INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN for FRANCE

March 2020

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SECTION A: NATIONAL PLAN

1. OVERVIEW AND PROCESS FOR ESTABLISHING THE PLAN

1.1. Executive summary

1.1.1. Context and targets

This draft integrated national energy and climate plan for France is based on two documents adopted at national level on the governance and programming of matters relating to energy and climate.

- **The Multiannual Energy Plan (programmation pluriannuelle de l'énergie, MEP), which establishes the priorities for government action in the field of energy for the next 10 years, divided into two five-year periods. It covers all energy types and all of the cornerstones of energy policy (managing energy demand, promoting renewable energies, safeguarding security of supply, controlling energy costs, developing networks in a balanced manner, etc.), and makes it possible to forge a coherent and integrated vision of the role of energies in French society and desirable future trends in this respect.**
- **The National Low-Carbon Strategy (stratégie nationale bas-carbone, SNBC), which is France's roadmap for climate change mitigation. This provides guidelines to enable the transition to a low-carbon economy across all sectors. It specifies France's short-term and medium-term greenhouse gas (GHG) emissions reduction targets (carbon budgets) and aims to achieve carbon neutrality, i.e. net zero emissions, by 2050.**

The MEP and the SNBC are closely linked: the energy scenario in the MEP is identical to that in the SNBC for the period covered by the former. The MEP covers the first 10 years of the SNBC as regards energy consumption and the energy mix. The MEP adopts an operational approach to this 10-year period in terms of government action to decarbonise energy. Compliance with the projections of the SNBC for the period until 2050 represents one possible trajectory for achieving France's climate targets. The SNBC covers all greenhouse gases, some of which are not covered by the MEP.

The scope of the MEP is restricted to metropolitan France, whereas the SNBC also covers the overseas departments. As a result, the parts of these documents incorporated into the Integrated National Energy and Climate Plan (PNIEC) may vary slightly in terms of scope.

The Law on Energy Transition for Green Growth (LTECV) of 17 August 2015 sets out the principles underpinning the process for drafting these two documents. The SNBC and the first three carbon budgets were adopted by decree (Decree No 2015-1491 of 18 November 2015). The MEP for the period 2016–2023 was also adopted by decree (Decree No 2016-1442 of 27 October 2016). The MEP and the SNBC are linked in terms of compatibility: the LTECV provides for the MEP to be compatible with the SNBC and the GHG emissions reduction targets set in the carbon budgets.

The LTECV states that these two documents should be revised every five years, with the exception of the first revision, which was initially planned for the end of 2018 for the MEP and mid-2019 for the SNBC. A full revision cycle for the MEP and the SNBC therefore started in 2017 and continued throughout 2018. A draft revised version of the SNBC was published in December 2018 (hereinafter the 'draft SNBC 2'). Prior to its adoption by decree, the draft underwent a process of statutory consultation (involving the Environmental Authority, the High Council for Climate, the Corsican Assembly, the overseas authorities, the National Council for Standards Assessment, the Regulatory Impact Mission of the Secretariat General of the Government and the public). A draft version of the MEP for the period 2019–2028 (hereinafter the 'draft MEP 2') was published in January 2019. Prior to its adoption by decree, the draft underwent a process of statutory consultation involving the energy committees.

The current draft integrated national energy and climate plan for France incorporates sections from the draft SNBC 2 and the draft MEP 2, and follows the general framework outlined in Annex I to the Regulation on the governance of the Energy Union.

The SNBC 2 and the MEP 2 were drafted for the purpose of ensuring that France can comply with the energy and climate targets imposed on it by the EU. The following table contains the EU targets that apply to France and the figures forecast for 2030 under a scenario that assumes the implementation of France's energy and climate strategy.

	Target	Timeline	Forecast
Final energy consumption	National target of -20% compared to 2012 EU target of -32.5% compared to trend-based scenario	2030	120.9 Mtoe or -32.6% compared to PRIMES 2007
Primary energy consumption	No national target EU target of -32.5% compared to trend-based scenario	2030	202.2 Mtoe or -24.6% compared to PRIMES 2007
Share of renewable energy in gross final energy consumption	National target of 33% EU target of 32%	2030	41 Mtoe or 33%
Renewable and recovered heat and cold in district heating	+1% per year up to 60%	2030	+0.9% per year up to 65%
Increase in the rate of renewable and recovered heat	+1.3% per year	2030	Between +1.2% and +1.8% per year
GHG emissions except for land use, land-use change and forestry (LULUCF) and except for sectors covered by the European carbon market (EU ETS)	-37% compared to 2005	2030	-42%
Land use, land-use change and forestry (LULUCF)	Emissions do not exceed removals in relation to the reference period of 2005–2009[1]	2021–2025 and 2026-2030	Overall compliance with no-debit rule

The trajectory corresponding to these targets differs slightly from that presented in the draft MEP and SNBC published in early 2019; in particular, it is slightly more ambitious in terms of energy efficiency

[1] For the land sector and with reference to a projected reference level for forests in relation to forestry management.

in the buildings and industry sectors, and includes recently implemented or planned measures (application of the Law on Energy and Climate adopted on 8 November 2019 regarding the renovation of 'thermal sieves' (buildings that lose a large amount of heat), freezing of the carbon component, etc.). The target for renewable energies was also increased to 33% of final energy consumption, compared to 32% in the initial draft.

The measures explicitly outlined in the final version of the MEP and therefore in the integrated national energy and climate plan will not be sufficient to achieve all the relevant targets by 2030, in particular with regard to a reduction in final energy consumption, meaning that additional measures must be taken. The gradual increases in the carbon component of taxation were suspended in November 2018, meaning that new measures are also required to achieve outcomes equivalent to those anticipated for this component.

These measures may be tabled by the governance bodies that have recently been set up (Ecological Defence Council, High Council for Climate, Citizens' Climate Convention).

As an indication of the amount of work that remains to be done, it has been estimated that the following outcomes would be achieved by 2030 if action were limited solely to the measures set out in the MEP:

- **a reduction of 39.5% in GHG emissions (with reference to 1990), compared to a target of 40% stipulated by law, and an expected outcome of 43.2% for the trajectory that serves as a basis for the MEP and the SNBC;**
- **a reduction of 17% in final energy consumption (with reference to 2012), compared to a target of 20% stipulated by law, and an expected outcome of 20% for the trajectory that serves as a basis for the MEP and the SNBC;**
- **a reduction of 36% in primary fossil fuel consumption (with reference to 2012), compared to a target of 40% stipulated by law, and an expected result of 41% for the trajectory that serves as a basis for the MEP and the SNBC;**
- **an increase of 33% in renewable energy consumption, in line with the target stipulated by law and the trajectory that serves as a basis for the MEP and the SNBC.**

1.1.2. Key strategies and measures relating to the five dimensions of the Energy Union

Generally speaking, and even though the data are broken down by dimensions and sectors, it is important to remember that many measures have cross-sector effects and promote the achievement of several targets. For example, measures that reduce levels of atmospheric pollutants typically have a positive impact on GHG emissions, and in some cases on energy efficiency. Conversely, care must be taken to avoid potential adverse impacts (for example, a deterioration in air quality caused by an increase in the use of wood). When working on the scenario that serves as a basis for the MEP and the SNBC, it was necessary to adopt a holistic and cross-sector approach to the various dimensions and sectors, even if it was impossible to examine all of the relevant topics in depth.

1.1.2.1. Decarbonisation

Carbon budgets: a key tool for steering the trajectory of GHG emissions reductions

The carbon budgets specified in the SNBC are greenhouse gas emissions caps that must not be exceeded at national level over specific five-year periods. They define the target trajectory for GHG emissions reductions in the short and medium term, in line with France's commitments at EU and international level. They are broken down as follows:

- **by major sectors (ETS emissions, ESR emissions and, from 2019: negative emissions linked to land use, land-use change and forestry),**

- **by major areas of activity (transport, residential and tertiary buildings, industry, agriculture, energy generation and waste);**
- **as a guideline, in annual time frames and by greenhouse gas.**

A comparison of France's emissions (based on the most up-to-date inventories) against the carbon budget for the period in question, including data broken down by sector, represents **a key indicator for tracking the implementation of the strategy**. In particular, a comparison of this kind highlights the recent impacts of measures that have been put in place.

Average annual emissions (in Mt CO_2eq)	**Reference years[2]**			**Second carbon budget**	**Third carbon budget**	**Fourth carbon budget**
Period	**1990**	**2005**	**2015**	**2019-2023**	**2024-2028**	**2029-2033**
Total (excluding LULUCF)	546	553	458	422	359	300
Total (including LULUCF)	521	505	417	383	320	258
of which ETS sector *(except for international and domestic aviation)*			100	97	80	66
of which ESR sector			353	321	274	229
of which domestic aviation			5	5	5	4
of which LULUCF sector	-26	-48	-41	-39	-38	-42

The first three carbon budgets were adopted by decree in 2015 at the same time as the SNBC, and cover the periods 2015–2018, 2019–2023 and 2024–2028 (Decree No 2015-1491 of 18 November 2015). A new carbon budget is drafted every five years when the strategy is revised. The draft SNBC 2 contains the next three future carbon budgets.

Guidelines in the SNBC

The draft SNBC 2 sets out 45 public policy guidelines, both cross-cutting and sectoral in nature, which are aimed at fostering the transition to a low-carbon economy and achieving carbon neutrality in 2050.

Planned policies and measures for decarbonisation

Emissions from the burning of fuels account for roughly 70% of GHG emissions in France, meaning that the decarbonisation of energy represents a vital step towards achieving the emissions reduction targets. Strategies for decarbonising energy include improving energy efficiency and developing renewable energies. The draft MEP 2 outlines the government actions to be taken over the next 10 years

[2] Historical GHG emissions data are taken from the national inventory available in 2018, which was when the bulk of work was carried out on the joint scenario for the MEP and the SNBC. Some of these data may therefore have been superseded by more recent inventories.

to reduce energy consumption in all sectors (see 'Planned policies and measures for energy efficiency') and to decarbonise the energy mix (see 'Planned policies and measures for renewable energies').

Emissions are also generated by non-energy sectors. In the waste sector, the Roadmap for the Circular Economy published in 2018 and the Law on the Fight against Waste and the Circular Economy adopted in 2020 are targeted at better manufacturing (ecodesign, use of recycled materials), better consumption (increase in rates of reuse and repair, lengthening of product lifespans), better waste management (optimised sorting of waste, increase in recycling and recovery) and better mobilisation of all stakeholders.

In the agriculture sector, the revised versions of certain plans linked to the Agri-Environmental Plan for France (the Vegetable Protein Plan, the Organic Plan and the Teaching to Produce Alternatives Plan) will help to transform agricultural practices with a view to reducing direct and indirect emissions of N_2O and CH_4. In addition, the Government's Major Investment Plan (GPI) , worth €57 billion over the five-year period between 2017 and 2022, incorporates an agricultural pillar aimed at accelerating changes to tools and practices. France has also come out in favour of strengthening the environmental component of the common agricultural policy (CAP). In addition to changes in agricultural practices, the measures resulting from the National Foodstuffs Meeting (EGA) organised by the Government in 2017 are aimed at influencing demand and consumption in agri-food sectors, for example through the adoption of regulations obliging operators in the food service industry to use a minimum amount of locally sourced or quality-certified agricultural products by 2022, and through the introduction of mandatory preliminary assessments for all such operators aimed at reducing food waste.

Cross-sector measures are also planned, in particular the taxation of HFCs and the introduction of a low-carbon label confirming that a particular project has been awarded emissions-reducing status. Although it was also planned that the carbon component of energy taxation would be subject to gradual increases, the latter were put on hold during 2019 in response to industrial action.

As regards the land use, land-use change and forestry (LULUCF) sector, policies and measures aimed at ensuring compliance with Regulation (EU) 2018/841 involve firstly action under the Agri-Environmental Plan for France, and secondly the revitalisation of forestry management. In particular, four mutually reinforcing tools have been identified in the forestry and timber sector:

- **use of bio-based products as substitutes for energy-intensive materials;**
- **recovery of energy from bio-based products or from the waste generated from these products as a substitute for fossil fuels;**
- **storage of carbon in wood and waste wood products;**
- **carbon sequestration in the forestry ecosystem.**

Several different national strategies and plans are aimed at leveraging these tools, in particular the National Bioeconomy Strategy, the National Forestry and Timber Plan, the National Biomass Mobilisation Strategy and the Strategic Wood Sector Contract.

Development of renewable energies

Targets relating to renewable energies were set in the Law on Energy Transition for Green Growth and updated in the 2019 Law on Energy and Climate. According to current plans, the share of renewable energies will be increased to 23% of gross final energy consumption by 2020, and to 33% by 2030. By this date, renewable energies must account for at least 40% of electricity production, 38% of final heat consumption, 15% of final fuel consumption and 10% of gas consumption in order to achieve this target.

The MEP sets a target of significant acceleration in the rate of development of renewable energies by 2028. This would serve as a basis for achieving the targets set by law for 2030. In particular, achieving the targets set in the MEP would allow the following:

- Doubling of installed renewable electricity capacities by 2028 compared to 2017, with an installed capacity of 101 to 113 GW by 2028 and 36% renewables in the electricity mix by 2028 (upper bracket). This represents a 50% increase in installed capacities between now and 2023.
- Increase of 40–60% in renewable heat production compared to 2016, with production of 219–247 TWh by 2028, or in other words 34–39% of total heat consumption.
- Increase in injected biogas volumes to 14–22 TWh by 2028, compared to 0.4 TWh in 2017. Biogas (whether injected or used directly) would then account for 6–8% of gas consumption in 2028.
- Increase in the share of advanced biofuels in fuels to 5 TWh (3.35 TWh in diesel and 1.65 TWh in petrol, without multipliers).
- Increase in the share of renewable and recovered district heating and cooling to 32.4–38.7 TWh by 2028, representing an increase by a factor of 2.4–2.8 compared to 2016.

1.1.2.2. Energy efficiency

A long-term vision

The Energy Code, which was recently updated by the 2019 Law on Energy and Climate, sets the following medium-term and long-term targets as a basis for joint action by citizens, businesses, regions and the state:

- **between 1990 and 2030, reduce GHG emissions by 40% (based on the trajectory outlined in the carbon budgets); by 2050, achieve carbon neutrality throughout the country, without the use of carbon offsetting, by reducing gross emissions by a factor of at least six compared to 1990;**
- **by 2050, reduce final energy consumption by 50% compared to the reference year of 2012, with an interim milestone of 20% by 2030;**
- **by 2030, reduce primary fossil fuel consumption by 40% compared to the reference year of 2012;**
- **by 2050, achieve a level of energy performance that complies with the 'low-energy building' standards across the entire building stock;**
- **fight energy poverty;**
- **safeguard the right of every household to access energy at a cost that is proportionate in relation to household resources.**

The MEP and the SNBC, both adopted by the Government, contain measures aimed at achieving these long-term targets and outline cross-cutting and sectoral policies and measures to this end.

