdC considered that the cost of nuclear generation had increased by 20% between 2010 and 2013 to EUR 62 (2012 value)/MWh, half of it reflecting increased maintenance costs and their accounting allocation. EDF estimated EUR 56 (2012 value)/MWh, assuming a 50-year operation and integrating the cost of the *Grand Carénage*. The ARENH price was revised to EUR 42/MWh in 2012.

In 2016, wholesale prices of electricity in Europe are very low, and well below what is considered necessary to recoup the large front-loaded investment cost of capital-intensive low-carbon electricity generation facilities, be it nuclear or variable renewable. This contributes to the difficult financial environment for EDF when the time of refurbishment and new build is coming. The 2016 average wholesale price of electricity is well below the ARENH price, rendering this floor price, designed to facilitate new entrants on the electricity market, unnecessary at the present time. The future of ARENH should be evaluated.

The overnight capital cost of construction of the EPR in Flamanville was initially estimated at EUR 3.3 billion, corresponding to a cost of electricity at EUR 46/MWh (a figure familiar in literature for a discount rate at 5%). Mass production was expected to reduce the costs by 20%. The construction on site started in 2007 with commercial operation expected in 2012. A number of problems have led to delays and overruns. In its report of 2012, the *Cour des Comptes* estimated the cost of electricity by EPR between EUR 70 and 90 (2010 value)/MWh, on the basis of an overnight capital cost of EUR 6 billion at that time. In September 2015, with 98% of the civil works completed and 60% of the mechanical equipment installed, the cost escalation had reached EUR 10.5 billion and the expected operation date was moved to the end of 2018. The overnight capital cost in the order of EUR 6 500/kW_e installed for this first-of-a-kind plant, combined with increased financing costs due to the delays in construction, explains why EDF is now working on the EPR NM (New Model) with simplified construction and significant cost reduction, to become the flagship for the future French new builds and the export market.

The economics of nuclear power is affected by the load factor. Because of the high fraction of nuclear-generated electricity, some of the French plants are operated in load-follow mode. The capacity factor may therefore appear somewhat low in France compared to a number of other countries. The 2016 report of the CdC indicates that a further reduction of the load factor to 50% would lead to an electricity generation cost increase to EUR 125/MWh (CdC, 2016).

It shows that, in case of the strict application of the Energy Transition for Green Growth Act's "50% nuclear target in 2025", the option to drastically reduce the load factor in a large number of plants, instead of closing a number of them, would worsen the economics.

NUCLEAR SAFETY

INSTITUTIONAL FRAMEWORK

Since the 2006 institutional reform, a comprehensive regulatory framework has been established, based on a 2012 ministerial order and 15 ASN technical regulatory resolutions in line with the WENRA (Western European Nuclear Regulatory Authorities) reference levels.

The Energy Transition for Green Growth Act reinforces the regulatory framework by widening the ASN enforcement powers (pecuniary sanctions, control over suppliers and subcontractors), by affirmation of the need for immediate dismantling instead of long-term safe storage after plant definitive shutdown, and by enhancing information and transparency.

Operating licences do not have time limitations, but periodic safety reviews have to take place every ten years (*révision décennale*), to check the conditions and conformity of the plants, and allow safety upgrading in light of operating experience, scientific developments and recent best practices.

FUKUSHIMA DAIICHI

Following the Fukushima Daiichi accident in March 2011, so-called "stress tests" have been applied to all operating nuclear power reactors in the European Union. This was organised by the European Commission and implemented with the National Safety Authorities and their technical safety organisations. The French Safety Authority (ASN) and its Technical Safety Institute (*Institut de Radioprotection et de Sûreté Nucléaire, IRSN)* have been central in this process which showed that, while safety improvements were necessary to increase the resistance towards extreme external events, none of the plants operated in the EU (and so the 58 French nuclear units) had to be shut down for safety reasons. In some countries and in France in particular, other nuclear facilities (fuel cycle facilities and research reactors) were also submitted to the stress tests, including the EPR under construction.

According to the report of the IRSN, which was released in conjunction with the ASN, a set of "hard core" safety measures for the protection of vital safety structures, systems and components are necessary to maintain critical safety functions in case of beyond-design-basis events, such as major earthquakes, extended fires or prolonged loss of power supply or emergency core cooling. A local emergency management centre also needs to be operational at each site. All the measures are under implementation at all plants, mainly programmed during outage periods. One specific issue was related to the resistance of the basemat of the Fessenheim reactors. The remedial works were completed in 2013, allowing the continuation of the operation until the 40 years are reached in 2017. Besides the onsite upgradings, EDF has also created the Nuclear Rapid Response Force (FARN). The aim is to be able to quickly deploy qualified staff and

equipment to any reactor site in case of an accident, to complement, if needed, what can be done on the site itself, in particular in terms of cooling and electricity supply.

PERIODIC SAFETY REVIEW AND LIFETIME EXTENSION

The French nuclear safety authority ASN carries out periodic safety reviews for the different fleet parts (so-called *palier*). ASN gave a generic position on the EDF's *Grand Carénage* programme (up to 60 years) in 2013. Orientations were provided for the fourth periodic safety review in 2015 and conclusions on generic studies and plant modifications (for the whole 900 MW_e fleet) are expected in 2018. From 2019 onwards, each 900 MW_e reactor will undergo modifications and controls. About one year after, ASN is expected to take a position on the extended operation for another 10 years, including a public consultation.

For long-term operation of the existing units, beyond the 40 years design lifetime, (Grand Carénage programme), EDF is responsible for preparing the safety files for each reactor and submit them to ASN. ASN will evaluate them, using to the maximum extent possible Generation III criteria for the safety level, and will also analyse the ageing and obsolescence for more than the next 10 years, anticipating a possible further lifetime extension up to 60 years. If safety levels are satisfactory, the authorisation for further operation will then be given for an extra ten years for each reactor, based on the principle of the "*révision décennale*". Timewise one can expect the decision-making process to fit with the timeline of reaching the 40 years operation of the plants.

In 2015, tests on the material of the EPR under construction in Flamanville, requested by the ASN, showed a high carbon content and a one-third lower than specified toughness. The safety-related assessments are ongoing, with result expected for end 2016. These tests triggered a general audit of the fabrication files of main nuclear components (reactor vessels, steam generators, primary piping, etc.) produced since 1965 at the Creusot plant, now part of AREVA. In a total of 10 000 analysed files, some anomalies, of diverse nature, were detected, related to components in operating EDF plants, but also to some components for export. Further Investigations are ongoing to evaluate the possible safety impact of each individual anomaly and take the appropriate action.

FUEL CYCLE ACTIVITIES

On the front end side, the new uranium-enrichment plant Georges Besse II, using centrifugation and replacing the closed Eurodif diffusion plant at Tricastin, started commercial operation in April 2011. The EUR 3 billion two-unit plant with a nominal capacity of 7.5 million SWU (separation work unit) was built and is operated by an AREVA subsidiary, with some minor shares proposed to customers. The south plant reached full capacity in 2015 and the north plant is expected to be at full capacity by end of 2016. EDF, as principal customer, signed a EUR 5 billion long-term delivery contract in 2009, running for 17 years till 2025, corresponding to the amortisation period of the plant. Korea Hydro and Nuclear Power signed a EUR 1 billion long-term contract in 2007. The plant, with a third unit to be built, has a potential increase to 11 million SWU, which was the capacity of the old plant, delivering enrichment needs for a nuclear "fleet" of 80 GW_e.

AREVA decided in 2007 to replace its uranium conversion production capabilities by investing in a new conversion plant at the Malvési and Tricastin sites in France; known as

the Comurhex II project. The new plant will have a full production capacity of 15 000 metric tonnes, with the possibility of increasing capacity later to 21 000 tonnes, if market conditions permit. At this point, Comurhex II is the only new conversion plant project to be launched in the world and it meets the most recent safety standards, particularly in terms of its ability to withstand earthquakes and flooding. The Comurhex II plant is designed to offer maximum security of supply for the French nuclear fleet. In 2015, the nuclear safety authority ASN approved AREVA's request to extend the operation of the Comurhex I production plant until the end of 2017. This will reduce the duration of the non-production phase, with integrated start-up of Comurhex II at both Malvesi and Tricastin sites planned for the end of 2018.

On the back-end side, EDF sends yearly 1 050 tonnes of spent fuel to the AREVA La Hague reprocessing plant (out of 1 200 tonnes used fuel discharged each year, the diference is kept for later reprocessing to feed fast neutron reactors in the future); 97% of the reprocessed material is recycled (1 000 tonnes of uranium and 10 tonnes of plutonium, allowing savings in terms of fresh uranium needed) and 3% constitute the ultimate vitrified waste. The plutonium is shipped to the Melox MOX fabrication plant – producing 120 tonnes of MOX fuel used in 24 units of 900 MW_e. The licensed capacity of Melox is 195 tonnes/year, providing spare capacity for foreign contracts. The strict application of the Energy Transition for Green Growth Act, leading to the shutdown of up to 20 of the 900 MW_e reactors by 2025, would seriously impact the balance and the economics of the French fuel cycle.

NUCLEAR WASTE MANAGEMENT AND DECOMMISSIONING

Waste disposal in France is pursued under the 1991 Waste Management Act, updated in 2006 after 15 years of intense research. ANDRA is responsible for the research and implementation of solutions for the long-term surface storage of conditioned waste, and for the final disposal of low-, intermediate- and high-level waste. ANDRA publishes a national waste inventory every three years.

The 2006 Nuclear Materials and Waste Management Programme Act declared deep geological disposal as the reference solution for high-level and long lived-waste, and set 2015 as the date for licensing a repository site and 2025 for its opening. It also confirmed reprocessing and recycling as a way to reduce the quantity and toxicity of final waste, and called on the construction of a prototype Generation IV fast-neutron reactor to test the transmutation potential of long-lived actinides (contained in spent fuel). A national waste management plan defining the goals and needed research is revised each three years.

A report produced under the 2006 Act identifies Bure as the best site for investigation of deep geological disposal in clay. A 2010 report evaluated that the transmutation of minor actinides in fast reactors would add 10% to the cost of power (and 20% if accelerator-driven systems are used instead as dedicated actinide burners). It also noted that the "spent fuel" from transmutation reactors would be in interim storage for 70 years. A 2012 report noted the great value of fast reactors for using plutonium and their potential for transmuting long-lived minor actinides, and flagged the need for an experimental reactor and the associated fuel cycle to test the industrial and economic viability of that concept, while maintaining France's technology leadership.

Drawing on the lessons of the Underground Research Laboratory in Bure, ANDRA is designing the 500 meter-deep repository, called CIGEO (*Centre industriel de stockage*

géologique). In 2017, ANDRA is expected to submit its master plan for the commissioning and operation of CIGEO, to be immediately followed by the licence application. Construction would start in 2020 and the pilot operation in 2025. This would then be the third of such geological disposal facilities to enter operation, after the ones in Finland and Sweden, but the first one to host vitrified waste resulting from reprocessing. In July 2016, The French Parliament confirmed the need of reversibility criteria for the CIGEO.

Thirteen experimental and power reactors are under decommissioning in France. Nine are first-generation gas-cooled, graphite-moderated reactors. The four others are the two fast-neutron reactors Phénix and Super Phénix, the experimental reactor at Brennilis and the PWR prototype at Chooz. The dismantling licence for Brennilis and Chooz were issued in 2006 and 2007 respectively and works are proceeding.

In 2008, ASN issued a policy recommendation for "immediate dismantling strategies" versus "safe storage for later dismantling". EDF is working along this line, but in June 2016 EDF announced that the effective decommissioning process of the domestic first generation graphite-moderated reactors (currently all closed down) could be delayed pending solutions for the handling of sites for the disposal of alpha-contaminated graphite.

Other nuclear facilities are also to be decommissioned. As examples one can cite the Eurodif enrichment plant closed in 2012, and the uranium -reprocessing plant UP1 at Marcoule closed in 1997. AREVA is in charge for the first one and CEA for the second one, after some transfers of liabilities from EDF and AREVA.

An important issue for the acceptability of nuclear energy is the assurance that the legacy, decommissioning and long-term waste management will be properly handled, and that the financing will be ensured and funds available when needed.

The first thing to do to determine the needed provisions is to estimate the costs of decommissioning and long-term waste management, which is not easy because the return of experience is limited (e.g. decommissioning) or not existing at all (e.g. deep geological disposal). In addition, the costs occur in a distant future, and evaluating the corresponding yearly provisions is much dependent on the discount rate. This said, whatever the uncertainties, the yearly feeding of the provisions converts into a rather small fraction of the cost of the electricity generated, or wholesale price sold, and even a drastic increase, while not to be neglected, would not, on its own, seriously affect the competitiveness of nuclear energy.

At the end of 2014, the total charge for decommissioning and waste management was EUR 99 billion for all nuclear facilities: EDF power plants, but also CEA and AREVA installations. It can be further subdivided roughly into 45% for decommissioning, 20% for spent nuclear fuel management, 5% for legacy waste management and 30% for long-term waste management, including CIGEO.

For the same year 2014, the necessary provisions − taking into consideration the remaining years of operation of the plants until the design lifetime is reached − amounted to EUR 52.5 billion taking into consideration 53% for decommissioning, 21% for spent fuel management, 7% for legacy waste management and 20% for long-term waste management. These EUR 52.5 billion provisions are for 65% related to EDF, 22% to CEA and 12% to AREVA.

Uncertainties are limited for spent fuel management thanks to the extensive experience in that field. They are higher for decommissioning costs where experience is more limited, and even higher for long-term waste management. In particular, the estimation

for the CIGEO varied from simple to double between EDF and ANDRA calculations. In 2016, the Ministry of Energy set the reference cost of CIGEO at EUR 25 billion (2011 values), a figure to be updated once the construction project starts. More than half is for the construction and one-quarter for operation over 100 years. This figure is higher than the EDF estimation and will require an increase of the provisions of EUR 800 million for EDF and EUR 250 million for AREVA. The last year decreases of the discount rates also impact the calculations of the necessary provisions for given charges.

The required EUR 52.5 billion of financial provisions for the end of 2014 were covered by EUR 41.2 billion of dedicated assets. Other provisions are not to be covered by dedicated assets because they represent costs that are due and paid during the operation of nuclear facilities (that is mainly the case of spent fuel treatment at La Hague, which is directly financed by power generation from NPPs. The *Cour des Comptes* reports (CdC, 2012 and 2014) reviewed the situation and made various recommendations to improve the framework, especially with regard to its governance or the evolution of the discount ceiling rate. Liquidity of some assets is impaired by the acceptance of securities issued by operators' subsidiaries and by inter-operators receivables. In the last few years the MEEM has been reinforcing the audit mechanisms so as to make them similar to the tools used in the insurance sector, and to increase the strength of the financing of the nuclear long-term legacy.

NUCLEAR FISSION RESEARCH AND DEVELOPMENT

For a number of years, public financing of nuclear research has been in the order of EUR 500 million per year, 90% of it for nuclear fission, the rest for fusion, not including the special contribution to the ITER project.

Nearly 80% goes to the CEA, covering 60% of their nuclear research activities, the other 40% coming from external contracts, in particular from industry. The Programme for Investment in the Future (*Programme d'investissements d'avenir, PIA)* for the period 2010-17, reserved EUR 1 billion for specific nuclear fission projects, in particular in support of the Jules Horowitz Research Reactor under construction and the planned ASTRID Demonstration Fast Neutron Reactor. Besides nuclear fission, France is also a key partner in nuclear fusion research, in particular hosting the international thermonuclear experimental reactor (ITER) project in Cadarache.

The CEA is pursuing the construction of the Jules Horowitz reactor (JHR) in Cadarache, a 100 megawatts thermal (MW_{th}) material testing reactor. This is the first such reactor built for several decades. It will replace a number of older research reactors which have been shut down or will soon be. The reactor will serve multiple goals, one being to support the long-term operation of the French nuclear power reactors. The overall cost of JHR was estimated at EUR 500 million (2005), of which EUR 200 million from the PIA. While works on site are progressing effectively, the start-up date has slipped in time and is now scheduled for 2020. Post-Fukushima safety requirements have also been applied to JHR. All these, and other external factors, have led to a threefold increase of the costs in 2015 euros.

In September 2010, the government confirmed its support and funding of EUR 650 million from the PIA for the 600 MW_e sodium-cooled ASTRID fast-neutron reactor (advanced sodium technological reactor for industrial demonstration), led by CEA, with involvement of EDF and AREVA. In December 2012, the project moved

towards the design phase. Work progresses on the associated fuel cycle research and facilities: a dedicated MOX fuel fabrication line and a pilot reprocessing plant. The target date for the commissioning of ASTRID is 2023.

CEA is leading the French activities and contributions in the Generation IV International Forum GIF. With the perspective of having Generation IV reactors commercially deployable as of 2040, CEA is investigating several fuel cycle strategies.

One will also note the successful greenfield decommissioning by the CEA of the Siloé research reactor in Grenoble within the foreseen budget and timing. It could serve as a reference for other cases.

ASSESSMENT

Nuclear power accounted for 46% of TPES and 78% of electricity generation in 2015. France's total installed capacity is 63.2 GW_e with 58 Generation II operating nuclear power units at 19 sites, all from the same technology and supplier, and all operated by EDF. Seventy per cent of the nuclear fleet started operation between 1977 and 1987. The fleet has an average age just over 30 years. An important issue in France therefore evolves around the economics of long-term operation (LTO, also called lifetime extension) of existing plants and the timely decision on the necessary upgrading and refurbishment programme, including for keeping up with the highest safety levels.

The Energy Transition for Green Growth Act caps the nuclear capacity at the present level (63.2 GW) and targets the reduction of the share of nuclear-produced electricity to 50% by 2025, which could lead to the closure of 17 to 20 reactors if the timeline is applied strictly and if these reactors cannot be used for electricity exports. The Act also calls for an increase of renewable- generated electricity from the 27% target in 2020 to 40% in 2030.

The implementation of the 50% target remains challenging given the large role nuclear electricity has in the French mix (78%) and the plants' average age of 30 years. Depending on the evolution of electricity demand and progress in the deployment of renewable sources, which also entail considerable uncertainty even if France has a certain overcapacity, the 50% target may have impacts on the economics of electricity and final electricity prices, greenhouse gas emissions and the reliability and security of supply in France and for neighbouring countries. The IEA considers the impact assessment of future demand/supply trends, to be performed by the government under the pluriannual energy programming (PPE), as crucial in this context.

First, security of electricity supply and reliability need to be ensured at a time of outages or suspension of plants for maintenance. Noting that hydropower was contributing 10% of the electricity generation in 2015 with not much more to be expected in the future, and that the recourse to more fossil fuels is not in line with low-carbon objectives, it means that non-hydro resources (wind and solar power, waste, biomass and biogas) would need to substitute for at least the 28% of reduced nuclear contribution by 2025, a significant increase from their current share of 6.8% in 2015. The objective of "50% nuclear in 2025" of the Energy Transition for Green Growth Act is only possible if there is a very high level of confidence that the alternative low-carbon means of generating electricity, mainly from variable renewable sources, will be available in that time frame, providing the same level of quality and reliability of supply, and at acceptable costs for the consumers and taxpayers. And, given the lower availability of the intermittent renewable sources, a simple substitution in terms of capacity is not sufficient.

Second, the feasibility needs to be further analysed on the basis of cost comparisons, which take into account the cost of renewables versus nuclear LTO for 20 years. For nuclear in particular, the option to drastically reduce the load factor on a large number of plants, instead of closing a number of them, would seriously impact the cost of the generated electricity.

Third, the 50% by 2025 requires EDF, as an industrial actor, to revise its refurbishment and safety upgrades programme. The *Grand Carénage* programme has never been conceived and organised on a global fleet basis and could be launched in steps through several investment projects. However, this programme should be optimised with all aspects of economy of scale and best use of manpower and resources.

Fourth, the shutdown of a large number of reactors over a short period of time could have negative impacts from an industrial policy perspective, which has historically been a major element of the French integrated nuclear policy (reactors and fuel cycle with reprocessing and currently the use of recycled materials as MOX fuel in the 900 MW_e plants), unless appropriate decisions are taken to minimise those impacts (such as speeding up the use of MOX fuel in the rest of the fleet).