Energy scenarios

Several energy scenarios were developed in connection with work on the MEP and the SNBC; these scenarios were used as a basis for designing and scaling the policies and measures relating to energy efficiency and reductions in energy consumption.

The energy scenario regarded as most probable in connection with work on the MEP was the 'with additional measures' scenario of the SNBC for the relevant period. This scenario will hereinafter be referred to as the 'reference scenario'. It was developed on the basis of the changes deemed most probable in the macroeconomic parameters. Pursuant to the statutory provisions, a scenario incorporating different macroeconomic assumptions was also developed under the MEP. The macroeconomic parameters, which included GDP, demographic growth and energy prices, were modified to provide an idea of the scale of additional measures that would be required to achieve the relevant public policy targets in the event of shifts in the economic climate.

Projections were drawn up for 2050, with interim milestones of 2015, 2020, 2025, 2030 and 2050. The deadlines that apply under the MEP (2023 and 2028) were identified on this basis. The scenarios are based on multiple interacting models.

Reduction in final energy consumption

The first pillar of the energy transition involves reducing energy consumption.

In application of Article 3 of Directive 2012/27/EU on energy efficiency, France has set itself the dual target of reducing its final energy consumption to **131.4 Mtoe** and its primary energy consumption to **219.9 Mtoe** by 2020 (excluding international bunkers and non-energy uses).

Generally speaking, the total figure for final energy consumption in France is already decreasing; at the same time, however, the current rate of this decrease is not sufficient to achieve the target for 2020 set under the Energy Efficiency Directive. The measures that have already been implemented would need to be stepped up quickly or new measures adopted in order to achieve the 2020 targets.

In application of Article 1 of the Regulation on the governance of the Energy Union and Article 3 of Directive 2012/27/EU, France has produced an initial estimate of its contribution to the EU target of reducing energy consumption by at least 32.5% by 2030 compared to a trend-based reference scenario.

Based on the reference scenario used for the MEP and the SNBC, which incorporates all the measures resulting from the MEP, estimated final energy consumption by 2030 is **120.9 Mtoe**, and estimated primary energy consumption by 2030 is **202.20 Mtoe**.

Planned policies and measures for energy efficiency

Specific sectoral energy consumption targets have been set under the MEP.

France has adopted two major cross-sector approaches to achieving its final energy consumption reduction targets; the first of these is the system of white certificates, and the second is the set of EU rules on the ecodesign of energy-related products and the energy labelling of these products. France also implements targeted measures in all the various sectors: residential, tertiary, industry, transport and agriculture. Flagship measures include the Long-Term Buildings Renovation Strategy, environmental and energy new-build regulations, the energy transition tax credit, the zero-rate eco-loan, energy audits and an extension of the conversion premium for replacing an old vehicle with a new high-performance vehicle.

1.1.2.3. Energy supply security

The security of supply is defined as the capacity of energy systems to meet demand continuously and at a reasonable cost for the foreseeable future. It is guaranteed in particular by managing energy demand, by producing energy at national and local level (in particular from renewable sources) and by diversifying supply. Maintaining a highly secure supply for the benefit of all consumers (citizens, government authorities and private-sector enterprises) represents a major challenge that must be tackled as part of the energy transition.

The main objectives relating to the security of supply are as follows:

- confirming the criteria that apply to the supply of gas and electricity;
- accelerating the reduction in peak electricity demand;

- mobilising biomass resources while striking an appropriate balance between biomass uses and food-production uses, and working towards the goal of sustainable soil quality, which is essential for the sustainable production of renewable biomass.

Measures to ensure the security of supply for liquid fuels

The security of supply for fuels is ensured throughout France. The distribution of oil depots and service stations ensures a high quality of supply across the entire country. Reduced demand for oil will affect the profitability conditions of infrastructures and depots such as service stations, and these latter may be forced to close. The closure of these service stations might also destabilise upstream logistics in the long term (interim storage depots). No significant problems of this kind are expected within the time frame covered by the MEP, but they may occur thereafter. A forward-looking approach based on the concept of a network of oil depots must therefore be adopted to safeguard the security of supply, at the same time as ensuring that service stations are distributed uniformly at regional level.

Measures to ensure the security of supply for gas products

The security of supply for gas is ensured throughout the country. Measures to ensure supply security have recently been consolidated by means of legislative and regulatory amendments concerning the storage of gas, aimed at ensuring that stores are adequately filled before the start of winter. Gas consumption (like fuel consumption) is likely to reduce. The infrastructure system that guarantees supply security is scaled correctly for the 2019–2023 period, in particular as regards active underground gas storage sites. There is currently no demand for new natural gas underground storage sites, or for the reopening of any of the three underground storage sites that are currently mothballed. Exempting these sites from the scope of the Regulation would make it possible to reduce transmission system tariffs, which would benefit natural gas consumers.

Increasing the level of natural gas consumption interruptibility to at least 200 GWh/day between now and 2023 at major consumption sites will also make the gas system more flexible.

Measures to guarantee the security of supply for electricity

According to analytical work carried out by RTE when working on the provisional balance sheet, the system is flexible enough to handle the integration of extensive renewable energy capacities (over 100 GW installed by 2035 based on the Ampère scenario) without any disruption to the supply/demand balance. It will be possible to use all the existing flexibility tools, in particular demand flexibility, storage and interconnections, to handle the new challenges that will arise in connection with the increase in electricity produced from non-controllable renewable sources.

Investigations carried out in late 2017 by RTE, and updated in 2018 and 2019, confirmed that shutting down the last coal-fired power plants between now and 2022 while meeting the supply security criteria at both national and local level based on the reference scenario under the MEP is a feasible option, provided that the Flamanville EPR comes online in 2022 at the latest.

It was announced in summer 2019 that the Flamanville EPR project had been delayed, prompting RTE to amend the analytical data underpinning its provisional balance sheet for 2019. One of the conclusions that emerged from this process was that it would be possible to start the process of shutting down the first coal-fired power plants in 2020, but that shutting down all of these plants between now and 2022 would require additional measures, particularly as regards peak demand management. The Government has undertaken to put the relevant measures in place to ensure that coal-fired electricity production can be phased out between now and 2022.

1.1.2.4. Internal energy market

Safeguarding the future of the energy system involves:

- **Most importantly, building an interconnected Europe. The main strategic guidelines of the national plan are aimed at building electrical interconnections with all of France's**

neighbours in order to benefit not only from the complementary nature of generation means at European level, but also from European solidarity. In particular, interconnections are planned with Spain, Italy, the United Kingdom and Ireland, and investigations will be carried out into the feasibility of strengthening interconnections with Germany, Switzerland and Belgium.

- **Promoting the shift towards decentralised generation, which entails changing the country's systems to make them smarter and more flexible; this can be achieved through the balanced development of systems, through the storage and transformation of energy and through energy demand management, in particular with a view to promoting local energy generation and developing smart grids and auto-generation.**

- **Laying the groundwork for interactions between electricity, gas and heat systems ('power-to-gas' and 'power-to-heat') at different levels for the purpose of optimising the operation and costs of these systems.**

The guidelines of the MEP and the measures carried out on its basis should make it possible to anticipate these changes by developing interconnections, smart grids, auto-generation/self-consumption options and storage facilities, with a view to supporting the energy transition in the regions.

1.1.2.5. Research, innovation and competitiveness

The transition to a low-carbon economy (i.e. one which consumes small amounts of materials and energy and is highly circular and decarbonised) involves a stepping-up of energy-related research and innovation measures aimed at developing the technologies and behaviours that will promote reductions in emissions while ensuring that France can compete on future markets for low-carbon goods and services.

Many specific research and innovation requirements have already been identified:

- **in energy-related sectors: decarbonisation of energy, energy efficiency, energy storage, smart management of transmission and distribution systems and carbon capture, storage and reuse solutions;**
- **in non-energy-related sectors: process improvements relating to 'carbon' and environmental efficiency, optimisation, recycling and reuse of resources;**
- **in relation to social innovations (changes to behaviours and attitudes, ownership of change, etc.) and organisational innovations (public policies etc.).**

Meeting these needs would make it possible to overcome the challenges involved in low-carbon transition, and to mobilise all the stakeholders involved in low-carbon research and innovation measures at national, EU and international level. Specific targets include the following:

- **continuing and boosting R&D and innovation funding for the energy transition, in particular through the Investments for the Future Programme (PIA), in accordance with the broad guidelines laid down by the Innovation Council (created in 2018);**
- **reiterating the undertakings given under the Mission Innovation initiative, in particular the increase in government R&D funding levels to accelerate the development of pro-energy transition technologies;**
- **stepping up France's participation in major international research programmes, in particular the future Horizon Europe framework programme;**

developing new training courses for careers relating to the energy transition, with the assistance of tertiary education establishments or institutes such as the Institutes for the Energy Transition.

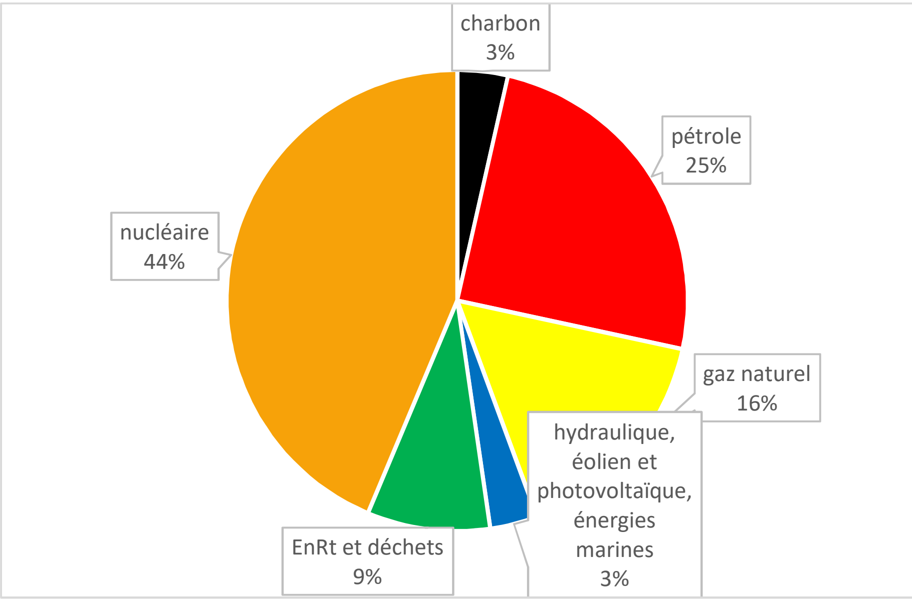
1.2. Overview of current policy situation

1.2.1. National and Union energy system and policy context of the national plan

In 2016, 232.4 Mtoe of primary energy was consumed in France. Of this total, 12% was generated from renewable or recovered energy sources. Primary energy consumption can be broken down as follows:

- **nuclear: 101.5 Mtoe**
- **oil: 57.7 Mtoe;**
- **natural gas: 37.2 Mtoe;**
- **renewable thermal energies and waste: 20.1 Mtoe;**
- **coal: 8.2 Mtoe;**
- **renewable electricity: 7.7 Mtoe.**

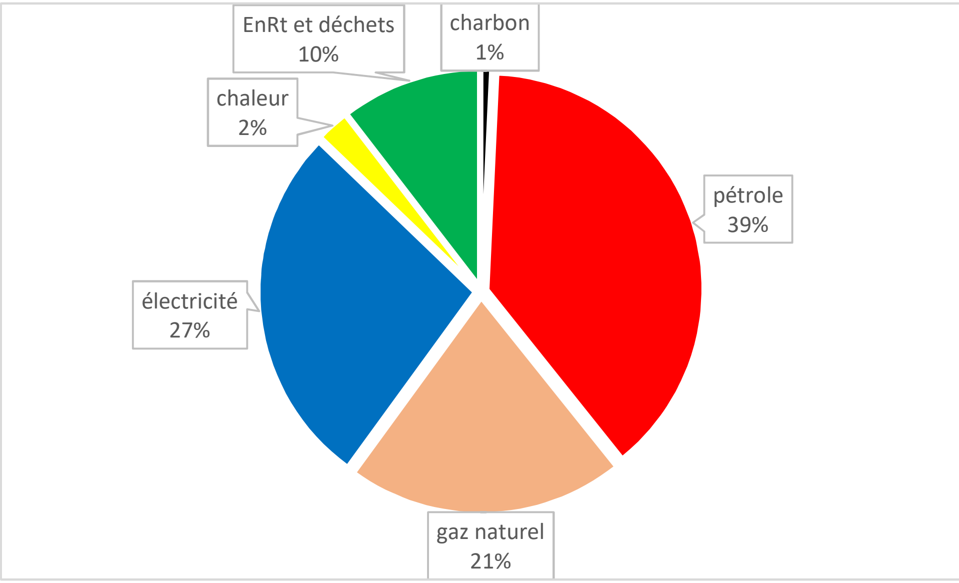
Figure 1: Breakdown of primary energy consumption in 2016 (%)



charbon	coal
pétrole	oil
gaz naturel	natural gas
hydraulique, éolien et photovoltaïque énergies, énergies marines	hydropower, wind and photovoltaic systems, marine energies,
EnRt et déchets	renewable thermal energies and waste
nucléaire	nuclear

In 2016, final energy consumption was 142 Mtoe.