Fifth, the impact on the decommissioning and long-term waste management policy needs to be considered. Preparations will have to be pursued actively from the safety, technical, industrial and financial perspectives. Ensuring the proper funding is particularly important. Concerning waste management, it is also important to keep the pace in developing the long-term solution via geological disposal. Funding for decommissioning and waste management is set aside during the operation period of the plants. The shutdown policy, in application of the Energy Transition for Green Growth Act, has therefore an impact on these important issues.

Implementing the Act targets with flexibility in time would allow France to develop a strong low-carbon energy policy based on sound economic, technical and industrial perspectives, including in the nuclear field, at a time when, in other parts of the world, nuclear programmes are developing fast. In this context, it seems therefore reasonable to apply the 50% nuclear "rule" with some "flexibility in time", and provide clarity in the pluriannual energy programming schemes while integrating also a potential for export.

In conclusion, while the 50% objective could be kept, its application should be moved beyond 2025, at a time to be determined, taking full consideration of the real evolution of the demand and export potential, and the real deployment of alternative low-carbon sources of electricity. The cap at 63.2 GW_e could be kept over time for the whole period and serve as the upper limit until the 50% are reached. A possible way forward could be to target the 50% share for around 2035. Between now and then, Generation II plants could undergo LTO programmes for 10 or 20 years and be further operated, as approved by the Safety Authority, and then be replaced by the Generation III plants so as to keep up to 50% nuclear-generated electricity, depending on the evolution of electricity demand. This way forward ensures continuity with a recommendation given in the 2009 in-depth review, while also respecting the spirit of the Act.

The energy and climate goals of the Act will require the national energy RD&D strategy and funding to be properly aligned, an intention which has been set out also in the Act. A key stated goal is a reduction in the share of electricity generated from nuclear power from 78% at present to 50% by 2025. The RD&D strategy will have to reflect the new strategic needs of the nuclear fleet, notably safety, decommissioning, waste management and new builds. The short- to medium-term research on the existing reactors will mainly be

financed by industry, in particular to reduce the costs of construction and generation, and to maintain the highest safety levels. Given the goal of achieving a 40% share of electricity generated from renewable sources by 2030, it will also become important to increase the flexibility of the nuclear fleet and adapt its operation to more variable and uncertain electricity supply from variable renewable sources. Next to large reactors, France should also research the potential for small and medium reactors, in step with global developments. Indeed, these reactors may show flexibility to adapt to the evolution of the electricity grid, contribute to co-generation and other non-electric applications, and be more easily financed because of their lower total capital investment and their shorter construction time.

In the longer term, Gen IV fast neutron reactors will make better use of uranium resources and may burn highly radioactive waste, reducing the lifetime and radiotoxicity of high-level nuclear waste, into an integrated closed fuel cycle approach. ASTRID, coupled with corresponding closed fuel cycle technologies, becomes a necessary element to demonstrate the technical and industrial feasibility of the technology, as well as its safety. Only via this demonstration phase will the technology become commercially available in the longer term for integration in the nuclear fleet (2050 and beyond). ASTRID is critical for maintaining the competence, skills and leadership of the French nuclear sector in this advanced nuclear domain and for allowing its participation in international co-operation programmes. It is therefore necessary to continue all efforts to build the demonstrator by the 2030 horizon.

RECOMMENDATIONS

The government of France should:

- *When implementing the target of reducing the share of nuclear to 50% in the mix, assess possible changes in energy demand and supply through the PPE, with a view to guarantee continuous security of electricity supply and maintain the low-carbon footprint. Take into account safety and economic aspects when deciding on the LTO of France's Generation II plants and new build Generation III plants.*
- *Ensure that the French nuclear industry is able to face the challenges ahead, including the LTO and new build programmes and their impact on the interconnected EU electricity market, and the role of the French nuclear sector on the international scene.*
- *Ensure timely management of high-level nuclear waste, in particular geological disposal, moving from research to design, authorisation and licensing, and construction of the facility, by involving all stakeholders.*
- *Continue to closely monitor and further develop the funding mechanisms for decommissioning and waste management to ensure the availability of the necessary funds when the time comes.*
- *In the area of nuclear RD&D, continue activities on safety and competitiveness of large water-cooled reactors, and engage in research on small and medium reactors, and, for the longer term, keep pace with the design and construction of the ASTRID industrial demonstration reactor and the associated research on the closed fuel cycle.*

References

ASN (Autorité de Sûreté Nucléaire) (2016), www.asn.fr/.

CdC (Cour des Comptes) (2016), *Maintaining Nuclear Power Plants,* February, www.ccomptes.fr/Accueil/Publications/Rapport -public-annuel-2016.

CdC (2014), *The Cost of Nuclear Generated Electricity,* May, *www.ccomptes.fr/Actualites/Archives/Le-cout-de-production-de-l-electricite-nucleaire*.

CdC (2012), *The Cost of the Nuclear Power Sector,* January, *ccomptes.fr/content/download/1794/17981/version/6/file/Rapport_thematique_filiere_electronucleaire.pdf*.

IEA (International Energy Agency) (2016a), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016b), *CO_2 Emissions from Fuel Combustion*, (database), OECD/IEA, Paris, www.iea.org/statistics/.

IEA/NEA (Nuclear Energy Agency) (2015), *Projected Costs of Generating Electricity*, OECD/IEA, Paris.

RTE (*Réseau de Transport d'Électricité*) (2016), *Bilan Prévisionnel*, Paris, www.rte-france.com/sites/default/files/bp2016_complet_vf.pdf.

WNA (World Nuclear Association) *Country Profile France*, website, (accessed 7 May 2016, *www.world-nuclear.org/information-library/country-profiles.aspx*.

11. ENERGY TECHNOLOGY RESEARCH, DEVELOPMENT AND DEMONSTRATION

Key data (2014)

Government spending on energy RD&D: EUR 1 054.3 million

Share of GDP: 0.49 units of GDP per EUR 1 000

RD&D per capita: EUR 15.9

OVERVIEW

The total government spending on energy research, development and demonstration (RD&D) of France has remained stable since 2011. In 2014, the French government spent EUR 1 054.3 million on energy RD&D.

The set of technology priorities has changed significantly since 2007, as France has sought to diversify its R&D portfolio beyond nuclear energy. Still today, nuclear RD&D holds the lions share, but other priorities, including smart grids and renewable energy are increasingly attractive for French industry and public research and development entities.

Fundamental research is carried out by a highly diverse range of institutions, complemented by the flagship Investment for the Programme for Investment in the Future (*Programme d'investissements d'avenir, PIA*), a multi-stakeholder programme designed to establish close links with industrial and commercial actors and to accelerate the deployment of innovative energy technologies.

Research in France operates throughout the whole value chain, and includes fundamental research carried out by public laboratories, industrial research by industrial/commercial institutions as well as pre-production trials and demonstration projects in partnership with public laboratories and industrial companies.

France is preparing an energy RD&D strategy for the energy transition to green growth.

INSTITUTIONAL FRAMEWORK

As part of the reforms under the 2005 POPE Law, France largely divided the funding and execution of RD&D activities into separate institutions. The reforms also saw the creation of new organisations and processes to improve co-ordination between research agencies and to increase the efficiency of the use of RD&D funds.

Funds for RD&D are mainly channelled through fundamental research agencies, the Environment and Energy Management Agency (ADEME), the Alternative Energies and Atomic Energy Commission (CEA) and the Public Investment Bank (*Banque publique d'investissements, BP*I) under the supervision of the relevant ministerial departments.

The National Research Agency *(Agence Nationale de la Recherche, ANR),* established in 2007, provides financing for basic RD&D in science and technology. ANR also aims to improve collaboration between public research institutions and industrial actors. Out of a total budget of EUR 575 million in 2014, around EUR 70 million was allocated to research activities related to the energy sector. New energy technologies include renewable energy, CO_2 capture, energy storage, energy networks, hydrogen and fuel cells.

The **Environment and Energy Management Agency** *(Agence de l'environnement et de la maîtrise de l'énergie, ADEME)* is the public body implementing for industrial development, focusing on renewable energy sources, heat, waste, energy efficiency, storage and smart grids. ADEME administers a range of demonstration funds and calls for specific projects, including the Heat and Waste Funds. As part of its remit, it produces roadmaps for energy technology RD&D that feed into the RD&D policy-making process.

The **Public Investment Bank** *(Banque publique d'Investissement France, BPI France)* is responsible for a range of RD&D funding streams. It manages the **Single Interministerial Fund** *(Fonds unique interministériel, FUI),* with allocations by relevant ministerial departments, support, together with regional funds, collaborative R&D projects for products or services in the final stages of the innovation cycle. In 2014, 132 projects received EUR 177.7 million from the Fund.

France has several public research institutions with a commercial activity, such as cEA, the *Centre scientifique et technique du bâtiment (CSTB), the Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR)* and the *Institut français du pétrole énergies nouvelles (IFPEN)* for industrial research and demonstration; and, at the implementation stage, these institutions work with private industry.

The French Alternative Energies and Atomic Energy Commission *(Commissariat à l'énergie atomique et aux énergies alternatives, CEA)* has been the historic hub for RD&D activities in nuclear energy. The CEA aims to keep France as an international leader in atomic energy technology, from new materials, novel reactor designs, safety, decommissioning and waste management, to the co-ordination of major international nuclear fusion power initiatives. The CEA is also a major RD&D actor in new energy technologies such as solar, fuel cells, hydrogen, energy efficiency and storage. The CEA energy research budget is approximately EUR 750 million[1], representing around 95% of all public nuclear energy research.

The **French Petroleum Institute New Energies** *(Institut français du pétrole énergies nouvelles, IFPEN)* is an independent research institute focusing on industrial development, education and training. It works on technologies for low-carbon transport and energy-efficient vehicles, biofuels, hydrogen and other low-carbon energy sources. Its budget has been gradually increasing to reach EUR 132 million in 2014.

The main institutions carrying out basic research along the energy RD&D value chain include the **CNRS** *(Centre National de Recherche Scientifique),* institutions and universities; the CEA and IFPEN for industrial research and demonstration; and the initiatives planned and supported under the PIA.

1. This figure includes all spending for research in nuclear and other low-carbon energies, including the RJH and the ASTRID reactors.

The **National Alliance for the Coordination of Energy Research** *(Alliance nationale de coordination de la recherche pour l'énergie, ANCRE)* was founded in 2009 as the forum for all energy RD&D activities carried out by public institutions in France. Its membership has grown from 4 to 19 institutions. Its remit is to help co-ordinate and improve the efficiency of energy RD&D carried out by national public institutions. It also participates in the implementation of national policies and strategies in the field of energy RD&D. ANCRE also contributes to the development of the national RD&D strategy, with dedicated scenarios and roadmaps.

NATIONAL POLICY FRAMEWORK FOR RD&D

The current public energy RD&D framework is articulated on the basis of the 2007 energy research and development strategy, the **National Strategy for Energy R&D** *(Stratégie nationale de la recherche pour l'énergie, SNRE)* which included a broad range of national RD&D priorities for the energy sector, including renewable energy; energy storage; fuel cells; carbon capture and storage (CCS); energy efficiency in buildings; low-carbon vehicles and transport systems; second-generation biofuels; and new nuclear power generation.

The SNRE was the result of a consultative process following the adoption of the previous 2005 National Strategy for Research (SNR) and the 2008 Grenelle Envrionment I Act. At the time, the SNRE was exemplary in its alignment with the broader energy policy and strategic direction in the French energy sector, establishing strong synergies with industrial innovation activities and supporting the links between fundamental research and market implementation through advanced demonstration and deployment funds. As required by law, the SNRE was evaluated in 2009 by the National Assembly's *Office parlementaire d'évaluation des choix scientifiques et techniques (OPECST)* and was to be revised by the government by 2012.

The Energy Transition for Green Growth Act *(Loi relative à la transition énergétique pour la croissance verte, LTECV)* of 17 August 2015 called for the creation of a new National Energy Strategy for Energy R&D. It should also take account of the direction in energy and climate policy, notably the low-carbon strategy (*stratégie nationale bas carbone*) and pluriannual energy programming (PPE) and be revised every five years. The new strategy is under preparation for publication at the end of 2016 and build on the new national overall R&D strategy.

France's recent national R&D strategy was presented in 2015 and has an energy component that will developed further. The strategy, building on the European Horizon 2020 model, has highlighted ten societal challenges and focus areas that will form the backbone of the priority-setting in the forthcoming strategy. Those relevant to the energy sector include:

- Under the societal challenge of "clean, safe and efficient energy" the focus areas are multi-scale governance of the energy system; dynamic energy management; energy efficiency; strategic materials; fossil fuel substitutes.
- Under the societal challenge of "sustainable cities and transportation", the focus areas are urban monitoring; new concepts for mobility; solutions and technologies for sustainable cities; and optimisation and integration of urban infrastructure and networks.

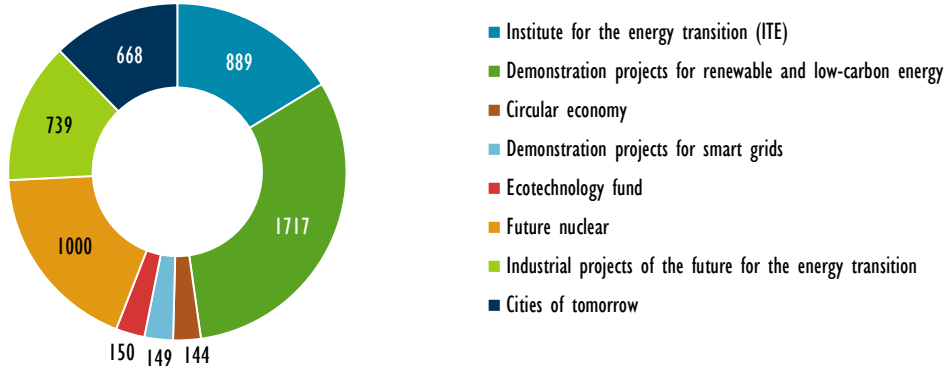
PROGRAMMES AND FUNDING

The **Programme for Investment in the Future** (PIA, *Programme d'investissements d'avenir*) is the key initiative to accelerate deployment of new energy technologies. It focuses on the stages of the innovation chain closest to market implementation, and its funding programme also includes technologies beyond the energy sector. With a EUR 5.5 billion allocation to the energy sector over the period of 2010-17, its programmes are implemented through eight key initiatives (Figure 11.1). The PIA operates through a combination of grants and financial tools, such as repayable advance loans or investments in equity.

Half the funds are allocated to ADEME in two initiatives. The first is the **demonstration project for the environmental and energy transition,** started in 2015 with two components: a EUR 1.7 billion allocation for direct financing of demonstration projects in the areas of renewable energy, smart grids and storage, energy efficiency and buildings renovation; and a second EUR 1.15 billion **programme dedicated to future transportation**, focusing on vehicles (e.g. low-consumption cars thanks to more efficient engines, auxiliary services and others) and to associated infrastructure, such as funding local authorities' plans to roll out charging points for electric vehicles.

A second flagship initiative in the PIA is the creation of the *Institut pour la transition énergétique (ITE).* The programme is administered by the ANR and aims to create internationally relevant technology innovation campuses in the field of renewable energy, new energy technologies and energy efficiency. The aim of the ITE is to build the future foundation of energy RD&D and its activities are to be aligned with the future SNRE.

Figure 11.1 Programme for Investment in the Future: Breakdown of the energy budget (in million EUR)

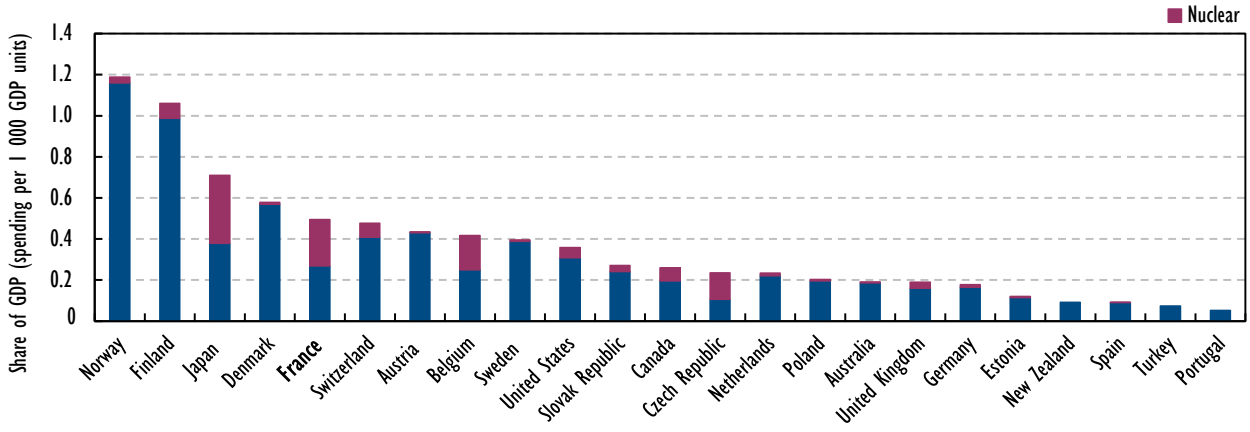


Source: MEDDE (2015), *Energy and Climate Panorama*, Paris.

A final key component of the PIA is the **Industrial Projects of the future (PIAVE)** initiative, co-ordinated by BPI France (*Banque publique d'investissement*) which started in 2015. Targeted areas are aligned with the 34 plans under the new national industrial reindustrialisation and development policy, the New Industrial France (*Nouvelle France Industrielle*), which was launched in 2013, with a focus on projects not receiving other public funds.

Overall public expenditure on RD&D in France amounted to 2.29% of GDP, 16% above the IEA average, while public expenditure on energy RD&D reached EUR 1 054.3 million in 2014, the latest available data. France has the highest nuclear RD&D among IEA countries as a share of GDP. Energy RD&D expenditure increased by an annual 12% since 2011, thanks to higher energy efficiency funding, but subsequently decreased in 2014 to reach 2009 levels.

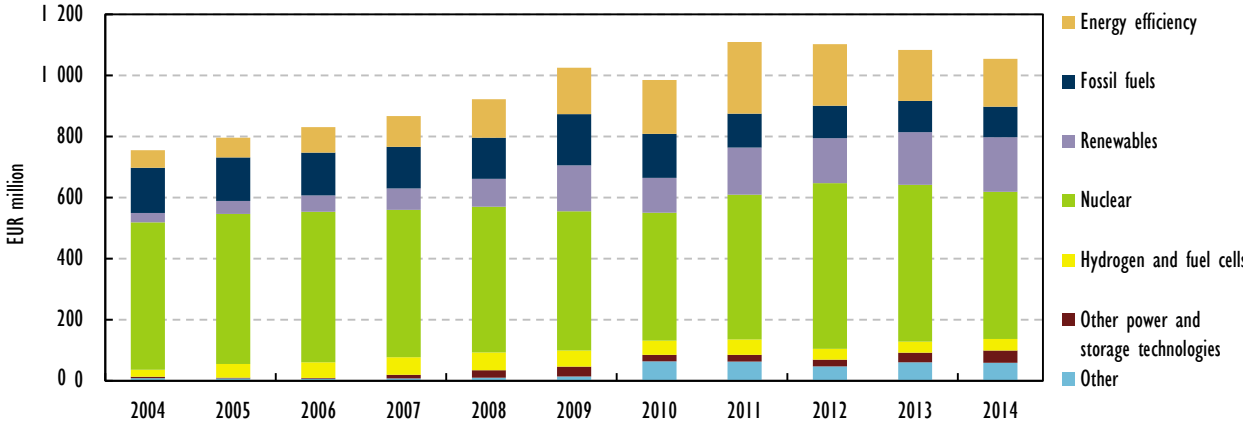
Figure 11.2 Government energy RD&D spending as a ratio of GDP in IEA member countries, 2014



Notes: Includes demonstration. Data are not available for Greece, Hungary, Ireland Italy, Korea and Luxembourg.

Source: IEA (2016), *"RD&D budget", Energy Technology RD&D* (database), www.iea.org/statistics/.

Figure 11.3 Government energy RD&D spending, including demonstration, in France, 2004-14



Source: IEA (2016), *"RD&D budget", Energy Technology RD&D* (database), www.iea.org/statistics/.

PRIVATE SECTOR

France's energy industry is a leading sector in energy RD&D investment. In total, EDF, ENGIE and AREVA dedicate around EUR 1 billion per year to R&D in low-carbon technologies. The French state has significant shareholdings in the sector.