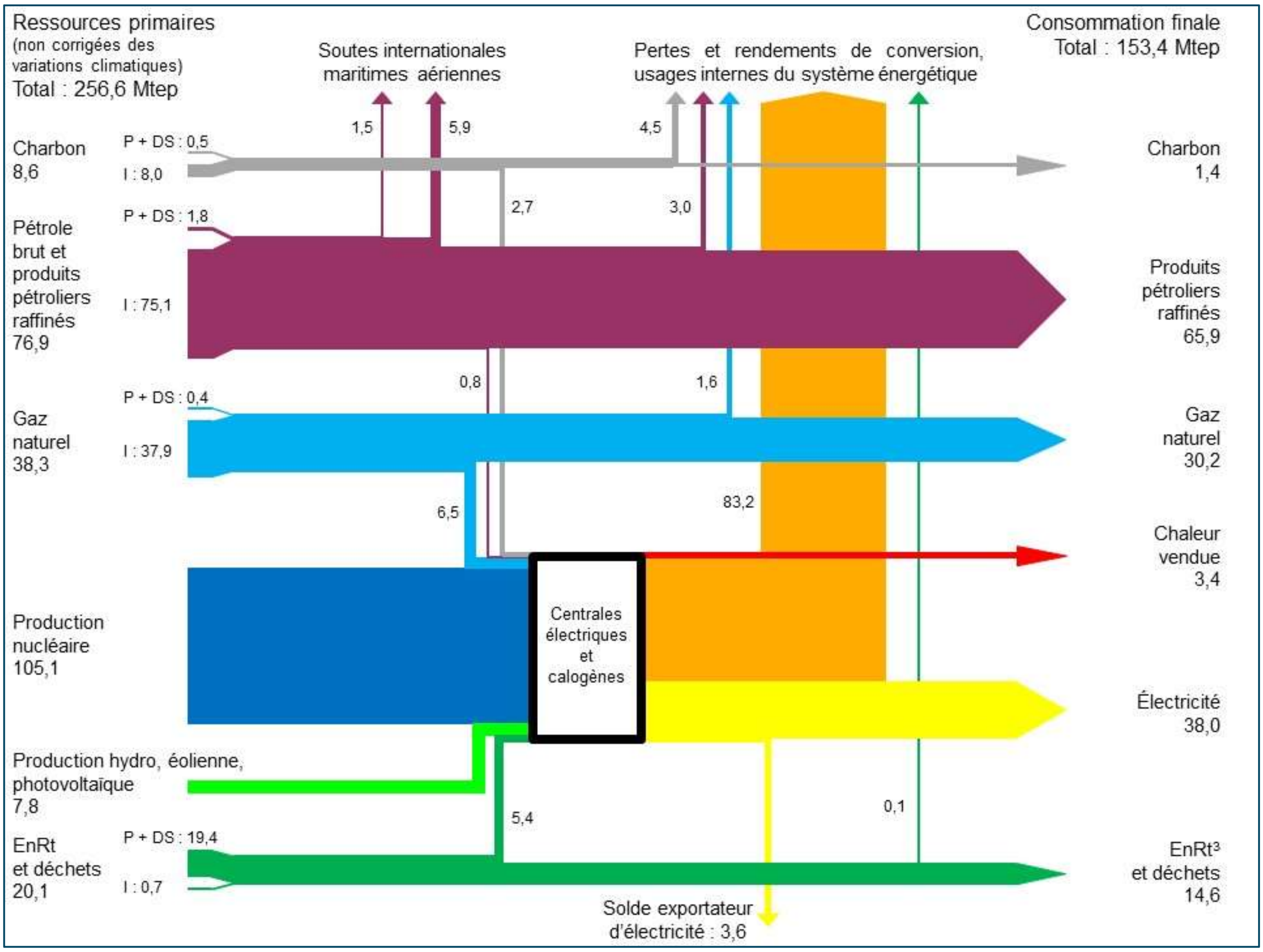
- **Of the total figure for energy use, 43% is accounted for by the occupation of buildings, either by individuals (residential, 27%) or businesses (tertiary, 16%): this includes heating, food preparation, refrigeration, lighting and the operation of devices.**
- **The transportation of persons or goods accounts for 29% of the total figure for energy use.**
- **Industry accounts for 17% of the total figure for energy use: this includes furnaces, processes, etc.**
- **Farming accounts for 3% of the total figure for energy use: this includes agricultural machinery, heating of greenhouses, etc.**
- **The remaining 9% of energy resources are used as raw materials rather than as a source of energy: oil can be used to produce plastics or as a fuel, for example.**



charbon	coal
pétrole	oil
gaz naturel	natural gas
chaleur	heat
EnRt et déchets	renewable thermal energies and waste
électricité	electricity

Sankey diagrams of the type shown below are commonly used to illustrate energy balance sheets; they depict all energy flows (supply, transformation, consumption, including losses) in the form of arrows, the size of which is proportionate to the amount of energy involved. The diagram below shows flows of energy from primary to final energy consumption. It also incorporates non-energy consumption (industrial processes), resulting in a total figure for final consumption of 153 Mtoe.

*Figure 3: Energy balance for metropolitan France in 2016 (Mtoe) – Source: SDES**



P: national primary energy production
DS: removal from storage
I: import balance
** including hydropower, wind and photovoltaic.*
*** renewable thermal energies (wood, wood waste, solar thermal, biofuels, heat pumps, etc.).*
Heat plants: i.e. a nuclear reactor used as a source of heat.
1 The magnitude of losses in the electricity sector is based on the international convention stating that nuclear electricity should be calculated as the heat produced by the reaction, with two thirds of this heat being lost during its conversion into electrical energy.
2 To obtain the total figure for energy available in metropolitan France (see Annex – 'Energy balance'), the 'electricity export balance' and 'international marine bunkers' must be deducted from 'primary resources'.
3 Final consumption is equal to final energy and non-energy consumption.
4 Including very small quantities of industrial gases used in the steel industry.

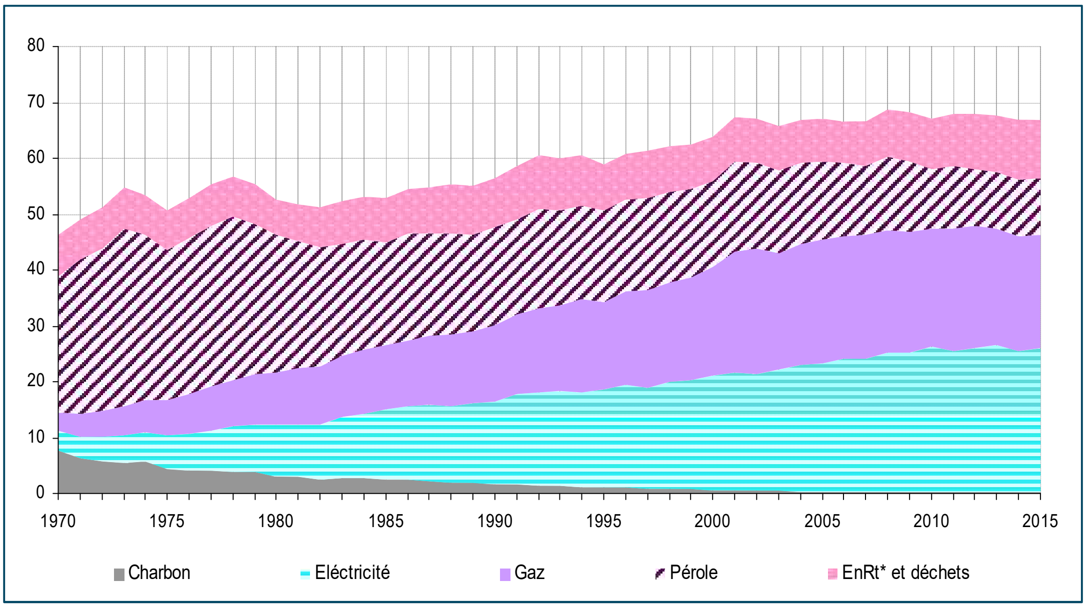
Ressources primaires (non corrigées des variations climatiques	Primary resources (not adjusted for climate variations)
Total : 256,6 Mtep	Total: 256.6 Mtoe
Charbon	Coal
Pétrole brut et produits pétroliers raffinés	Crude oil and refined petroleum products
Gaz naturel	Natural gas
Production nucléaire	Nuclear production

Production hydro, eolienne, photovoltaique	Production from hydropower, wind and photovoltaic systems
EnRt et déchets	Renewable thermal energies and waste
Soutes internationals maritimes aériennes	International marine/aviation bunkers
Pertes et rendement de conversion, usages internes du système énergétique	Conversion losses and gains, uses within the energy system
Consommation finale	Final consumption
Total : 153,4 Mtep	Total: 153.4 Mtoe
Produits pétroliers raffinés	Refined petroleum products
Chaleur vendue	Heat sold
Électricité	Electricity
EnRt[3] et déchets	Renewable thermal energies[3] and waste
Centrales électriques et calogènes	Power plants and heat plants
Solde exportateur d'électricité	Electricity export balance

The main source of energy in the transport sector is oil. By way of contrast, the sources of energy used in the buildings sector are much more diverse: electricity, gas, oil, coal and renewable energies.

Energy sources are much more diversified in the buildings sector than in the transport sector. Electricity accounts for the largest share and gas for the second-largest share, followed by oil and wood for heating.

*Figure 4: Final energy consumption in the residential and tertiary sectors (Mtoe) – Source: SDES**

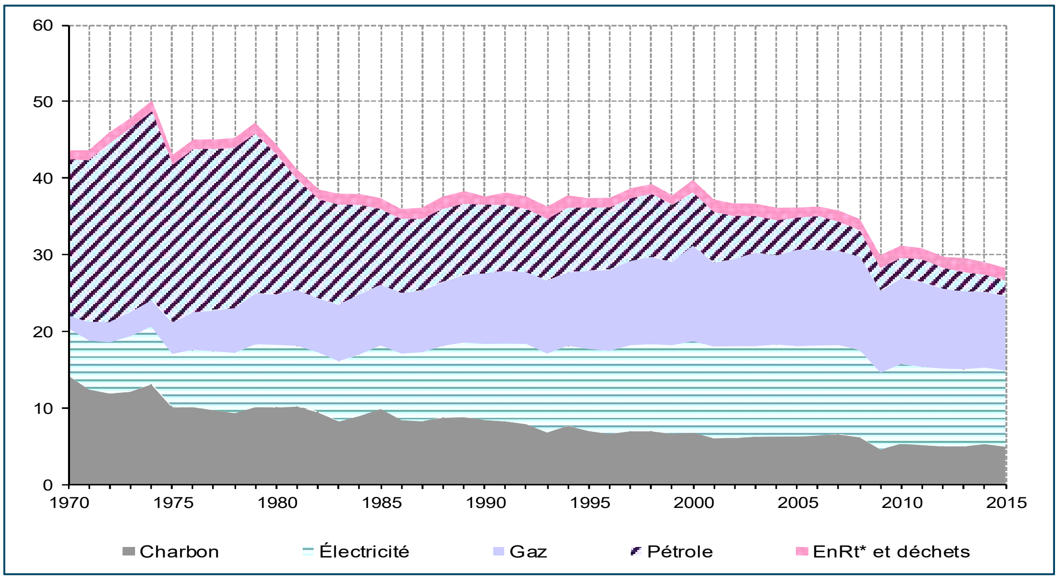


Charbon	Coal
Électricité	Electricity
Gaz	Gas
Pétrole	Oil
EnRt* et déchets	Renewable thermal energies* and waste

The sources of energy used undergo changes over time. In the early 1970s, petroleum was the main energy source used by industry. Following the oil shocks of the 1970s, petroleum gradually lost ground to gas and electricity for certain industrial uses and for the heating of buildings.

Industry still uses small quantities of coal. The main energy sources are electricity and gas. Petroleum currently accounts for only a small share of the total figure, and the same is true for renewable energies.

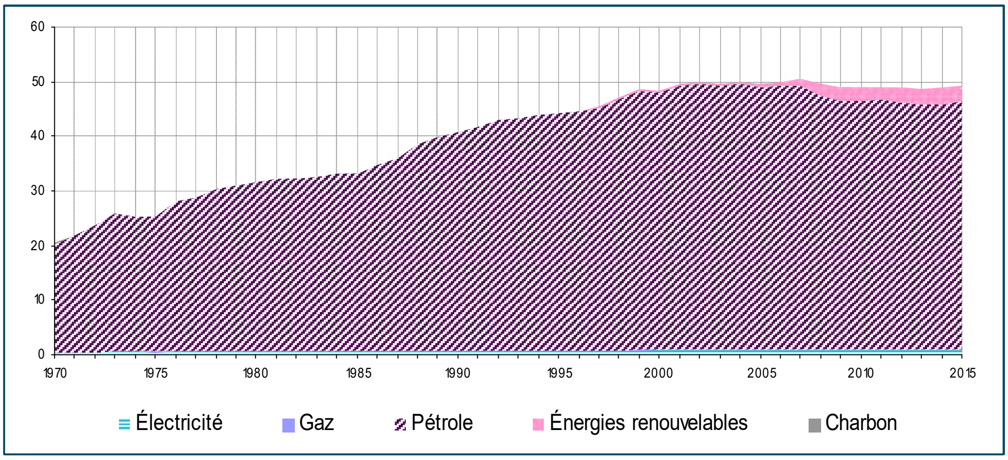
*Figure 5: Final energy consumption in the industrial sector (Mtoe) – Source: SDES**



Charbon	Coal
Électricité	Electricity
Gaz	Gas
Pétrole	Oil
EnRt* et déchets	Renewable thermal energies* and waste

The transport sector still relies almost exclusively on petroleum as an energy source. Biofuels account for only a small share of the total figure, and electricity for a marginal amount.

Figure 6: Final energy consumption in the transport sector

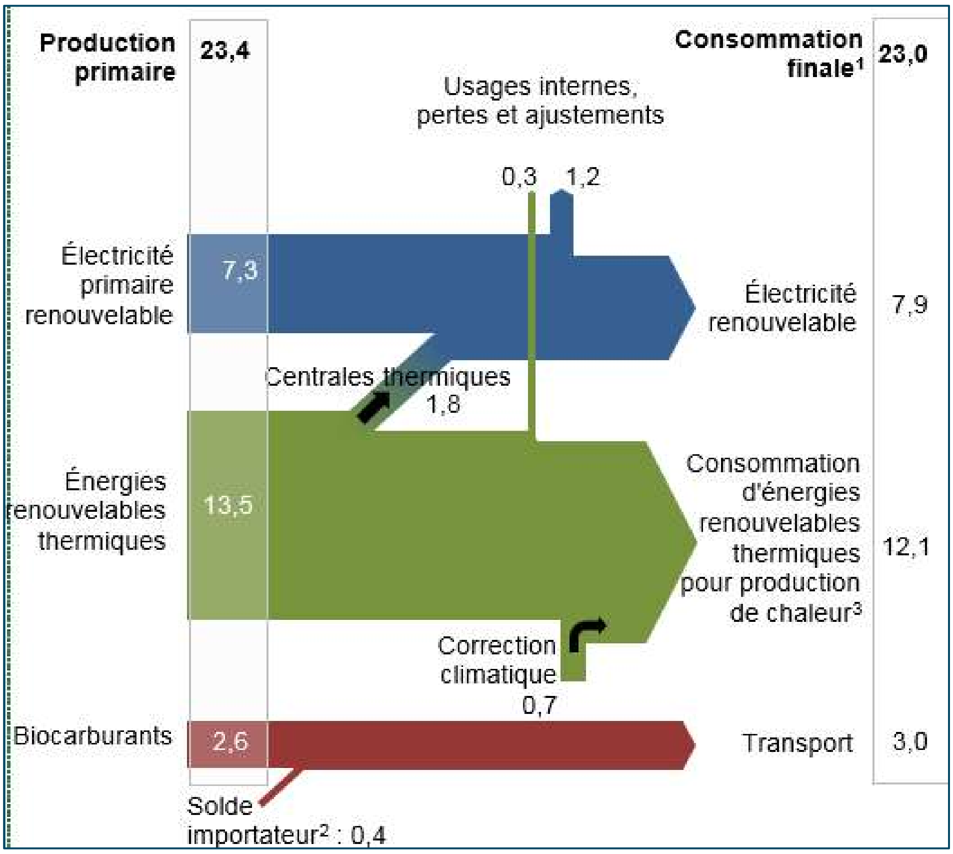


Électricité	Electricity

Gaz	Gas
Petrole	Oil
Énergies renouvelables	Renewable energies
Charbon	Coal

The diagram below shows that renewable energies are used on a primary basis for heating (53%), on a secondary basis for electricity production (34%), and lastly for transport (13%).