EDF accounts for 40% of EU-wide spending of all energy utilities on R&D (ESMT Innovation Index). In 2016, EDF opened its R&D Lab in Paris-Saclay, with around 1000 staff. Paris-Saclay is the research and innovation cluster that accounts for 20% of French R&D expenditure.

According to the State Shareholding Agency (*Agence des participations de l'État, APE*), EDF had a budget of about EUR 440 million per year, mainly focused on nuclear (France, United Kingdom) and intelligent grids, energy efficiency and electric vehicles as well as renewable energies. The R&D budget of ENGIE for low carbon technologies amounted to EUR 200 million per year along three key priorities (low-carbon power generation, intelligent energy management, notably in cities, and the natural gas supply chain of the future). The R&D budget of AREVA was EUR 231 million in 2014 and EUR 273 million in 2013.

Table 11.1 illustrates the position of the French energy business in the latest available global ranking of the EU Industrial R&D Investment Scoreboard which ranks the world top 2 500 companies across several industrial sectors in 2013.

Table 11.1 Global ranking of France's energy sector R&D spending, 2013

Global ranking	Name	Industrial sector	R&D 2013 (EUR million)	R&D average 3-years growth	Sales 2013 (EUR million)	R&D intensity
102	Alstom	Industrial engineering	1 012	1.8%	20 269	5.0%
116	Total	Oil and gas producers	949	9.9%	171 655	0.6%
156	Électricite de France (EDF)	Electricity	718	13.9%	75 594	0.9%
266	AREVA	Electricity	354	-21.8%	9 240	3.8%
481	GDF Suez (now ENGIE)	Gas, water and multi-utility	161	-10.2%	89 300	0.2%

Source: JRC (2014), *2014 EU Industrial R&D Investment Scoreboard*.

PRIORITIES

France has a long-standing goal of achieving RD&D investment parity between nuclear and other new energy technologies. While an equal share has not yet been reached, the technology mix has changed significantly. Fossil fuel RD&D funding has decreased by 30% since 2009, as funding has been redirected towards low-carbon technologies. In particular, funding for renewable energy technology RD&D has increased by 50% over the last six years. Biomass technologies account for over half RD&D on renewable energy.

Reflecting the strategic priorities of the French electricity industry, public research funding on future electricity grids has grown threefold since 2009. Progress towards the long-term strategy of rebalancing RD&D priorities in favour of other low-carbon technologies beyond nuclear R&D is ongoing. The new SNRE is to address the energy-specific challenges raised in the previous strategy (SNR), notably multi-scale governance

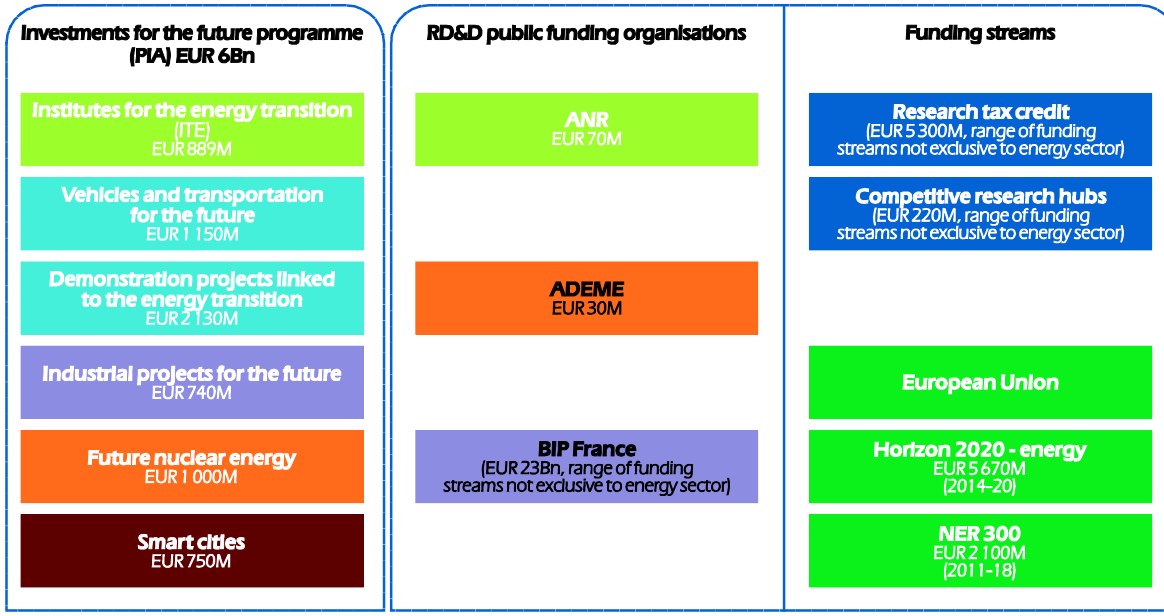
of energy systems; dynamic management of energy systems; energy efficiency; reduced needs for strategic materials; and decarbonisation of energy and chemistry sectors.

INTERNATIONAL COLLABORATION

France participates in several regional or international collaborative efforts, particularly those focusing on renewable energies and smart grids. The country participates in 24 IEA Technology Collaboration Programmes (TCPs) focusing on smart grids, renewables, energy modelling and energy-efficient equipment and buildings.

France also participates in all TCPs related to fusion power, and is the site of the international thermonuclear experimental reactor (ITER), the major international initiative to build a first full-scale electricity-producing fusion power station. The ITER reactor is expected to be fully commissioned by 2020 25 and begin fusion experiments in 2027-32. France is in the process of withdrawing from the Hydropower TCP and of becoming a member of the Ocean TCP. In addition, France (and other EU members) participates in the fusion-related TCPs through the European Atomic Energy Community (EURATOM).

Figure 11.4 Funding streams and institutions for public RD&D



France is a key participant in the European Strategic Energy Technology (SET) Plan, the European Union's central co-ordination effort for energy RD&D launched in 2008. France participates in several European Research Area Networks (ERA-NETs). These are networks of national science and technology funding organisations in Europe which aim to co-ordinate national and regional activities and research programmes. Participants in the ERA-NET projects can be co-funded via the EU Framework Programme for Research, Technological Development and Demonstration activities. France is actively participating in ERA-NET activities, particularly within the fields of advanced electricity systems, and energy efficiency in buildings and transportation.

French energy RD&D actors are also involved in a number of EERA Joint Programmes[2], contributing to the co-ordination of public research efforts to develop low-carbon technologies.

Figure 11.5 Participation in IEA Technology Collaboration Programmes (TCPs)

End-use technologies	
Buildings	
Buildings and Community Systems (EBC TCP)	●
District Heating and Cooling (DHC TCP)	
Efficient Electrical End-Use Equipment (4E TCP)	●
Energy Storage (ECES TCP)	●
Heat Pumping Technologies (HPT TCP)	●
Electricity	
Demand-side Management (DSM TCP)	
Smart Grids (ISGAN TCP)	●
High-Temperature Superconductivity (HTS TCP)	
Industry	
Clean and Efficient Combustion (Combustion TCP)	
Industrial Technologies and Systems (IETS TCP)	
Transport	
Advanced Fuel Cells (AFC TCP)	●
Advanced Materials for Transportation (AMT TCP)	
Advanced Motor Fuels (AMF TCP)	●
Hybrid and Electric Vehicles (HEV TCP)	●
Fossil fuels	
Clean Coal Centre (CCC TCP)	
Enhanced Oil Recovery (EOR TCP)	●
Fluidized Bed Conversion (FBC TCP)	●
Gas and Oil Technologies (GOTCP)	
Greenhouse Gas R&D (GHG TCP)	●

Renewable energy and hydrogen	
Bioenergy TCP	●
Concentrating Solar Power (SolarPACES TCP)	●
Geothermal TCP	●
Hydrogen TCP	●
Hydropower	●
Ocean Energy Systems (OES TCP)	
Photovoltaic Power Systems (PVPS TCP)	●
Renewable Energy Tech. Deployment (RETD TCP)	●
Solar Heating and Cooling (SHC TCP)	●
Wind Energy Systems (Wind TCP)	●
Fusion power	
Co-operation on Tokamak Programmes (CTP TCP)	
Environmental, Safety and Economic Aspects of Fusion Power (ESEFP TCP)	
Fusion Materials (FM TCP)	
Nuclear Technology Fusion Reactors	
Plasma Wall Interaction (PWI TCP)	
Reversed Field Pinches (RFP TCP)	
Spherical Tori (ST TCP)	
Stellarator-Heliotron Concept (SH TCP)	
Cross-cutting	
Climate Technology Initiative (CTI TCP)	
Energy Technology Systems Analysis (ETSAP TCP)	●

ASSESSMENT

The energy RD&D framework in France is based on the 2007 energy RD&D strategy and the Grenelle Environment I and II Acts. A new energy strategy for RD&D (SNRE) is currently being prepared by the two ministries in charge of energy and of research, and is to be adopted by end of 2016.

The National Strategy for RD&D was introduced in March 2015, setting several priorities and directions with ten research challenges, among which '"clean, safe and efficient energy", and five key areas that should be part of the forthcoming strategy: multi-scale governance of energy systems; dynamic management of energy systems; energy efficiency; reduced needs for strategic materials; and decarbonisation of the energy and chemistry sectors. These challenges reflect the needs for both the direction and the stated targets in the Energy Transition for Green Growth Act, and the competitive advantages of French industrial and RD&D institutions. The Act specifies that the national strategy is to be drafted in accordance with the pluriannual energy programming (PPE) process and the national low-carbon strategy. Drafting the SNRE, starting in 2016, implied a large consultation with the relevant stakeholders, in particular ANCRE and ADEME. According to a second specification of the Act, the new strategy is to

2. European Energy Research Alliance (www.eera-set.eu/).

be developed in collaboration with local governments so as to address the multi-faceted governance of the energy system. The specific articulation of this requirement is yet to be determined.

The Energy Transition for Green Growth Act requires that the new National Energy RD&D Strategy and its funding be properly aligned with the energy and climate goals, a key goal being the reduction in the share of electricity generated from nuclear power. The RD&D strategy will reflect the future needs for the nuclear fleet, notably safety, decommissioning, waste management and new builds. The short- to medium-term research on the existing reactors will be financed mainly by industry, in particular to reduce the costs of construction and generation, and to maintain the highest safety levels.