*Figure 7: Energy balance sheet for renewable energies in France in 2015 (Mtoe) – Source: SDES**



Internal uses, losses and adjustments: this includes network losses, non-recorded internal consumption by installations and the statistical margin of error.

Production primaire	Primary production
Consommation finale	Final consumption
Usages internes, pertes et ajustements	Internal uses, losses and adjustments
Électricité primaire renouvelable	Primary renewable electricity
Électricité renouvelable	Renewable electricity
Énergies renouvelables thermiques	Renewable thermal energies
Consommation d'énergies renouvelables thermiques pour production de chaleur	Consumption of renewable thermal energies for heat production
Correction climatique	Climate correction
Biocarburants	Biofuels
Transport	Transport
Solde importateur	Import balance

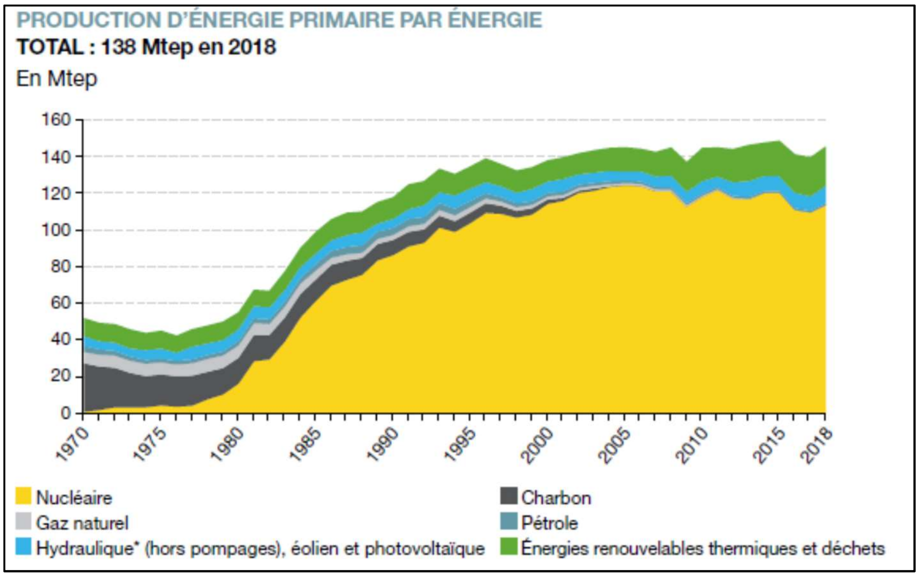
1.2.1.1. Energy production

France imports almost all of the gas, oil and coal it uses as sources of energy.

The country has produced no coal at all since 2004. Gas and oil produced within the country account for around 1% of consumption, and this figure will drop in step with the gradual scaling back of research into and use of hydrocarbons (in line with the policy adopted by France in 2017).

The only energy produced by France on a large-scale basis is electricity. The graph below shows the leading position occupied by nuclear in this respect.

*Figure 8: Primary energy production in 2018 by origin (Mtoe) – Source: SDES**

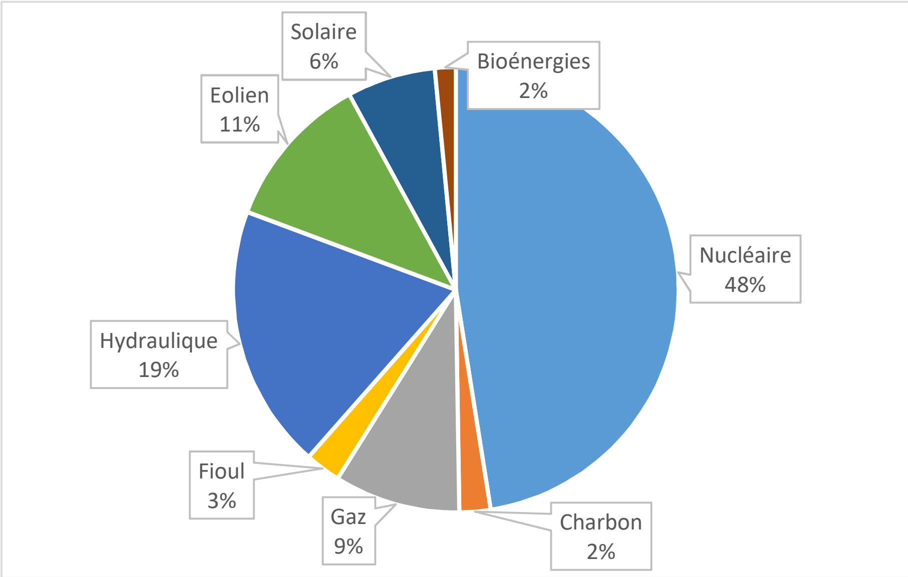


PRODUCTION D'ÉNERGIE PRIMAIRE PAR ÉNERGIE	PRIMARY ENERGY PRODUCTION BY ENERGY
TOTAL: 138 Mtep en 2018	TOTAL: 138 Mtoe in 2018
En Mtep	In Mtoe
Nucléaire	Nuclear
Gaz naturel	Natural gas
Hydraulique* (hors pompages), éolien et photovoltaïque	Hydropower* (except pumps), wind and photovoltaic
Charbon	Coal
Pétrole	Oil
Énergies renouvelables thermiques et déchets	Renewable thermal energies and waste

1.2.1.2. France's electricity production capacity

On 31 December 2018, the total installed capacity of electricity production facilities in metropolitan France was almost 133 GW.

Figure 9: Breakdown of installed electricity generation capacities in 2018 (%) – Source: RTE



charbon	coal
gaz	gaz
fioul	fuel oil
Hydraulique	Hydropower
éolien	Wind
Solaire	Solar
Bioénergies	Bioenergies
Nucléaire	Nuclear

The vast majority of electricity is produced in nuclear power plants or from fossil fuels (coal, natural gas, fuel oil); increasingly, renewable energies are also being used (hydropower, solar, wind, bioenergies).

France's nuclear production facilities comprise 58 reactors divided between 19 power stations, with a total output of 63,130 MW. The reactors are all pressurised water reactors (PWRs).

There are several 'tiers' of nuclear reactors in France:

- **CP0: 6x 900 MW reactors: these are the oldest reactors that are still in operation,**
- **CPY: 28x 900 MW reactors,**
- **P4: 8x 1,300 MW reactors,**
- **P'4: 12x 1,300 MW reactors,**
- **N4: 4x 1,450 MW reactors,**
- **EPR: 1x 1,600 MW reactor, scheduled to come online in 2023.**

The main renewable energies used to produce electricity are as follows (based on capacities as at 31 December 2018):

- **hydropower (25.5 GW): France's hydropower capacity has been stable since the late 1980s;**
- **wind power (15.1 GW): growth in installed onshore wind capacities has accelerated in recent years (+1.6 GW in 2018);**

- **solar power (8.5 GW): a steady increase in solar power has also been observed (+873 MW in 2018), thanks in particular to significant cost reductions;**
- **bioenergies (2.0 GW): installed capacities in the bioenergies sector (paper waste, household waste, biogas, wood energy and other solid biofuels) rose by 73 MW in 2018, mainly thanks to vigorous growth in the number of power plants using wood energy, solid fuels and biogas.**

France's park of thermal power stations powered with fossil fuels can be broken down as follows:

- **gas-fired generation facilities (12.2 GW);**
- **coal-fired generation facilities (3 GW, representing a sharp drop since 2012);**
- **fuel oil-fired generation facilities (3.4 GW, currently being phased out).**

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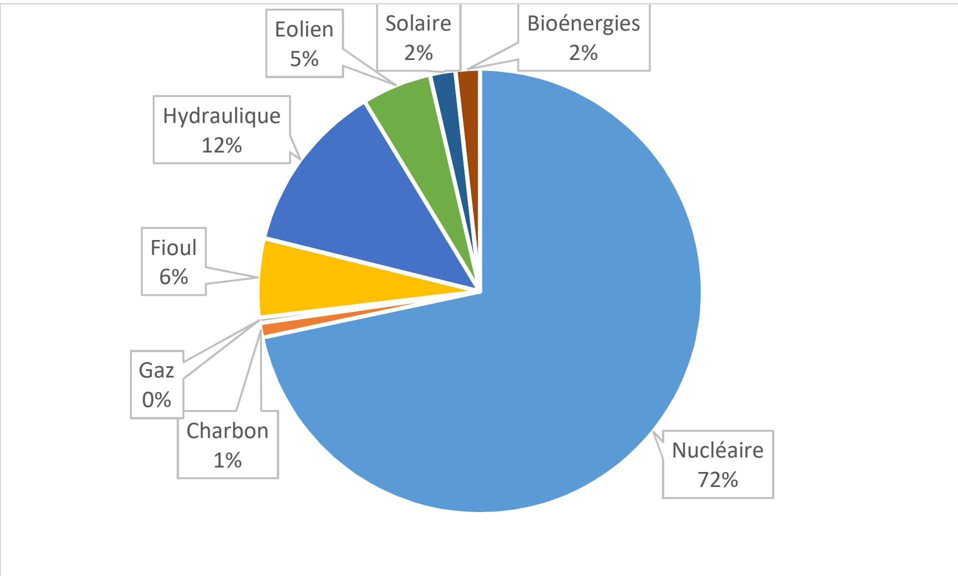
1.2.1.3. Electricity production

A total of 548.6 TWh of electricity was produced in France in 2018, representing an increase of almost 4% compared to 2017. France exported 86.3 TWh and imported 26.1 TWh of electricity, which meant that it had an export balance of 60.2 TWh; this represented an increase of 58.4% compared to 2017.

Figure 10: Breakdown of energy generation by sector in 2018 – Source: RTE



charbon	coal
gaz	gaz
fioul	fuel oil
Hydraulique	Hydropower
éolien	Wind
Solaire	Solar
Bioénergies	Bioenergies
Nucléaire	Nuclear

Nuclear production accounted for 71.7% of all the electricity produced in 2018.

Note: final electricity consumption in 2018 was 38 Mtoe, accounting for 27% of final energy consumption (source: SDES)

1.2.2. Current energy and climate policies and measures relating to the five dimensions of the Energy Union

1.2.2.1. Decarbonisation and energy efficiency

The following section provides an overview of the policies and measures implemented by France with a view to reducing GHG emissions, decreasing energy consumption and promoting renewable energies. The aim of these policies and measures is to deploy all possible mitigating measures across all sectors: transport, residential and tertiary buildings, energy, industry, waste, agriculture and forestry.

A detailed description of the policies and measures that have been implemented in France can be found in the Fourth Biennial Report forwarded to the UNFCCC in early 2020, and in the reports on policies and measures forwarded in March 2019 in application of Article 13 of the Monitoring Mechanism Regulation.

Transport

The policies and measures implemented in this sector are primarily aimed at improving the energy efficiency of new road transport vehicles by encouraging buyers to purchase the highest-performing vehicles (energy/CO_2 label, bonus/penalty system, conversion premium) and requiring automotive manufacturers to comply with emissions standards (EU regulation obliging manufacturers to meet the target of 95 g CO_2/km for personal-use vehicles by 2020). They are also aimed at encouraging the development of low-emission vehicles (in particular through bonuses for purchasing rechargeable electric and hybrid vehicles, by promoting the roll-out of recharging infrastructure and by setting targets for low-emission vehicles purchased in connection with the renewal of publicly owned fleets); at promoting the development of biofuels and other alternative fuels (by means of tax measures); and at supporting modal shifts (by improving the availability of non-road transport services and infrastructures, through measures that encourage cycling and active mobility, and by providing transport service users with more information about the impact of greenhouse gases emitted by transport services). Voluntary undertakings have also been made by professionals in the passenger and goods transport sector (CO_2 Objective Programme).

Residential and tertiary buildings

Actions implemented with a view to reducing emissions in the residential and tertiary buildings sector are primarily aimed at improving the thermal performance of building shells, promoting the use of high-efficiency heating equipment and less carbon-intensive energies, and improving the energy efficiency of other types of equipment (lighting, cooking, hot water for sanitary use, specific electricity consumption). These tools can be broken down into those that apply to new builds and those that apply to existing buildings.

The 2012 heating regulation imposed a general requirement for low-consumption standards in new builds from 2013 onwards. The ‘E+C- label’ pilot scheme, which was launched in late 2016, introduced an innovative environmental standard for new builds that combines requirements relating to both energy and GHG emissions. It lays the groundwork for the environmental regulations that will apply to new builds in the future. These future regulations (RE2020) are currently being drafted, but will include ambitious criteria in respect of energy efficiency, the use of renewable thermal energies and GHG emissions during a building’s lifetime.

A great many measures of various types are being implemented to improve the energy performance of existing buildings: regulations on the quality of renovations; labels certifying high-efficiency renovations; support for renovations (tax credit, zero-rate or reduced-rate loan, grants for low-income households, third-party financing etc.); vocational training courses; encouraging households to opt for renovations or to change their behaviours (schemes involving the provision of information on building performance and available funding sources for renovations, allocation of heating costs to individual households in multi-household dwellings); obligation to install thermal insulation when carrying out major building renovations etc. Tax expenditure is also used to fund purchases of renewable energy equipment by individuals (solar water heaters, heat pumps etc.).

Industry

France’s policy on reducing GHG emissions in the industrial sector mainly involves capping emissions from the industrial installations that emit the most GHGs via the EU’s emissions quota trading system, improving energy efficiency (by means of green loans for SMEs and industrial intermediate-sized enterprises, grants from the Agency for the Environment and Energy Management (ADEME) for research into energy efficiency in industry and reductions in the public electricity grid usage tariff for companies that consume a lot of energy and that introduce an energy efficiency policy) and recovering waste heat (with mandatory cost/benefit analyses for new installations that generate waste heat with a view to determining whether this heat could be used in a district heating or cooling network).