Given the goal of achieving a 40% share of electricity generated from renewables by 2030, it will also be important to increase the flexibility of the nuclear fleet and adapt its operation to variable and uncertain electricity supply from intermittent renewable sources. Next to large reactors, France should also research the potential for small and medium reactors, in step with global developments with a view towards export opportunities. Indeed, these smaller reactors may show flexibility to adapt to the evolution of the electricity grid, contribute to co-generation and other non-electric applications, and be more affordable owing to their lower total capital investment and their shorter construction time.

Finally, France will pursue its R&D efforts to develop Generation IV reactor designs with the ASTRID demonstration reactor programme and associated research on the closed fuel cycle. It is envisaged to construct a 600 MW_e prototype of a commercial series of sodium-cooled fast reactors (SFR) which are likely to be deployed as from about 2050.

Funding priorities and levels have remained stable since 2009, with a slight peak in 2011 thanks to higher energy efficiency investments. The diversification of RD&D funding sources and technology areas achieved since 2007 is good, even if nuclear energy still dominates public energy RD&D expenditure. While the goal of full parity in the RD&D budget between nuclear and new energy technologies is yet to be reached, France is emerging as a world leader in smart grid and system integration technologies.

The ambitious target in the Energy Transition for Green Growth Act of reaching a 40% share of renewable energies in the generation mix should be complemented by further efforts in the technologies and strategies that afford a low-cost integration of wind and solar power.

Smart grid technology is a focus area of France, ranking first in an analysis by the European Commission's Joint Research Centre. France has several advanced demonstration projects, and has designated some regions to develop high scale pilot projects (for instance SMILE in Bretagne-Pays de Loire and FLEXGRID in PACA region in the south-east of France). The new Industrial Plan for Smart Grids dedicates EUR 200 million to these projects (contributions from network operators, PIA, local authorities, etc.). France is well placed to innovate in areas that can support its energy transition. RD&D priorities on technology solutions to increase flexibility of power systems are welcome, in particular power-to-gas and other demand-response technologies. The public RD&D budget for storage technologies is a fundamental pillar which should be strengthened for a widespread deployment that may not be adequately addressed by the private sector.

Given the ambitious goals in the Energy Transition for Green Growth Act for building renovations, and the diversity of the French building stock, particular attention should be paid to standardisation and modular designs of retrofitting technologies. Accelerating the speed of the transition towards sustainable buildings will require stronger links between the deployment and capacity building agencies and the actors in the research and demonstration phases.

France has yet to develop an integrated research planning, with a feedback process for evaluating the effectiveness of its national energy research strategy. There is a general review procedure for R&D through the *Haut Conseil d'évaluation de la recherche et de l'enseignement supérieur* which evaluates the general performance of individual research centres on a qualitative basis. The National Alliance for the Co-ordination of Research (ANCRE) was created to address some of these issues and contribute to a national strategy formulation by raising awareness of gaps in French energy RD&D and by increasing the collaboration between research bodies and industry. As France continues to implement its low-carbon transition, the role of such institutions and processes will need to be reinforced.

RECOMMENDATIONS

The government of France should:

- *Reinforce the national strategy for energy RD&D and its funding to be consistent with long-term goals of the Energy Transition for Green Growth Act by formalising the co-ordination between the ministries, the National Research Agencies, and local authorities when developing the new national energy RD&D strategy and its revision every five years.*
- *Put in place a systematic mechanism for monitoring and evaluating the effectiveness of research programmes. Assess the continuity between research, demonstration and deployment activities.*
- *In line with the energy transition, reinforce innovation activity in smart grids, storage, electric vehicles and demand-side flexibility, in support of variable renewable electricity integration.*

References

IEA (International Energy Agency) (2016), "RD&D budget", *IEA Energy Technology RD&D* (database), www.iea.org/statistics/.

JRC (European Commission Joint Research Centre (2014), *2014 EU Industrial R&D Investment Scoreboard,* available at: http://iri.jrc.ec.europa.eu/documents/10180/354280/Scoreboard%202014%20Ranking%20world%20top%202500%20companies.

MEDDE (Ministry of Ecology, Sustainable Development and Energy) (2015), *Energy and Climate Panorama*, MEDDE, Paris.

PART III
ANNEXES

ANNEX A: ORGANISATION OF THE REVIEW

REVIEW CRITERIA

The Shared Goals, which were adopted by the 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 C.

REVIEW TEAM

The review team visited France from 19 to 23 October 2015. The team met with government officials, energy industry, interest groups and various other organisations. This report was drafted on the basis of these meetings, the team's preliminary assessment of the country's energy policy, the government response to the IEA energy policy questionnaire and developments that took place since the visit in 2015.

The members of the team were:

IEA member countries

Mr. Bo Diczfalusy, Sweden (team leader)

Ms María Jiménez Navarro, Spain

Mr. Marc Deprez, Belgium

Mr. James Baker, United Kingdom

Mr. Ralf Vermeer, Netherlands

European Commission

Mrs Camille Hubac

OECD Nuclear Energy Agency (NEA)

Mr. Marc Deffrennes

International Energy Agency

Mr. Aad van Bohemen

Mr. Luis Munuera

Ms Costanza Jacazio

Ms Sylvia Beyer (desk officer)

The team is grateful for the co-operation and assistance of the many people it met throughout the visit and the review project. Thanks to the hospitality, openness and willingness to share information, the visit was highly informative, productive and enjoyable. The team wishes to express its gratitude to MEEM Mr. Laurent Michel, Director General in the Ministry of Environment, Energy and the Sea, and his team, notably Mr. Richard Lavergne, Mr. Julien Tognola, Ms Georgina Grenon, and Mr. Quentin Perret for their input and support throughout the visit and their ability to respond to the team's many requests. The team is also grateful to the French Energy Regulator CRE and the Energy Ombudsman of France for inviting the review team for discussions in their premises and providing information to the IEA.

Sylvia Beyer managed the review and drafted the report, with the exception of Chapter 5 on Natural Gas (drafted by Ms Costanza Jacazio), Chapter 11 on Energy RD&D (drafted by Mr. Luis Munuera) and Chapter 10 on Nuclear Energy (drafted by Mr. Marc Deffrennes). Ms Soyeon Park, Ms Sonja Lekovic and Ms Yun Ji Suh drafted the supply and demand sections of the report.

The report was prepared under the guidance of Aad van Bohemen, Head of IEA Country Studies Division. Helpful comments were provided by the review team members and the following IEA staff, including Manuel Baritaud, Cédric Philibert, Carlos Fernández Alvarez, Rebecca Gaghen, and Caroline Lee. Useful comments and synergies were provided by the OECD Environment Directorate which carried out the *Environmental Policy Review of France* in 2016, Ms Frédérique Zegel and Ms Virginie Marchal.

Special thanks go to the IEA Secretariat with regard to the data, publication and editing. The report has received valuable support with timely and comprehensive data from Ms Roberta Quadrelli, Mr. Remi Gigoux, Ms Soyeon Park, and Ms Yun Ji Suh from the IEA energy statistics and energy balances, including the RD&D and the Energy Efficiency Indicators Databases.

Mr. Oskar Kvarnström and Mr. Bertrand Sadin ensured the preparation and design of the figures, maps and tables. The IEA Communication and Information Office (CIO), in particular Ms Rebecca Gaghen, Ms Astrid Dumond, Mr. Bertrand Sadin and Ms Madgalena Sanocka, provided essential support towards the report's production and launch. The author thanks in particular for the time and dedication of Ms Viviane Consoli, Ms Therese Walsh and Ms Rebecca Gaghen who ensured the editorial finalisation of the report.

ORGANISATIONS VISITED

French Alternative Energies and Atomic Energy Commission (CEA)

Agence de l'environnement et de la maîtrise de l'énergie / Environment and Energy Management Agency (ADEME)

Alliance Nationale de Coordination de la Recherche pour l'Énergie (ANCRE)

Agence régionale de l'environnement et des nouvelles énergies Île-de-France (ARENE IdF)

Association nationale de défense des consommateurs et usagers (CLCV)

Association Française Indépendante de l'Électricité et du Gaz (AFIEG)

Association Nationale des Opérateurs Détaillants en Énergie (A.N.O.D.E)

Autorité de Sûreté Nucléaire / Nuclear Safety Authority (ASN)

Commission de Régulation de l'Énergie / Regulatory Commission of Energy (CRE)

Directions régionales de l'environnement, de l'aménagement et du logement (DREAL)

Directions régionales de l'environnement, de l'aménagement et du logement Île-de-France (DRIEE)

Électricité de France (EDF)

ENGIE

Energy ombudsman/Médiateur national de l'Énergie

Fédération nationale des collectivités concédantes et régies (FNCCR)

Fédération nationale des syndicats d'exploitants agricoles (FNSEA)

GRTgaz

Institut Français du Pétrole Énergies Nouvelles (IFPEN)

Ministère de l'Environnement, de l'Énergie et de la Mer/Ministry of Environment, Energy and the Sea (MEEM)

Mouvement des Entreprises de France (MEDEF)

Réseau de Transport d'Électricité (RTE)

Syndicat des énergies renouvelables (SER)

Réseau pour la transition énergétique (CLER)

Réseau Action Climat (RAC)

Union Professionnelle des Industries Privées du Gaz (UPRIGAZ)

Union Française des Industries Pétrolières (UFIP)

Union Française de l'Électricité (UFE)