Energy

In addition to sectoral policies aimed at managing energy demand (particularly in the residential and tertiary buildings and transport sectors), a number of other cross-sector measures help to limit energy demand and promote renewable energies. In particular, these measures include the following:

- **The carbon component of energy taxation, which is calculated in proportion to the CO_2 content of fossil fuels, and which promotes energy efficiency and the emergence of low-carbon solutions in the road transport, building and industry (non-ETS) sectors.**
- **The system of white certificates, which imposes a mandatory energy-saving requirement on the main energy suppliers (companies selling electricity, gas, domestic fuel oil etc.). This serves as an incentive for these companies to take proactive steps to promote energy efficiency among energy consumers.**
- **The obligation for large companies to carry out an energy audit every four years.**
- **The Heat Fund, which provides funding for the production of heat from renewable sources in the tertiary, industry and collective housing sectors.**
- **Support programmes for renewable energies (electricity and biogas): calls for tenders, obligation for small-scale installations to purchase renewable energies, supplement paid for high-power installations. These schemes are designed to achieve the quantitative targets for developing renewable energies under the MEPs.**
- **Capping of emissions from installations producing electricity and heat and from refineries, through the EU emissions quota trading system.**

Agriculture and forestry

Policies and measures in the field of agriculture are aimed at improving the management of nitrogenous fertilisers, preventing organic nitrogen surpluses, reducing emissions from livestock manure, promoting renewable energies of agricultural origin (in particular anaerobic digestion), boosting the energy performance of holdings and maintaining and increasing carbon stores on plots and in soils. Progress towards these goals is outlined in a series of cross-disciplinary plans: the Agricultural Holding Competitiveness and Adaptation Plan, the Vegetable Protein Plan, a number of different schemes for accessing aid under the common agricultural policy, the Methane Energy and Nitrogen Autonomy Plan and the Agri-Forestry Development Plan.

Measures implemented in the forestry sector are aimed at improving the management of forests for the purpose of promoting carbon sequestration in the forestry ecosystem, and at increasing the use of bio-based products (allowing both the storage of carbon and the substitution of energy-intensive materials or materials from which energy can be recovered).

Waste treatment

Reducing emissions from the waste sector involves preventing waste (ban on single-use plastic bags, the fight against food waste, penalties for planned obsolescence); increasing the accountability of manufacturers; implementing measures that promote sorting with a view to increasing the proportion of waste that can be recycled (obligation to sort papers, cardboard, plastics, metals, wood, glass from economic activities, obligation to sort biowaste (applies to major manufacturers and will apply to households by 2025); expansion of the sorting guidelines, etc.); and tax measures aimed at limiting the amount of waste sent to landfill or incinerators (waste component of the general tax on polluting activities). Funding for the waste management and prevention policy is provided via the Waste Fund (fed by revenues from the waste component of taxation), and through calls for projects for 'Zero-waste regions' projects that are funded by local authorities.

Cross-sector policies and measures

Companies are obliged to produce balance sheets of their GHG emissions. These obligations apply across all sectors and all greenhouse gases.

Companies (as well as local authorities with over 50,000 inhabitants, central government services and publicly funded institutions) must publish regular balance sheets of their GHG emissions and an action plan for reducing these emissions. In addition, large companies must ensure that their non-financial reports include details of any significant GHG volumes emitted in connection with their activities, particularly as a result of consumers using the goods and services that they produce. Institutional investors must publish information on their contribution to climate targets and the financial risks associated with the energy and environmental transition.

Cross-sector policies and measures for fluorinated gases

The provisions of Regulation (EU) No 517/2014 ('F-Gas II') limit emissions of fluorinated gases from refrigeration and air-conditioning equipment used in buildings, industry and refrigerated transport containers. In particular, it establishes a mechanism for gradually reducing the volumes of HFCs placed on the market, as well as for imposing sectoral bans on the marketing of products and equipment containing GHGs that exceed a certain GWP.

1.2.2.2. Energy supply security

Levels of energy independence (the ratio between primary energy produced and primary energy consumed) are close to 0% for gas, coal and oil. This means that France imports almost all of the fossil fuels that it uses.

The first stage in achieving the security of supply is therefore to diversify import sources, with a view to preventing adverse impacts in the event of a political or economic crisis. Growth of renewable energies will help to increase the country's security of supply by reducing its dependence on imports.

Diversification of the energy mix and the electricity mix will also boost the security of the country's energy supply. As far as the electricity system is concerned, diversification of the mix will forestall the crisis that could potentially occur in the event that a generic fault were to be identified in multiple nuclear reactors constructed at the same time and according to the same design. Decentralised means of production reduce the probability of large-scale technical malfunctions.

Organisational continuity in the national supply system

The security of supply also has an organisational dimension within the country:

- **for oil and gas – seamless logistics are required to convey the right resources to the right place at the right time;**
- **for electricity – production and demand must be balanced in real time, since the storage of electricity is almost impossible.**

Guaranteeing the security of supply at a reasonable cost represents another major challenge.

Supply/demand imbalances have not caused any power cuts in France over the past few years. A number of tense situations were encountered involving unavailability of the generating fleet, particularly during January 2017, but no power cuts occurred and there was no use of exceptional tools.

The supply of gas has not been interrupted to any customer in recent years, despite a number of potentially problematic situations.

There was scope for problems to arise in connection with the supply of petroleum-based fuels, mainly as a result of logistical issues caused by industrial action that might have affected supply throughout the country.

France's security of supply is based on the following two pillars:

- **diversifying the means of generating electricity or the means of supplying gas and oil, which are not produced within the country;**
- **protecting imports across all vectors, in particular through the strengthening of infrastructures.**

The following sections provide details of the challenges that must be overcome in relation to the security of supply for different energy sources.

Security of supply for coal: absence of policy challenges

The burning of coal emits large quantities of greenhouse gases. Coal now accounts for only 3.4% of the energy resources used to produce energy in France. Its use is expected to drop yet further with the shutting down of France's coal-fired power plants; the deadline for this shutdown has been announced as 2022. The supply of coal does not therefore constitute a strategic problem from the perspective of energy policy.

Australia was the main supplier of coal for France in 2016 (31% of all imports). Russia ranked second (27%, year-on-year increase of eight percentage points), followed by Colombia (14%) and South Africa (11%). The United States, which was France's main supplier in 2013, dropped to fifth position, accounting for 8% of France's coal imports.

Security of supply for oil

A range of different challenges are faced in connection with the security of supply for oil, depending on the time frame considered:

- **the short-term objective is to avoid any interruption in supply to refineries and service stations;**
- **the medium-term objective is to make the necessary investments into the transmission and distribution network to ensure that the demand for petroleum products can be met.**

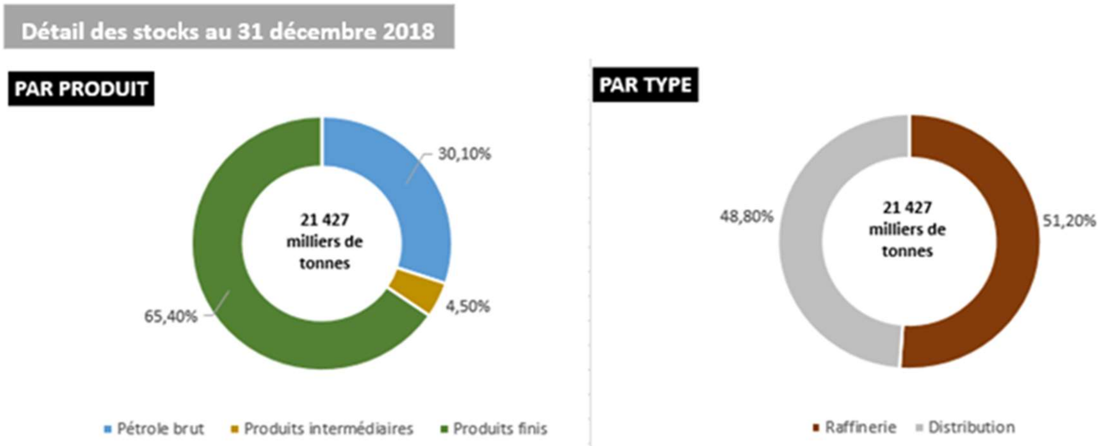
The petroleum logistics network in metropolitan France incorporates the following elements:

- import depots for petroleum products, located as close as possible to refineries or ports, which provide the main storage capacities;
- transport pipelines for crude oil or finished products (pipelines);
- depots for temporary storage prior to final delivery to consumers via the network of service stations.

Each level of infrastructure is an essential link in the supply security chain. The density of the network, and in particular the network of temporary storage depots, helps to ensure high security of supply across the entire country. A decrease in oil demand will alter the profitability of infrastructures. It will be important to ensure that this does not jeopardise the security of supply for hydrocarbons.

France’s overall petroleum product storage capacity has been stable since 2015 at around 46 Mm³, including 23.2 Mm³ in refineries (15.7 Mm³) and outside refineries (7.5 Mm³). Over 60% of this storage capacity is used for finished products.

Figure 11: Breakdown of storage on 31 December 2018 – Source: Professional Oil Committee (CPDP)



Détail des stocks au 31 décembre 2018	Stores on 31 December 2018
Par produit	By product
Par type	By type
21 427 milliers de tonnes	21,427,000 tonnes
21 427 milliers de tonnes	21,427,000 tonnes
Pétrole brut	Crude oil
Produits intermédiaires	Semi-finished products
Produits finis	Finished products
Raffinerie	Refinery
Distribution	Distribution

The distribution of storage capacities across metropolitan France is influenced by the location of refinery facilities and import sites, and also by the routes of large-scale oil transmission infrastructures (oil pipelines). The regions of Normandy and Provence-Alpes-Côte d’Azur alone account for 48% of storage capacities. The regions of Nouvelle-Aquitaine and Hauts-de-France are also significant, albeit to a lesser extent, since they account for 18% of capacity due to the presence of major import depots.

Since 1 July 2012, the strategic stores that must be established and maintained by operators have been equivalent to 29.5% of the quantity of petroleum products distributed in metropolitan France during the year n-1, minus the quantity of crude oil produced within France (Decree of 29 January 2016). Stores that are established in this way with a view to meeting the strategic storage obligations account for 88% of the petroleum products stored in France. The minister responsible for energy has approved a map of strategic storage locations, indicating the sites where operators must establish stores with a view to guaranteeing security of supply flows and consumption.

Security of supply for natural gas

Security of supply for gas: level and criterion

The security of supply for natural gas involves ensuring that gas can be supplied continuously despite the various hazards affecting the gas system, in particular bad weather and failures of supply sources; it also involves ensuring that natural gas can be transmitted continuously throughout the network despite a number of potential risks, in particular congestion.

The aim of ensuring the security of supply for natural gas is to guarantee that consumers can be supplied with natural gas under the following circumstances (with the exception of consumers who have signed an interruptible supply contract):

- a very cold winter of the sort that is statistically likely to occur once every 50 years;
- a three-day period with extremely low temperatures of the sort that are statistically likely to occur once every 50 years.

The aim of broadening the scope for interruptibility is to increase the number of consumers willing to tolerate interruptions in their supply of natural gas, which will automatically reduce the supply standard. The possibility of further reducing the supply standard will continue to be examined, at the same time as strengthening the courses of action available in the event of a crisis.

The security of supply standard is more stringent than the minimum level provided for in Regulation (EU) 2017/1938 of the European Parliament and of the Council. Based on the findings made in the relevant inspection report, no alterations to the current criterion are currently proposed.

Obligations incumbent upon players in the gas supply chain

Obligations relating to continuity of supply

Suppliers of natural gas are obliged to ensure continuity of supply for all their customers at a level that corresponds to the security of supply standard (with the exception of customers that have signed an interruptible supply contract)[3].

In addition, suppliers of natural gas must be able to ensure continuity of supply to these same consumers even if their main source of supply fails for a maximum of six months, under average weather conditions. A ministerial authorisation must be granted before a company can supply gas on the French market. Supply authorisations must be updated annually, and evidence of compliance with the obligations relating to continuity of supply may be requested at the same time.

Obligations relating to diversification

Suppliers with a share of the market that exceeds a certain percentage are obliged to diversify the points at which their supply enters the country. The details are outlined in Article R. 121-1 of the Energy Code. To avoid penalising new market entrants, the obligation does not apply to suppliers with a share of a market below 5%.

Obligations relating to continuity of supply

Natural gas TSOs and DSOs must ensure that their infrastructures are designed in such a way as to ensure that natural gas can be transmitted in quantities that allow the security of supply standard to be met.

[3] The aim of ensuring the security of supply for natural gas is to guarantee that consumers can be supplied with natural gas under the following circumstances (with the exception of consumers that have signed an interruptible supply contract): a very cold winter of the sort that is statistically likely to occur once every 50 years; a three-day period with extremely low temperatures of the sort that are statistically likely to occur once every 50 years.

In addition, the public service obligations incumbent upon infrastructure operators mean that they must give advance notice of the dates when their infrastructure will be unavailable, so that suppliers can ensure continuity of supply.

Sizing of the gas system and storage

The gas system has been expanded significantly over the past decade in order to facilitate the flow of natural gas.

It currently includes seven main interconnection points (import capacities of around 2,335 GWh/day) and methane terminals on three continental seaboards (import capacities of around 1,160 GWh/day), providing access to diversified gas sources: North Sea, Russia, the Netherlands, Maghreb, and also – in a more general sense – the international liquefied natural gas (LNG) market.

Within continental metropolitan France, the flow of gas is facilitated by a network of transmission and distribution systems that operate in synergy with natural gas storage infrastructures. Completion of the Val-de-Saône and Gascogne-Midi projects allowed the establishment of a single market from 1 November 2018, since the French gas system is now deemed to have adequate capacity for the internal circulation of natural gas.

The current sizing of the gas system makes it possible to guarantee the supply of natural gas to French consumers. The drop in natural gas consumption that is likely to occur in the future will necessitate efforts to optimise the use of current infrastructures or the scaling down of these infrastructures.

The need to optimise the use of existing infrastructures applies in particular to underground natural gas storage infrastructures. According to the revised provisions that entered into force on 1 January 2018, the list of essential underground natural gas storage infrastructures that are necessary to guarantee the security of supply is defined under the MEP. The operators of these essential storage infrastructures are obliged to maintain them in good working order and to auction off their capacities; they are also subject to economic regulation. In return, they are able to recover the costs of these essential infrastructures on a guaranteed basis. The revised provisions guarantee that the natural gas stores required for the security of supply will be established within the country.

Protective measures in the event of a gas crisis

In the event of a crisis, and if preventive measures are not adequate to guarantee the supply of natural gas to French consumers, the following specific measures can be taken:

- recommendation by the public authorities to moderate energy consumption;
- triggering of interruptibility clauses in natural gas supply contracts;
- as a last resort, load shedding of consumers by the operator of the system to which they are connected;
- if the supply of natural gas to domestic consumers and core welfare services still cannot be guaranteed despite these measures, a call for European solidarity.

Security of supply for electricity

The purpose of ensuring the security of the electricity system is to avoid localised power cuts or blackouts on a larger geographical scale. It can be broken down into two separate goals.

- *Electricity system reliability*, which refers to the capacity of the electricity system to convey electricity from producers to consumers; this is achieved in particular by keeping infrastructures in good working order and by carrying out short-term balancing. Operating reliability also covers events such as major storms or system imbalances owing to an incident abroad that may cause large-scale power cuts. The associated challenges are beyond the scope of this document.