UFC Que Choisir

WWF France

ANNEX B: ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2013	2014	2015E
TOTAL PRODUCTION		**44.2**	**111.9**	**130.7**	**135.4**	**135.7**	**137.1**	**137.3**
Coal		18.0	8.2	2.5	0.2	0.2	0.2	0.0
Peat		-	-	-	-	-	-	-
Oil		2.1	3.5	1.8	1.1	1.0	0.9	1.0
Natural gas		6.3	2.5	1.5	0.6	0.3	0.0	0.0
Biofuels and waste[1]		9.8	11.0	10.8	15.3	15.7	14.5	14.8
Nuclear		3.8	81.9	108.2	111.7	110.4	113.7	114.0
Hydro		4.1	4.6	5.7	5.4	6.1	5.4	4.7
Wind		-	-	0.0	0.9	1.4	1.5	1.8
Geothermal		0.0	0.1	0.1	0.2	0.2	0.2	0.2
Solar/other[2]		0.0	0.1	0.1	0.2	0.5	0.7	0.8
TOTAL NET IMPORTS[3]		**138.3**	**113.8**	**124.8**	**123.2**	**116.5**	**106.8**	**107.7**
Coal	Exports	1.3	0.6	0.5	0.2	0.1	0.0	0.1
	Imports	10.8	13.7	13.5	12.4	11.8	9.2	8.8
	Net imports	9.5	13.0	13.0	12.2	11.6	9.2	8.7
Oil	Exports	13.6	14.6	22.7	23.1	19.2	19.0	21.3
	Imports	142.2	100.5	112.5	104.9	97.7	95.8	98.2
	Int'l marine and aviation bunkers	-7.2	-5.6	-7.9	-7.8	-7.7	-7.4	-7.3
	Net imports	121.5	80.3	82.0	74.0	70.8	69.3	69.6
Natural Gas	Exports	0.1	0.3	0.7	2.6	4.5	6.4	4.9
	Imports	7.6	24.7	36.4	42.1	42.5	40.1	39.4
	Net imports	7.6	24.4	35.8	39.5	38.0	33.8	34.6
Electricity	Exports	0.6	4.5	6.3	4.3	5.2	6.5	6.4
	Imports	0.4	0.6	0.3	1.7	1.0	0.7	0.9
	Net imports	-0.2	-3.9	-6.0	-2.6	-4.2	-5.8	-5.5
TOTAL STOCK CHANGES		**-2.3**	**-1.7**	**-3.5**	**2.6**	**0.8**	**-1.3**	**0.7**
TOTAL SUPPLY (TPES)[4]		**180.1**	**224.0**	**251.9**	**261.2**	**253.0**	**242.6**	**245.7**
Coal		29.3	20.2	15.0	12.1	12.4	9.3	8.9
Peat		-	-	-	-	-	-	-
Oil		119.8	84.0	82.2	75.6	71.2	70.2	70.7
Natural gas		13.5	26.0	35.8	42.5	39.0	32.6	35.0
Biofuels and waste[1]		9.8	11.0	10.8	15.4	15.9	14.8	15.1
Nuclear		3.8	81.9	108.2	111.7	110.4	113.7	114.0
Hydro		4.1	4.6	5.7	5.4	6.1	5.4	4.7
Wind		-	-	0.0	0.9	1.4	1.5	1.8
Geothermal		0.0	0.1	0.1	0.2	0.2	0.2	0.2
Solar/other[2]		0.0	0.1	0.1	0.2	0.5	0.7	0.8
Electricity trade[5]		-0.2	-3.9	-6.0	-2.6	-4.2	-5.8	-5.5
Shares in TPES (%)								
Coal		*16.3*	*9.0*	*6.0*	*4.6*	*4.9*	*3.8*	*3.6*
Peat		-	-	-	-	-	-	-
Oil		*66.5*	*37.5*	*32.6*	*28.9*	*28.1*	*29.0*	*28.8*
Natural gas		*7.5*	*11.6*	*14.2*	*16.3*	*15.4*	*13.4*	*14.3*
Biofuels and waste[1]		*5.4*	*4.9*	*4.3*	*5.9*	*6.3*	*6.1*	*6.1*
Nuclear		*2.1*	*36.5*	*43.0*	*42.8*	*43.6*	*46.9*	*46.4*
Hydro		*2.3*	*2.1*	*2.3*	*2.1*	*2.4*	*2.2*	*1.9*
Wind		-	-	-	*0.3*	*0.5*	*0.6*	*0.7*
Geothermal		*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Solar/other[2]		*0.0*	*0.0*	*0.0*	*0.1*	*0.2*	*0.3*	*0.3*
Electricity trade[5]		*-0.1*	*-1.7*	*-2.4*	*-1.0*	*-1.6*	*-2.4*	*-2.2*

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.

2015 estimated data are only available for energy supply and economic indicators.

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015E**
TFC	**142.2**	**143.2**	**163.2**	**161.4**	**157.5**	**147.7**	**..**
Coal	14.0	7.8	4.4	3.5	3.2	3.2	..
Peat	-	-	-	-	-	-	..
Oil	96.0	75.2	81.2	71.6	68.4	67.3	..
Natural gas	10.3	23.9	32.1	33.0	33.3	28.2	..
Biofuels and waste[1]	8.9	9.7	9.0	11.6	12.2	10.9	..
Geothermal	0.0	0.1	0.1	0.0	0.0	0.0	..
Solar/other[2]	-	0.0	0.0	0.1	0.1	0.1	..
Electricity	12.8	26.0	33.1	38.2	37.9	35.7	..
Heat	0.3	0.5	3.2	3.5	2.3	2.2	..
Shares in TFC (%)							
Coal	*9.8*	*5.4*	*2.7*	*2.1*	*2.0*	*2.1*	..
Peat	-	-	-	-	-	-	..
Oil	*67.5*	*52.5*	*49.7*	*44.3*	*43.4*	*45.6*	..
Natural gas	*7.2*	*16.7*	*19.7*	*20.4*	*21.2*	*19.1*	..
Biofuels and waste[1]	*6.3*	*6.7*	*5.5*	*7.2*	*7.8*	*7.4*	..
Geothermal	*0.0*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	..
Solar/other[2]	-	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	..
Electricity	*9.0*	*18.2*	*20.3*	*23.7*	*24.1*	*24.2*	..
Heat	*0.2*	*0.3*	*2.0*	*2.2*	*1.5*	*1.5*	..
TOTAL INDUSTRY[6]	**56.3**	**46.3**	**50.9**	**40.8**	**41.7**	**39.9**	**..**
Coal	7.3	6.1	3.8	3.1	2.9	2.9	..
Peat	-	-	-	-	-	-	..
Oil	35.0	17.8	19.3	15.8	14.9	15.2	..
Natural gas	5.7	11.1	14.7	10.4	12.9	10.9	..
Biofuels and waste[1]	1.2	1.5	1.6	1.5	1.4	1.3	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	-	-	-	..
Electricity	7.2	9.9	11.6	10.1	9.6	9.6	..
Heat	-	-	-	-	-	-	..
Shares in total industry (%)							
Coal	*12.9*	*13.2*	*7.5*	*7.5*	*6.9*	*7.3*	..
Peat	-	-	-	-	-	-	..
Oil	*62.1*	*38.3*	*37.9*	*38.6*	*35.8*	*38.1*	..
Natural gas	*10.0*	*23.9*	*28.8*	*25.5*	*30.9*	*27.3*	..
Biofuels and waste[1]	*2.1*	*3.2*	*3.1*	*3.6*	*3.4*	*3.3*	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	-	-	-	..
Electricity	*12.8*	*21.3*	*22.7*	*24.7*	*23.0*	*24.0*	..
Heat	-	-	-	-	-	-	..
TRANSPORT[4]	**24.7**	**38.6**	**45.0**	**43.8**	**43.3**	**43.5**	**..**
OTHER[7]	**61.2**	**58.2**	**67.3**	**76.8**	**72.5**	**64.2**	**..**
Coal	6.6	1.7	0.6	0.4	0.3	0.3	..
Peat	-	-	-	-	-	-	..
Oil	37.0	19.6	18.2	15.5	14.0	12.6	..
Natural gas	4.6	12.8	17.5	22.5	20.4	17.2	..
Biofuels and waste[1]	7.7	8.2	7.1	7.7	8.1	6.7	..
Geothermal	0.0	0.1	0.1	0.0	0.0	0.0	..
Solar/other[2]	-	0.0	0.0	0.1	0.1	0.1	..
Electricity	5.0	15.4	20.5	27.0	27.2	25.1	..
Heat	0.3	0.5	3.2	3.5	2.3	2.2	..
Shares in other (%)							
Coal	*10.8*	*2.9*	*0.9*	*0.5*	*0.4*	*0.4*	..
Peat	-	-	-	-	-	-	..
Oil	*60.4*	*33.7*	*27.0*	*20.2*	*19.4*	*19.6*	..
Natural gas	*7.5*	*22.0*	*26.0*	*29.3*	*28.1*	*26.8*	..
Biofuels and waste[1]	*12.6*	*14.0*	*10.5*	*10.1*	*11.2*	*10.4*	..
Geothermal	-	*0.2*	*0.2*	*0.0*	*0.0*	*0.0*	..
Solar/other[2]	-	-	-	*0.1*	*0.1*	*0.2*	..
Electricity	*8.2*	*26.4*	*30.5*	*35.2*	*37.6*	*39.0*	..
Heat	*0.4*	*0.8*	*4.8*	*4.6*	*3.2*	*3.5*	..

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.
2015 estimated data are only available for energy supply and economic indicators.