- *Security of the electricity supply*, which refers to the balance between supply and demand; at any given time, the quantity of electricity consumed must be equal to the quantity of electricity produced and injected into the system, making allowances for the uncertainties associated with both production and consumption. A balance must be achieved both at an operational management level and in the long term. This involves managing two different kinds of phenomena:
    - handling consumption peaks which, because of the sensitivity to temperature of electricity consumption in France, requires sufficient capacity to be available during the relevant periods (either production or load shedding);
    - managing rapid fluctuations in supply and demand; compensating for these fluctuations requires an adequate number of flexibility tools to be available within the electricity system. These tools include demand management, storage, interconnections and controllable production units.

The security of supply criterion is based on a probabilistic approach that evolves in response to changes in the tools.

The criterion that applies in respect of the security of the electricity supply is that mean annual downtime caused by failure should not exceed three hours over a 10-year period. Failure includes both load shedding of end customers and the use of 'exceptional' measures, including non-market measures: worsening of the electricity system's operating margins, activation of interruptibility contracts, and reduction in voltage on distribution systems. This falls under the remit of the electricity TSO (RTE). This criterion is concerned with managing the system, i.e. achieving a balance between supply and demand, rather than with technical malfunctions. It therefore depends to a very great extent on the ability to anticipate demand, the structure of demand and changes in consumption peaks.

The following methods are used to handle consumption peaks:

- **production capacities that are not normally used;**
- **interconnections (links with the electricity systems of neighbouring countries for the purpose of importing their electricity);**
- **reducing electricity consumption; for example, peak/off-peak hours encourage households to consume electricity outside busy periods.**

According to the criterion that is currently applied, all failures are recorded identically, regardless of the number of customers affected. Consideration should be given to adopting a different approach in the future.

Security of supply criterion

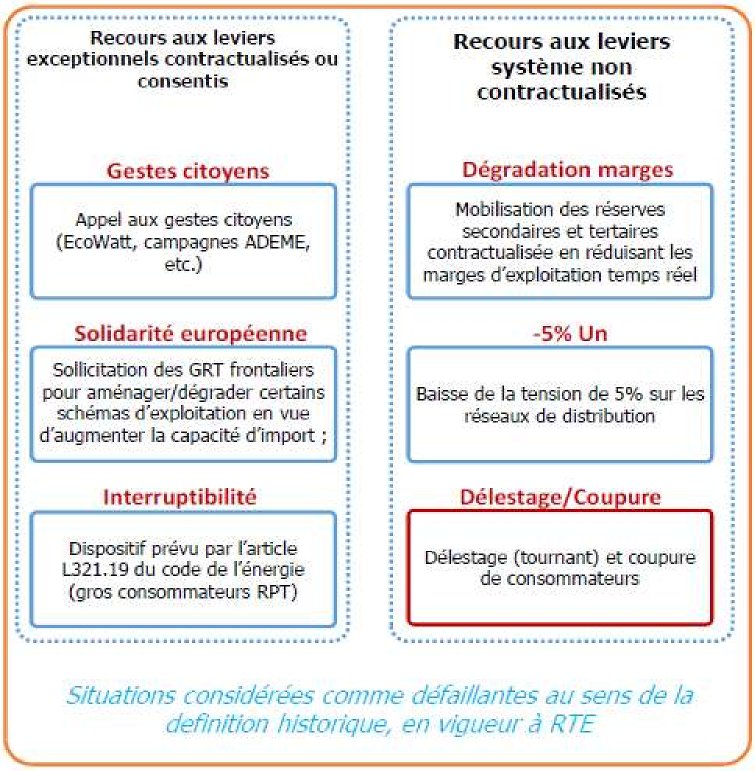
The provisional balance sheet for the supply/demand of electricity[4], which is drawn up every year by RTE, serves as a reference tool for assessing the risks to the security of France's electricity supply. The last provisional balance sheet that was published contains an in-depth examination of the relationship between supply and demand over the past five years. It quantifies the mean downtime, analyses the risk

4. Provisional balance sheet for the supply/demand of electricity: **https://www.rte-france.com/fr/article/bilan-previsionnel**

scenarios and assesses the electricity production and load shedding capacities required to safeguard the security of the electricity supply.

Article D. 141-12-6 of the Energy Code specifies the criterion for failure of the electricity system as 'a mean annual downtime caused by failure to balance electricity supply and demand that does not exceed three hours'. The Energy Code does not explicitly define the meaning of the term 'failure', however. According to the definition used by RTE as a basis for modelling, failures are situations in which the normal functioning of the market no longer allows supply and demand to be balanced. In such cases, the transmission system operator must use exceptional means (both contractual and non-contractual), as presented in the following figure:

Figure 12: Disruptions – Source : RTE, 2018



Recours aux leviers exceptionnels contractualisés ou consentis	Use of exceptional contractual or agreed tools
Gestes citoyens	Public action
Appel aux gestes citoyens (EcoWatt, campagnes ADEME, etc.)	Call for public action (EcoWatt, campaigns by ADEME, etc.)
Solidarité européenne	European solidarity
Sollicitation des GRT frontaliers pour aménager/dégrader certains schémas d'exploitation en vue d'augmenter la capacité d'import ;	Call for border TSOs to manage/degrade certain operating modes with a view to increasing import capacities
Interruptibilité	Interruptibility
Dispositif prévu par l'article L.321.19 du code de l'énergie (gros consommateurs RPT)	Mechanism provided for by Article L. 321.19 of the Energy Code (major consumers within the public transmission system)
Recours aux leviers système non contractualisés	Use of non-contractual system tools
Dégradation marges	Worsening of margins

Mobilisation des réserves secondaires et tertiaires contractualisée en réduisant les marges d'exploitation temps réel	Mobilisation of secondary and tertiary contractual reserves by reducing real-time operating margins
-5% Un	-5% Un
Baisse de la tension de 5% sur les réseaux de distribution	5% voltage drop on distribution systems
Délestage/Coupure	Load shedding/power cuts
Délestage (tournant) et coupure de consommateurs	Load shedding (rotational) and cutting off consumers
Situations considérées comme défaillantes au sens de la définition historique, en vigueur à RTE	Situations regarded as failures according to the historical definition used by RTE

The likelihood of a disruption is calculated according to the definition provided by RTE, based on a number of different scenarios that take a range of factors into account, in particular temperatures, interconnections and the production risks faced in the various sectors. According to RTE's models, a likelihood[5] of disruption of three hours per year is equivalent to the likelihood that a consumer will be cut off for less than two hours[6].

1.2.2.3. Internal energy market

Network development

Rapid growth in the decentralised production of electricity has resulted in the emergence of new production zones, in some cases strengthening the transmission and distribution networks as a result. In addition, the intermittent nature of some of the renewable energies currently in development across Europe heightens the need for interconnections between France and its neighbours and for the development of new flexibility tools.

It is estimated that the following sums will need to be invested over the next decade:

- **around €2 billion per year for the transmission network, including €500 million for the connection of new offshore wind installations;**
- **€4 billion per year for the distribution network. Investment needs will continue to grow: the current distribution networks were designed to supply consumers rather than to accommodate production. At present, the low- and medium-voltage network is adequately dimensioned for the bulk of the new decentralised renewable energy capacities; it must therefore undergo modifications to ensure that it can convey both electricity delivered by producers and electricity supplied to consumers.**

In general terms, the increase of decentralised production (particularly in consumption zones that are less densely populated) necessitates the establishment of new networks or the strengthening of existing networks. The location and size of production installations are of vital importance in terms of connection costs.

Smart grids

5. In the mathematical sense of the term.
6. A power cut is recorded as soon as one consumer is cut off. There does not need to be a widespread blackout.

The transition to smarter grids involves a number of different factors, including the roll-out of new families of equipment (sensors, remotely operated equipment, communication equipment, etc.), the digitalisation of existing equipment and the development of software and IT systems able to handle the volumes of data collected by the grids. Smart grids enable active demand management and improved energy efficiency.

Smart meters

New meters (Linky for electricity and Gazpar for gas) are being introduced with the aim of gaining more information on how users consume energy and improving the quality of service provided to them. Both meters will allow more granular measurements of consumption and supply information on energy quality. Linky will allow the distribution system operator to carry out remote management operations, for example by cutting off a single home instead of an entire neighbourhood in the event of a problem.

In particular, Linky and Gazpar will also allow preventive network maintenance operations to be carried out on the basis of earlier and more timely information. This is expected to reduce network management costs and improve network efficiency. Investment into the Linky scheme will total around €5 billion, and the same figure for the Gazpar scheme will be around €1 billion. According to calculations carried out by the Energy Regulatory Commission (CRE), the improvements in energy efficiency anticipated in connection with these meters will balance out the investment costs.

The Linky meter will promote more effective management of the low-voltage network, in particular by allowing the voltage level to be monitored more accurately and faults and consumption anomalies to be detected more rapidly. Further developments that will be possible thanks to the smart meter include optimised management and development of the distribution network and the large-scale integration of renewable energies and electric vehicles.

Benefits to the consumer include remote meter readings and bills based on actual rather than estimated data. Certain tasks will become more straightforward thanks to the meter (such as switching contract or supplier). The use of the Linky smart meter will also provide a boost to demand management services; for example, a supplier would be able to offer its customers the option of compensated curtailment during peak periods, by reducing the amount of electricity consumed only by specific appliances (such as freezers) for half an hour.

The Gazpar meter will make it possible to prioritise renovation operations in the highest-consuming buildings or neighbourhoods. The Linky meter will allow suppliers to offer new tariffs with a view to facilitating peak demand management and remote management.

The National Commission for Data Protection and Liberties (CNIL) was closely involved in all stages of work on the meters and introduced further protections for consumers[7], in the interests of data confidentiality, protection of privacy and security of the metering system. Measures provided for in this respect include the following:

- **secure management of the data stored in information systems; consumers will retain ownership of their data;**
- **consumer education measures explaining the new options that are available and the associated rights.**

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[7] https://www.cnil.fr/en/node/23936

In both cases, the Network and Information Security Agency (ANSSI) was involved in the process to ensure that that all the necessary protective measures had been taken.

The National Frequency Agency (ANFR)[8] and the National Agency for Food, Environmental and Occupational Health and Safety (ANSES) also carried out research into health-related issues with a view to ensuring that all users are protected.

Electricity demand management: curtailment

The option of curtailing the supply of electricity has been available for many years; 'off-peak periods' during which the price of electricity is lower encourage consumers to use appliances at times when less electricity is being consumed overall. Smart grids are different because they allow the granular and automated management of electricity demand. Operators will be able to offer services that alter the times of consumption dips and peaks without causing any inconvenience to consumers. This will make it easier to implement curtailment measures.

It will be possible for consumers to offer flexible curtailment capacities ranging from several kilowatts (individual households) to several megawatts (industrial operators); spread across multiple consumers, this will allow demand to be reduced significantly if an imbalance arises between production and consumption.

Curtailment of consumption accordingly helps to increase the security of supply within the network and eliminates the need to develop new production capacities in the medium term, thereby reducing costs.

Curtailment capacities rose to 2.9 GW in 2019. The MEP sets a target of 6.5 GW for total curtailment capacity by 2028.

The vast majority of curtailment operations affect industrial operators, with little use made to date of distributed curtailment (i.e. cutting off power to individual households). The distributed curtailment capacity can be estimated at 1.5 GW by 2030.

1.2.2.4. Research, innovation and competitiveness

Existing plans and strategies

France is involved in a number of international initiatives, most notably the Mission Innovation initiative launched in November 2015 by President Hollande, President Obama and President Modi during COP21, in the presence of around 20 Heads of State or Government. This initiative was launched in response to the finding that innovation will be an essential factor in meeting long-term commitments under the Paris Agreement, and that efforts in this direction must be accelerated. The initiative has three goals:

- **doubling public R&D funding for carbon-free energies between 2015 and 2021;**
- **strengthening cooperation between Member States on the relevant R&D measures;**
- **mobilising private investors to bring new solutions to the market.**

Eight 'innovation challenges' were also launched as part of the initiative, in relation to the following topics: smart grids, off-grid energy access, carbon capture/storage/recovery, advanced biofuels, conversion of solar energy into fuels, advanced materials, decarbonised heating and cooling for buildings and hydrogen. France is involved in all of these challenges, and is jointly responsible for work on the challenge relating to off-grid energy access.

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[8] https://www.anfr.fr/fr/toutes-les-actualites/actualites/compteurs-linky/#menu2

At European level, France actively participates in measures under the Strategic Energy Technology (SET) Plan, particularly through the various working groups responsible for implementing the action plans recently adopted under the aegis of this body.

At national level, France's National Research Strategy is structured around 10 key challenges facing society, three of which relate to the energy transition: 'Rational resource management and climate change adaptation', 'Clean, safe and efficient energy' and 'Sustainable urban transport and systems'. The National Energy Research Strategy is the energy pillar of this strategy. It is based on four areas of work:

- **targeting key topics for the energy transition;**
- **growing Research & Development & Innovation (R&D&I) capacities in tandem with the regions and the industrial base, particularly SMEs and intermediate-sized enterprises;**
- **developing skills and knowledge for and by R&D&I;**
- **creating a streamlined and high-performance governance framework that facilitates dynamic operational steering of the National Energy Research Strategy.**

Support and funding

In recent years, France has earmarked around €500 million of public funding per annum for research in the field of new energy technologies (renewable energies, energy efficiency, carbon capture and use, storage and networks, cross-sector fields), according to the nomenclature proposed by the International Energy Agency; this is equivalent to slightly more than 40% of France's research spending in the field of energy.

Funding is awarded not only to public research bodies, but also for R&D measures carried out by ADEME (particularly in the area of 'Demonstrators'), BPI France and the Caisse des Dépôts et Consignations (CDC), as well as the National Research Agency (ANR) (Energy Transition Institutes and generic calls for projects).

Between 2010 and 2017, ADEME implemented measures under the first two pillars of the PIA: 'Ecological and energy transition demonstrators' and 'Vehicles and transport of the future'. These measures addressed multiple topics, which can be split into four main groups:

- **production of renewable energies, energy storage and smart electricity networks;**
- **energy efficiency in buildings, industry and agriculture and bio-based chemistry;**
- **circular economy and waste;**
- **transport (including all its components) and mobility.**

A range of different funding tools were implemented, as well as calls for projects relating to demonstrators, an SME initiative and equity-based measures, ultimately making it possible to fund 745 projects with a total funding amount of €2.5 billion on the basis of 85 calls for projects (overall budget for projects: €7.22 billion).

With a view to building upon the PIA 1&2, ADEME is implementing several different measures under the PIA 3 (launched in 2017), worth €1 billion in total:

- **'Regional demonstrators and those for ambitious innovation', with €400 million in equity and €300 million in State aid (the CDC is also an operator, with separate loans for the regional component). From the perspective of ADEME, this builds on measures under PIA 1&2 that provided support for 'ecological and energy transition demonstrators'.**
- **'Innovation competition' dedicated to SMEs, with €150 million in State aid (BPI is also an operator with €150 million, which must also cover the regional component).**

- **Support for ‘Innovation ecosystems’ in the field of sustainable mobility; €150 million in State aid.**

Incentives designed to stimulate research and innovation in the field of renewable energies – the Energy Transition Institutes

The Energy Transition Institutes (ITE) are public/private platforms aimed at establishing centres of excellence that bring together academic researchers, major corporations and local SMEs to work on specific topics relating to the energy transition, with a view to promoting innovation by aligning public R&D funding with industrial strategies. The activities of the ITE are targeted at the industrial development of an entire sector, from technological innovations right through to demonstrators and industrial prototypes.

Under the PIA, the National Research Agency funds the work of these Energy Transition Institutes (which currently number around 10) in the following areas:

- **green chemistry and agri-based materials;**
- **renewable marine energies;**
- **solar energies;**
- **geothermal;**
- **smart electricity grids;**
- **energy efficiency;**
- **sustainable buildings;**
- **carbon-free vehicles and mobility.**

Around €450 million has been earmarked for this programme to date, and up to 50% of the Energy Transition Institutes’ activities have been financed via this funding stream.

1.2.3. Administrative structure of implementing national energy and climate policies

The Directorate-General for Energy and Climate (DGEC), which operates under the aegis of the Ministry for Ecological and Inclusive Transition, is responsible for drafting and implementing policies on energy, energy feedstocks and the fight against climate warming and atmospheric pollution. It was set up in 2008 by means of Decree No 2008-680 of 9 July 2008 and the Order of 9 July 2008. Structures within this Directorate-General include the Directorate for Energy and the Climate and Energy Efficiency Department:

- **The Directorate for Energy drafts and implements policies aimed at guaranteeing the security and competitiveness of France’s energy supply. It ensures that the energy markets (electricity, gas, oil) are functioning properly under competitive and environmentally friendly conditions. It is also responsible for France’s nuclear energy policy. Its work in these areas takes account of the challenges relating to climate change, and it also monitors the development of clean technologies. The Directorate for Energy also implements the Government’s decisions on renewable energies.**
- **The Climate and Energy Efficiency Department drafts and implements policies on the fight against climate change, climate change adaptation and the fight against atmospheric pollution. It proposes measures aimed at promoting demand management and the rational use of energy across all energy uses, as well as measures aimed at promoting the use of renewable heat. It drafts technical regulations designed to make road vehicles safe and to reduce the level of polluting emissions from such vehicles. It proposes and implements**

measures that incentivise the faster placement on the market of safer or more environmentally friendly vehicles.

1.2.4. Regional cooperation

1.2.4.1. Pentalateral Energy Forum

Introduction

The Pentalateral Energy Forum is a platform for voluntary regional cooperation that has existed since 2005. Its members include Belgium, France, Germany, Luxembourg, the Netherlands and, since 2011, Austria, which between them account for over one third of the EU's population and over 40% of the EU's electricity production. Switzerland joined the Forum as a permanent observer in 2011, and contributes actively to its technical work and decision-making processes. The Pentalateral Energy Forum also works closely with the European Commission on an invitation basis, with the aim of improving cooperation between all stakeholders in order to create a regional electricity market as an intermediate step towards a single electricity market in the EU.

The ministers responsible for energy policy meet regularly for the purpose of steering these cooperative efforts. The Penta coordinators and the Penta NECP Committee monitor work under the leadership of the Director-Generals of the countries that belong to the Pentalateral Forum. The work programme is implemented by the electricity TSOs, the relevant ministries, the national regulatory authorities, the European Commission and the market operators, which meet regularly within three Support Groups.

The most successful development over the past 15 years has been the shift by the Penta countries to a regional approach to energy market policy, instead of the previous purely national approach. Specific regional milestones have been adopted for the various dimensions, and these still remain relevant.

Internal electricity market/market integration:

The Support Group Penta 1 (SG1) focuses on the coupling of the electricity markets in the region. The Group pursued the goal of encouraging flow-based market coupling (FBMC) of the day-ahead markets, and in May 2015, the countries of the Penta region were the first in the European Union to introduce a model of this kind. The FBMC model has undergone continuous improvements since then with a view to generating yet greater welfare gains, and is currently being used as a basis for full flow-based market coupling at EU level for day-ahead markets.

In addition, as well as increasing the transmission capacity available for cross-border trade on the intraday market, SG1 has promoted a coordinated approach to intraday capacity calculations following the introduction (in March 2016, as the first step towards the coupling of the EU's intraday markets) of an day-ahead flow-based market coupling model for all the borders in the region.

The Support Group has witnessed first-hand the dramatic changes in the electricity landscape and electricity market governance. Back in 2005, the electricity companies were still working in isolation from each other; over the years, however, the Support Group has actively encouraged cooperation between stakeholders. Positive outcomes of this process include the regional grouping of TSOs within associations, the merger of power exchanges or TSOs and the emergence of new regional players (TSCNet, Coreso, the former CASC-CWE, SSC).

In view of the fact that new implementation plans must be drafted in line with the provisions of the Clean Energy Package, the Penta countries will coordinate their activities closely and explore the options for joint action.

Internal electricity market/flexibility:

Support Group 3 (SG3) focuses on issues relating to flexibility in the region. Work within SG3 has centred to date on balancing, the intraday market and the role of demand management, which are the three main areas of regional cooperation that aim to improve the flexibility of our electricity markets. Various technical reference documents have been drafted that summarise the main obstacles to increased use of flexibility in the Penta region. As well as traditional participants (national regulatory authorities/TSOs), other stakeholders such as DSOs, major consumer protection organisations and renewable energy producers were also eligible to become members of SG3.

The Pentalateral Forum evaluates current approaches to balancing and exchanges best practices in this area. It also plays a key role in implementing the European Union's guidelines on electricity balancing. A separate group of experts has worked on a report describing the current situation with regard to demand management in the Penta region, emphasising the rules and responsibilities of the new market players in each country within the region. A workshop on hydrogen is planned with a view to identifying potential topics for future cooperation between the Penta countries on this issue.

Security of supply:

Support Group 2 (SG2) focuses on issues relating to the security of supply in the region. A Memorandum of Understanding signed in June 2017 formalised cooperation between the Penta countries in relation to the security of supply. On this basis, and having regard to the new EU Regulation on risk-preparedness, a crisis exercise (PENTEX 2018) was organised in 2018 for the purpose of achieving a better mutual understanding of national concerns, identifying the main (cross-border) crises that the region could potentially face and evaluating various crisis mitigation measures.

A key milestone was passed in March 2015, when the first regional Generation Adequacy Assessment (GAA) carried out by the TSOs of the Pentalateral Energy Forum was published. The methodology applied when working on the GAA was based on a probabilistic and chronological approach with hourly calculations for the years 2015/2016 and 2020/2021, representing a significant improvement on previous deterministic approaches. In addition, the Penta TSOs had access to a common set of regional data based on the same scenarios and hypotheses, such as a regional model of heat-sensitive load and harmonised probabilistic hydrological data.

The governments of the Penta countries believe that these dimensions are still relevant. The Pentalateral Energy Forum will serve as a platform not only for continuing efforts in the areas referred to above, but also for the Penta countries to work on the following priorities over the next few years.

Decarbonisation in the electricity sector

Shared vision of carbon-free electricity in the Penta countries by 2050

The Penta countries will share their visions of what a carbon-free electricity system might look like in 2050 (with interim milestones in 2030 and 2040), based on a highly efficient system using mainly renewable energies, the gradual elimination of electricity produced from fossil fuels and the efficient end use of electricity. As a first step, national scenarios describing what the electricity system might look like in 2050 will be compared as a basis for identifying the shared and differing features of these scenarios, and the way in which they would guarantee security of supply. This will allow the Penta countries to reach a shared understanding of expectations and of the challenges involved in creating a future electricity system.

Cross-border cooperation on renewable electricity

The Penta countries will engage in voluntary efforts aimed at developing a range of shared proposals for cooperation at different levels, including an exploration of options for opening up national tendering procedures/cross-border tendering procedures, and shared tendering procedures for all Penta countries that are interested and that make increasing use of a European framework that is conducive to renewable energies and of existing cooperation mechanisms, such as joint projects and statistical transfers (‘menu cluster’) for all interested Penta countries.

The Penta countries also support the efforts currently being undertaken by the European Commission and the Member States with a view to establishing a new EU financing mechanism for renewable energies.

Elimination of regional restrictions on e-mobility services and options

The Penta countries will help to increase the share of renewable energies in the transport sector by promoting e-mobility (including fuel-cell vehicles). They will allow the unrestricted integration and implementation of e-mobility options and services within the Penta region by identifying and (where applicable) eliminating obstacles to the cross-border roll-out of e-mobility and recharging services, and by ensuring interoperability.

Research into carbon pricing options and their cross-border impact on electricity prices

The Penta countries that have plans for or are considering the introduction of carbon pricing will engage in voluntary exchanges of views on policy approaches in this area, advantages and disadvantages in terms of reducing CO_2 emissions, security of supply, price trends and the establishment of a level playing field for their industries.

Internal electricity market

Market integration

The Penta countries will step up their FBMC monitoring efforts yet further with a view to increasing cross-border trade and social welfare and maximising consumer benefits. They will use more innovative monitoring methods based on shared key indicators with a view to assessing progress towards a totally carbon-free electricity market within the Penta countries by 2050.

They will work together to achieve prompt implementation of the Clean Energy Package and to assess potential cross-border impacts on the energy market (e.g. tracking developments with regard to redispatching in the Penta region and improving cooperation in this area).

Flexibility

The Penta countries will examine the impact of implementing flexibility options such as energy demand management, Power-to-X (PtX), hydrogen, the role of storage and electric mobility, as well as specific obstacles to sectoral coupling that are linked to electricity in some way.

They will also examine the future potential of joint approaches to hydrogen within their energy systems as an increasingly renewable energy vector (in respect of guarantees of origin, cross-border infrastructure, the respective roles of TSOs and DSOs and hydrogen blending standards), and exchange information and best practices on support schemes for hydrogen and innovative projects and on the future role of hydrogen in a more general sense.

Security of supply

The Penta countries will make long-lasting improvements to generation adequacy assessments within the region, based on the most reliable meteorological data and the latest figures and targets under the Penta countries’ national energy and climate plans; the findings will be used as a basis for decisions on future energy mixes and other sensitivity analyses. The Penta TSOs are currently working on the third assessment for the period between now and 2021/2025, taking into account regional scenarios (based on national scenarios), improved flow-based calculations and sensitivities linked to demand flexibility.

Within the framework of the Clean Energy Package (CEP), and more specifically in the context of regional cooperation and the Regulation on risk-preparedness, discussions have been held with ENTSO-E, the Commission and other stakeholders with a view to adopting rules governing intra-Member State cooperation aimed at identifying potential regional crisis scenarios and preventing, preparing for and managing crises in the electricity sector, in keeping with the principles of solidarity and transparency and giving full consideration to the requirements of a competitive internal electricity market. The Penta countries will work together as partners to develop detailed regional crisis responses.

Tools for funding the energy transition

The Pentalateral Energy Forum will start to exchange information on potential regional approaches aimed at bringing about improvements to energy efficiency and rolling out renewable energies, for example by working together with financial institutions (such as the EIB) on joint approaches intended to reduce risks in these two sectors, thereby making it easier for the Penta countries to achieve their targets.

1.2.4.2. North Seas Energy Cooperation

France forms part of the wider North Sea region, which offers considerable potential in terms of renewable energies. The European Commission has estimated that North Sea offshore wind could cover up to 12% of the EU's electricity consumption by 2030.

Wind energy production and network infrastructure projects may have cross-border impacts on energy prices, security of supply and the environment, including the availability of maritime space and the pace of innovation, and cooperation in this area would therefore greatly benefit the North Sea countries.

The North Seas Energy Cooperation (NSEC) is a voluntary, regional, bottom-up and market-based cooperation initiative set up in 2016, aimed at – wherever possible and on a mutually advantageous basis – harnessing synergies, avoiding incompatibilities between national policies, sharing international best practices and promoting joint strategies. Its objective is to coordinate and facilitate the profitable roll-out of offshore renewable energies, in particular wind energy, with a view to guaranteeing a supply of sustainable, safe and affordable energy for the North Sea countries based on an accelerated and better coordinated roll-out of offshore wind energy and on potential joint projects or clusters of projects. The NSEC favours an incremental approach aimed at deeper integration and increased efficiency of wholesale electricity markets; it is also engaged in efforts to reduce GHG emissions, combat discrepancies in average wholesale prices and improve security of supply in the region.

The North Seas Energy Cooperation is made up of 10 countries and the European Commission: Belgium, the Netherlands, Luxembourg, France, Germany, the United Kingdom, Ireland, Norway, Sweden and Denmark.

Regional cooperation

In response to a request from the Government issued in connection with the drafting of this plan, experts from the NSEC's Support Groups shared information and lessons learned in respect of specific topics, for example obstacles faced and best practices for the national development of wind energy, as well as the bundling of national trajectories for renewable energies (specifically wind) for the period between now and 2030 and market integration.

France also consulted the other North Sea countries on its national energy and climate plan as regards the planned roll-out of wind energy between now and 2030 and other issues relating to network planning.

The Support Groups engage in cooperation on the following topics:

- **Support Group 1: maritime spatial planning and environmental impact assessments;**
- **Support Group 2: development and regulation of offshore grids and other offshore infrastructures;**
- **Support Group 3: support and financing mechanisms for offshore wind projects;**
- **Support Group 4: standards and technical rules in the offshore wind sector.**

Maritime spatial planning and environmental impact assessments

France is involved in efforts to develop a joint methodology for environmental impact assessments under the aegis of the NSEC. A better understanding of the potential environmental limits to the large-scale development of North Sea wind projects is an essential prerequisite for achievement of the EU's energy and climate targets, and further work is needed in terms of maritime spatial planning and environmental impact assessments before the North Sea's full potential can be leveraged. Through their respective authorities responsible for energy, maritime spatial planning and the environment, the North Sea countries will continue to cooperate closely in the field of maritime spatial planning, environmental research and assessments of the cumulative effects of wind farms, with a view to building knowledge and supporting the roll-out of wind projects in the North Sea.

Offshore grids and other offshore infrastructures

The NSEC serves as a platform for cooperation on concepts for potential joint wind projects and for coordinated electricity infrastructure, including transport infrastructure.

France works together with other countries on specific potential cooperation projects under the aegis of this platform. In addition to joint offshore wind projects that will be supported by several Member States and connected to the electricity systems of these latter, this includes work on potential 'hybrid' solutions using network connection cables to transmit offshore wind, and on interconnection capacities between countries and the corresponding market adaptations.

In this way, France contributes to efforts to broaden cooperation on potential hybrid projects and to identify and overcome any legal, regulatory and commercial obstacles. The coordination of activities aimed at greater interconnection between the NSEC countries will mean that increasing amounts of surplus energy production can cross borders in order to meet internal market demand for high-efficiency energy.