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015E**
ELECTRICITY GENERATION[8]							
Input (Mtoe)	36.7	98.3	127.6	137.5	133.2	131.9	..
Output (Mtoe)	15.7	35.9	46.0	48.5	48.8	47.9	48.4
Output (TWh)	182.5	417.2	535.2	564.3	567.2	557.0	563.2
Output Shares (%)							
Coal	*19.7*	*8.5*	*5.8*	*4.7*	*4.3*	*2.2*	*2.2*
Peat	-	-	-	-	-	-	-
Oil	*40.2*	*2.1*	*1.3*	*1.0*	*0.4*	*0.3*	*0.3*
Natural gas	*5.5*	*0.7*	*2.2*	*4.2*	*3.0*	*2.3*	*3.5*
Biofuels and waste[1]	*0.1*	*0.4*	*0.7*	*1.1*	*1.2*	*1.2*	*1.3*
Nuclear	*8.1*	*75.3*	*77.6*	*75.9*	*74.7*	*78.4*	*77.7*
Hydro	*26.1*	*12.9*	*12.4*	*11.1*	*12.5*	*11.3*	*9.7*
Wind	-	-	-	*1.8*	*2.8*	*3.1*	*3.8*
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	*0.3*	*0.1*	*0.1*	*0.2*	*1.0*	*1.2*	*1.5*
TOTAL LOSSES	**38.1**	**76.3**	**94.0**	**98.9**	**93.6**	**93.3**	**-0.2**
of which:							
Electricity and heat generation[9]	20.8	62.0	78.3	85.2	81.2	81.1	..
Other transformation	5.3	2.4	1.9	1.3	1.8	1.8	-0.2
Own use and transmission/distribution losses[10]	12.1	11.9	13.8	12.5	10.6	10.4	..
Statistical Differences	**-0.2**	**4.5**	**-5.3**	**0.9**	**1.9**	**1.7**	**..**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015E**
GDP (billion 2010 USD)	1223.98	1907.28	2346.48	2646.84	2724.58	2729.47	2761.02
Population (millions)	53.33	58.23	60.87	64.97	65.88	66.17	66.49
TPES/GDP (toe/1000 USD)[11]	0.15	0.12	0.11	0.10	0.09	0.09	0.09
Energy production/TPES	0.25	0.50	0.52	0.52	0.54	0.57	0.56
Per capita TPES (toe/capita)	3.38	3.85	4.14	4.02	3.84	3.67	3.70
Oil supply/GDP (toe/1000 USD)[11]	0.10	0.04	0.04	0.03	0.03	0.03	0.03
TFC/GDP (toe/1000 USD)[11]	0.12	0.08	0.07	0.06	0.06	0.05	..
Per capita TFC (toe/capita)	2.67	2.46	2.68	2.48	2.39	2.23	..
CO_2 emissions from fuel combustion ($MtCO_2$)[12]	474.2	345.5	364.6	340.1	317.1	285.7	..
CO_2 emissions from bunkers ($MtCO_2$)[12]	22.6	17.3	24.2	23.9	23.6	22.7	..
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-12**	**12-13**	**13-14**	**14-15**
TPES	1.3	1.2	0.4	-1.8	0.4	-4.1	1.3
Coal	-2.2	-2.9	-2.2	-2.5	8.5	-25.4	-4.4
Peat	-	-	-	-	-	-	-
Oil	-2.1	-0.2	-0.8	-1.5	-2.9	-1.3	0.6
Natural gas	3.9	3.2	1.7	-5.2	2.1	-16.4	7.5
Biofuels and waste[1]	0.7	-0.2	3.7	-1.7	6.8	-7.0	2.0
Nuclear	19.7	2.8	0.3	-0.4	-0.4	3.0	0.2
Hydro	0.7	2.1	-0.6	-3.2	20.4	-11.2	-12.6
Wind	-	-	71.0	22.5	7.5	7.5	22.8
Geothermal	26.6	1.4	3.3	2.3	18.0	1.4	0.9
Solar/other[2]	2.1	-0.5	9.4	71.4	14.1	22.5	20.2
TFC	0.0	1.3	-0.1	-2.2	2.0	-6.2	..
Electricity consumption	4.3	2.4	1.4	-1.1	1.5	-5.8	..
Energy production	5.6	1.6	0.4	-0.5	1.3	1.0	0.1
Net oil imports	-2.4	0.2	-1.0	-1.4	-1.6	-2.1	0.4
GDP	2.6	2.1	1.2	1.1	0.7	0.2	1.2
TPES/GDP	-1.3	-0.9	-0.8	-2.9	-0.2	-4.3	0.1
TFC/GDP	-2.5	-0.8	-1.3	-3.3	1.4	-6.4	..

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.

2015 estimated data are only available for energy supply and economic indicators.

Footnotes to energy balances and key statistical data

1. Biofuels and waste comprises 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 peat, biofuels and waste and trade of heat.
4. Excludes international marine bunkers and international aviation bunkers.
5. Total supply of electricity represents net trade. A negative number in the share of TPES 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, CHP 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 and solar thermal, 10% for geothermal and 100% for hydro, wind and solar photovoltaic.
10. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
11. Toe per thousand US dollars at 2010 prices and exchange rates.
12. "CO_2 emissions from fuel combustion" have been estimated using the IPCC Tier I Sectoral Approach from the 2006 IPCC Guidelines. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 2013 and applying this factor to forecast energy supply. Projected emissions for coal are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

ANNEX C: 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 Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

ANNEX D: 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.

AFNI	*Agence France Nucléaire International*
AODE	*Autorité organisatrices de la distribution d'énergie*
ARENH	*l'accès régulé à l'électricité nucléaire historique*
BEV	battery electric vehicle
CCS	carbon capture and storage
CdC	*Cour des Comptes*
CEF	Connecting Europe Facility
CIM	*Compagnie Industrielle Maritime*
CITE	credit for the energy
CNRS	*Centre National de Recherche Scientifique*
CPN	*Conseil de politique nucléaire*
CPSSP	*Comité professionnel des stocks stratégiques pétroliers*
DEAL	*De l'aménagement et du logement*
DGEC	Directorate-General for Energy and Climate
DHC	district heating and cooling
DNTE	Debate on the Energy
DOM	*D'outre-mer*
DR	demand response
DRM	demand-response management
DSM	demand-side management
DSO	distribution system operator
EC	European Commission
EED	Energy Efficiency Directive
ELD	*entreprises locales de distribution*
EPC	energy performance certificate
EPR	European Pressurised Water Reactor
ESC	energy saving certificates
ESG	environmental, social and corporate governance
ETS	Emissions Trading Scheme
EU	European Union
EU-ETS	European Emissions Trading Scheme
EURATOM	European Atomic Energy Community
EV	electric vehicle
FCR	frequency containment reserves
FID	final investment decision
FIT	feed-in tariffs
FNCCR	*Fédération nationale des collectivités concédantes et régies*

FQD	Fuel Quality Directive
FTE	full-time equivalent
GHG	greenhouse gas
GDP	gross domestic product
HEP	high energy performance
HHI	Herfindahl-Hirschman index
IAEA	International Atomic Energy Agency
ICV	internal combustion engine vehicles
IED	Industrial Emission Directive
IFPEN	*Institut français du pétrole énergies nouvelles*
IRD	Institute of Research for Development
ITER	international thermonuclear experimental reactor
ITO	independent transmission operator
JHR	Jules Horowitz reactor
LCOE	levelised cost of electricity
LCPD	Large Combustion Plant Directive
LEB	low-energy building
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LTO	long-term operation
LULUCF	land use, land-use change and forestry
MESR	Ministry of Higher Education and Research
MHI	Mitsubishi Heavy Industries
NAP	national allocation plan
NDC	Nationally Determined Contributions
NEEAP	National Energy Efficiency Action Plan
NESO	National Emergency Structure Organisation
NGL	natural gas liquids
NPP	nuclear power plants
NREAP	National Renewable Energy Action Plan
OECD	Organisation for Economic Co-operation and Development
ONFI	ONF International
OPEC	Organization of the Petroleum Exporting Countries
OPECST	*Office parlementaire d'évaluation des choix scientifiques et techniques*
OPEN	*Observatoire permanent de l'amélioration énergétique du logement*
PE	primary energy
PFN	*Plateforme France Nucléaire*
PHEV	plug-in hybrid electric vehicles
PPE	programmation pluriannuelle de l'énergie
PPI	programmation pluriannuelle de l'investissement
PPP	purchasing power parity
PWR	pressurised water reactor
RAC	*Réseau Action Climat*
R&D	research and development
RD&D	research, development and demonstration
RED	Renewable Energy Directive
RR	restoration reserves
SAGESS	*Société anonyme de gestion des stocks de sécurité*
SFR	sodium-cooled fast reactors

SHEM	*Société Hydroélectrique du Midi*
SME	small and medium-sized enterprises
SSO	storage system operator
SWU	separation work unit
TCP	Technology Collaboration Programmes
TFC	total final energy consumption
TIGF	*Transport et Infrastructures Gaz de France*
toe	tonnes of oil equivalent
TPA	third party access
TPES	total primary energy supply
TSO	transmission system operator
TURPE	tarif d'utilisation des réseaux publics d'électricité
TYNDP	ten-year network development plan
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value-added tax
WENRA	Western European Nuclear Regulatory Authorities

UNITS OF MEASUREMENT

bcm	billion cubic metres
bcm/y	billion cubic metres/year
b/d	barrels per day
GW_e	gigawatt electrical capacity
GWh/d	gigawatt hours/day
kV	kilovolt
kW	kilowatt
L	litre
mcm	million cubic metres
Mt	million tonnes
$MtCO_2$	million tonnes carbon dioxide
Mtoe	million tonnes of oil equivalent
MW	megawatt
MW_e	megawatt electrical capacity
MWh	megawatt hour
MW_{th}	megawatt thermal capacity
tCO_2	tonne of CO_2
toe/y	tonne of oil-equivalent/year
TWh	terawatt hour


Online bookshop
www.iea.org/books
PDF versions at 20% discount
International Energy Agency
iea
Secure Sustainable Together
E-mail: books@iea.org
Global Gas Security series
Energy Technology Perspectives series
Energy Statistics series
Energy Policies Beyond IEA Countries series
Gas
Coal
Oil
World Energy Outlook series
Renewable Energy
Energy Efficiency Market Report
Energy Policies of IEA Countries series
World Energy Investment series
Medium-Term Market Reports series

IEA PUBLICATIONS,
International Energy Agency
Website: www.iea.org
Contact information: www.iea.org/aboutus/contactus

Cover design: IEA. Photo credits: © Graphic Obsession

Typeset in France by IEA, January 2017

IEA/OECD possible corrigenda on: www.oecd.org/about/publishing/corrigenda.htm

Energy Policies of IEA Countries

France

France has a significantly low-carbon electricity mix, owing to the key role of nuclear energy. However, much of France's nuclear fleet is reaching the end of its lifetime. Against this background, France has started an ambitious energy transition: it is a world leader in designing a governance framework with a national low-carbon strategy, carbon budgets, a carbon price trajectory and plans for energy investment.

France plans to reduce the share of nuclear to 50% in the electricity mix by 2025. While some nuclear reactors may continue long-term operation under safe conditions, maintaining security of supply and a low-carbon footprint while reducing nuclear energy will require investments in renewable energy and efficiency. The 2016 IEA review of France's energy policies highlights these and several other areas that are critical to the success of the energy transition. For example, planned growth of the share of electric vehicles and variable renewable electricity will require enhanced power system operation and flexibility, including demand-side response, smart grids and metering, and more interconnections.

The financing of this transition depends upon continued carbon price signals, increasingly open markets, competition, and consumer empowerment in gas and electricity retail markets.

This review analyses the energy policy challenges facing France and provides recommendations for further policy improvements. It is intended to help guide the country towards a more secure, sustainable and affordable energy future.