The NSEC has drawn up a list of areas where mutually beneficial joint projects could potentially be carried out. These include: (1) the wind farm IJmuiden Ver (United Kingdom); (2) CGS IJmuiden Ver (Norfolk); (3) COBRA Cable; (4) the offshore wind farm connected to the Netherlands; and (5) the North Seas Wind Power Hub.

The NSEC is developing detailed concepts for the implementation of projects selected from the list above.

It will continue to work on action plans for specific hybrid projects that may also be implemented at national and regional level. In addition, the NSEC will continue to serve as a platform for examining ways of addressing the lack of regularity certainty at national and EU level in relation to hybrid projects, and for debating the options available for overcoming these challenges.

Support and financing mechanisms for offshore wind projects

France benefits from its participation in the NSEC in several ways with regard to these measures. The NSEC serves as a platform for exchanges of views on best practices as regards the design of support schemes, for the development and drafting of new concepts that respond to the novel challenges being faced in connection with support for offshore wind, and for the exploration of potential opportunities for future joint offshore wind projects.

France is engaged in efforts under the aegis of the NSEC to coordinate its tender timetable, to exchange views on best practices for the design of offshore wind funding schemes, and to identify, where possible, shared principles and potential opportunities for the alignment of funding.

France regularly shares information on its national tender timetable with other NSEC countries for the purpose of identifying potential overlaps and allowing the greatest possible flexibility in respect of calls for tenders in the North Sea region, with the ultimate aim of ensuring that tendering procedures create strong competition and are as cost-efficient as possible for consumers. Alongside other criteria and to the extent possible, France is willing to take account of this overview of tender timetables in its future planning of calls for tenders, in order to avoid unnecessary duplication and to create a stable pool of capacity for stakeholders without the repeated need to stop and then restart.

As part of the NSEC, France shares and evaluates information on the estimated trajectory for renewable offshore wind, on its plans for the roll-out of offshore wind and on best practices in respect of the design of calls for tenders in the field of offshore wind.

During the ministerial meeting held at Esbjerg on 20 June 2019, the North Sea countries agreed to work together with a view to achieving a joint installed capacity for offshore wind of at least 70 GW by 2030 (total indicative figure), based on national plans.

This total planned capacity (at least 70 GW by 2030) may be implemented by means of an overall trajectory for the region with interim milestones of around 25 GW by 2020 and 54 GW by 2025, with the aim of more accurately mirroring developments as regards the roll-out of offshore wind in the region.

Again under the aegis of the NSEC, France is involved in the assessment and development of options for the increased mobilisation of funding for joint projects, for example through European funds such as the European Fund for Strategic Investments (EFSI) and the Connecting Europe Facility (CEF), as well as through institutional investors. These joint projects might include cross-border renewable energy projects, in line with the CEF's proposal.

Harmonisation of rules, regulations and technical standards

The NSEC aligns technical requirements and standards that are likely to further reduce the cost of offshore wind deployments. The aim of this process is to align technical standards, regulations and rules in the five areas that have been identified. These include: (1) aviation, marking and lighting, (2) health and safety, (3) certification of regulatory requirements, (4) wind farm planning and site surveys, and (5) research approaches. The NSEC draws up proposals and recommendations that are implemented in close collaboration with industry. The aim of these recommendations is to reduce costs in a workable manner. The NSEC will continue to cooperate on the alignment of technical requirements and standards and to exchange best practices with a view to reducing anti-industry regulations and costs.

1.2.4.3. High-Level Group on 'Interconnections for South-West Europe'

The Quadrilateral Summit on Interconnections, which gathers together the Heads of State or Government of Spain, France and Portugal and the President of the European Commission, and which took place in Madrid on 4 March 2015, decided to set up a **High-Level Group on Electricity and Gas Interconnections for South-West Europe.** This High-Level Group, which was launched formally in Paris on 30 June 2015, gathers together representatives of three countries and the European Commission, as well as the national regulators and TSOs. Its purpose is to gain a holistic overview of projects across the entire region and to involve all stakeholders, in particular TSOs and regulators. It receives support from the Commission through the recognition of these projects as projects of common interest, and through access to EU financing tools.

1.3. Consultations and involvement of national and EU entities, and their outcome

1.3.1. Involvement of stakeholders, the national parliament, local and regional authorities, civil society and the general public

The current integrated national energy and climate plan is based on the MEP 2 and the SNBC 2. These documents underwent an extensive consultation process when they were drafted; this process is described below.

1.3.1.1. Process for drafting the MEP

Stakeholder engagement

The process for revising both the MEP and the SNBC kicked off in June 2017, with a joint meeting of the Monitoring Committee for the MEP and the Steering Committee for the SNBC. The Monitoring Committee for the MEP is made up of around 80 members of French society, most of whom represent bodies that belong to the National Council for Ecological Transition (CNTE) and the High Council for Energy (CSE). This Committee met three times over the course of the year so that it could express its opinions on the progress of work. The Monitoring Committee and the Steering Committee are made up of representatives of businesses, civil society and trade unions, representatives of Parliament and representatives of local authorities.

The workshops held on the topic of demand management were also attended by individuals working on the revision of the SNBC. These workshops were organised on by sector. They each met four times during the period between June 2017 and June 2018:

- industry;
- buildings;
- transport;
- economy;
- agriculture and forestry.

In addition, 24 workshops were held between October 2017 and January 2018, covering all the topics specifically addressed by the MEP. Each workshop was attended by between 20 and 50 individuals. The members of the Monitoring Committee were invited to each workshop, as well as bodies working in the specific area to be debated. Over 100 presentations were discussed and 70 written contributions shared during these workshops. Workshops on anticipating energy demand were organised by sector:

- biofuels;
- biogas;
- solid biomass;
- offshore wind/marine renewable energies;

- onshore wind;
- geothermal;
- hydropower;
- nuclear;
- photovoltaic;
- waste energy recovery.

Workshops on energy systems were organised by theme:

- supply and demand for petroleum products;
- supply and demand for gas;
- gas transmission networks, storage and import infrastructures for natural gas;
- distribution networks and new uses of natural gas;
- heating in the residential and tertiary buildings sector;
- heating in the industry and agriculture sector;
- district heating and cooling;
- electricity mix;
- electricity networks;
- demand management (curtailment etc.);
- self-consumption;
- storage;
- security of supply for electricity and gas;
- recharging infrastructures for alternative fuels.

Public engagement

A public debate was organised by the National Public Debate Commission (CNDP) between 19 March 2018 and 29 June 2018. The debate incorporated the following:

- a website centred around the debate, an online questionnaire, brochures produced by stakeholders;
- thematic workshops (Europe/international, innovation, stakeholder opinions);
- workshops on controversial topics (involving experts) and expert hearings;
- a citizens' forum (panel of 400 people, selected at random);
- regional initiatives;
- targeted initiatives implemented with partners.

The Government made available a public enquiry file containing information for citizens on the challenges faced in connection with the MEP, with a view to seeking citizens' opinions on a number of key topics: https://ppe.debatpublic.fr/dossier-du-maitre-douvrage-dmo

Topics on which citizens' opinions were sought included the following in particular:

- Initiatives regarded as particularly effective by citizens in terms of reducing energy consumption: the measures that would most likely to encourage them to take action both at home and with regard to their mobility choices.

- The development of different renewable energy production sectors: wind, photovoltaic, anaerobic digestion, etc.,

- Security of supply guarantees. What do they think of the way in which the criteria are defined? Would alternative definitions or levels be more appropriate? Would consumers be more willing to tolerate the risk of power cuts if the cost of energy were reduced?

The 86 meetings organised in connection with the public debate were attended by almost 8,000 people in total. The website was visited 47,572 times, with 561 opinions posted, 140 contributions published and 193 brochures uploaded by stakeholders, 2,379 comments posted on the information and opinions available on the website, and 666 questions submitted by Internet users. The Special Public Debate Commission published a report that can be accessed at the following link: https://ppe.debatpublic.fr/.

The Government paid close attention to the contributions made by citizens during the debate. Its decision of 30 November 2018 followed up on the National Public Debate Commission's recommendations, and was published in the Official Journal on 4 December 2018. The findings that emerged from the consultation were taken into account when drafting this document.

A summary of the debate is available at the following link: https://ppe.debatpublic.fr/compte-rendu-bilan-du-debat.

In addition, a post-debate public consultation on the MEP was subsequently organised under the guidance of the National Public Debate Commission, involving the following:

- presentations of the draft MEP in several regions of France;
- a meeting where the draft MEP was presented to France's neighbours, and a more formal written consultation;
- a meeting on 14 June 2019 with the parties responsible for organising the 86 local debates on the MEP;
- a meeting in September 2019 to exchange views with members of G400 Energy (a group of 400 individuals selected at random from across France to play an active role in the public debate on the MEP).

Finally, the current draft version of the revised MEP underwent a public consultation via the website of the Ministry for Ecological and Inclusive Transition.

Formal gathering of opinions

Formal consultations were held on the draft MEP. Opinions were gathered from the following bodies:

- the Environmental Authority (in respect of its strategic environmental assessment);
- the National Council for Ecological Transition;
- the High Council for Energy;
- the Management Committee for the Public Electricity Service Contribution (CSPE);
- the Committee for the Public Electricity Distribution System;
- the European Commission;
- the public.

The following countries, some of which share borders with France, were also consulted, since their electricity systems are interconnected with France's system: Germany, Austria, Belgium, Luxembourg, Italy, Spain, United Kingdom, Ireland, the Netherlands, Portugal and Switzerland.

These opinions will be taken into account in the final MEP.

1.3.1.2. Process for drafting the SNBC

The reference scenario and the guidelines outlined in the SNBC were developed in close cooperation with stakeholders with a view to identifying all of the challenges involved and ensuring that the strategy would subsequently be viewed positively by the greatest possible number of these stakeholders. Based on initial interdepartmental efforts aimed at supplying a holistic overview of climate policy from the outset, civil society representatives (stakeholders) and the general public were asked on several occasions to get involved, to submit their suggestions and to express their opinions. This iterative process ended with an official referral of the strategy to the following bodies prior to its adoption by decree: the Environmental Authority, the High Council for Climate, the Corsican Assembly, the overseas authorities affected by the strategy and the National Council for Standards Assessment. This was followed by a final public consultation carried out in early 2020.

Cooperation with stakeholders

The reference scenario and the guidelines outlined in the SNBC were drafted jointly with stakeholders on the basis of regular exchanges of views with these latter.

These exchanges of views took place firstly via the Information and Orientation Committee for the SNBC, which is made up of around 120 members of the National Council for Ecological Transition (including representatives of each group within civil society, e.g. representatives of workers and employers, consumer rights activists, environmental NGOs, local authorities and members of parliament), and which held joint meetings with the Monitoring Committee for the MEP. The Information and Orientation Committee met six times after June 2017, at each key stage of the revision process (for the purpose of validating the hypotheses underpinning the strategy's reference scenario, for example). The interdepartmental services affected by the strategy also took part, with a view to ensuring that the strategy would be supported and put into practice by each of the departments involved in its implementation.

In addition, working groups were set up and met an average of four times; these working groups included members of the Information and Orientation Committee and sectoral experts, in particular representatives of specialised trade associations, research institutes and universities. The working groups were structured as follows:

- Five sectoral groups: transport, buildings, agriculture, forestry and industry/waste.
- Two cross-disciplinary groups: the economy, and other cross-disciplinary areas.

The experts within the working groups made particularly significant contributions in relation to the modelling of hypotheses for the reference scenario (based in particular on sector-specific ideas about carbon neutrality, proposed additional measures, comparisons with existing scenarios and the need for the broadest possible consensus on the hypotheses chosen for the reference scenario), in relation to the strategic guidelines outlined in the SNBC and in relation to the indicators selected in this connection. In addition, 24 workshops were held between October 2017 and January 2018 on all the topics specifically addressed in the MEP.

Preliminary public consultation

French citizens were invited to take part in the revision process for the SNBC by responding to an online questionnaire between 13 November and 17 December 2017. Over 13,000 responses were collected. Citizens' contributions were collected together in a compilation (available in a long and summarised version) and in a selection of the most notable (also available in a long and summarised version); these can be accessed at the following link: https://www.ecologique-solidaire.gouv.fr/revision-strategie-nationale-bas-carbone-contributions-des-citoyens.

The vast majority of suggestions submitted during this consultation corresponded to policy initiatives that were in progress or that had already been implemented. This is reassuring, because it suggests that the policies being implemented are closely aligned with citizens' expectations.

Nevertheless, some of the suggestions related to topics that had not previously been identified as priorities. The suggestions were often expressed as recommendations for action. For example, it was recommended that advertising be better regulated, with a view to informing consumers and guiding their choices. Certain recommendations also related to the need to make the energy and climate transition more effective and consensual, and to ensure that it is inclusive and beneficial for as many stakeholders as possible. In particular, Internet users highlighted the need for more trust in products and services relating to the transition and in professionals working in this sector on the basis of the information supplied (on labels etc.) and on the basis of public policies, by increasing transparency and reducing inconsistencies.

This questionnaire was not carried out as a survey; the contents of the responses and their relevance in terms of informing decisions on future areas of action were more important than the frequency of responses.

The online summary consolidates these contributions, with a particular focus on those most likely to provide concrete pointers for the content of the SNBC.

The outcomes of this consultation were presented and forwarded to the members of the Information and Orientation Committee and the working groups. They also served as input into the public debate on the revision of the MEP (see the following paragraph).

The outcomes of the Public Debate that was organised in connection with the MEP also served as valuable input when revising the SNBC. For example, recommendations relating to the clarity of the document were taken into account; an explanation of the legal framework is provided in a separate annex, which outlines the legislative and regulatory provisions governing the content and scope of the Strategy, the carbon budgets and the process for revising the Strategy. The recommendation relating to a specific summary of the strategic environmental assessment has been followed up on by publishing a non-technical summary of the strategic environmental assessment. The Special Public Debate Commission also issued the following recommendation; 'Highlight the link between the various programming documents, in particular the SNBC and the MEP'. The links between the SNBC and the other national and regional plans and programmes are outlined in the published report accompanying the strategy.

The report on the public debate on the MEP also highlights key concerns regarding the role to be played by citizens in the ecological and energy transition. Concerns that came to the fore during the public debate included consumer information and social innovation for behavioural change. These topics are addressed in the revised SNBC, particularly in the section on 'Education, awareness-raising, ownership of challenges and bottom-up solutions'. The SNBC also identifies individual and collective behaviours, including moderation of use, as one of the major levers for achieving carbon neutrality, along with energy efficiency, decarbonisation of the energy sectors and an increase in carbon sinks and bio-based production. Finally, the section entitled 'Research and innovation policy' promotes citizen involvement with a view to ensuring that future innovations are social as well as technological.

Opinion of the Expert Committee for Energy Transition

Pursuant to Article L. 222-1 D of the Environment Code in the version in force prior to the promulgation of the Law on Energy and Climate, the Expert Committee for Energy Transition must issue an opinion on compliance with the carbon budgets already adopted and on implementation of the current strategy no later than six months before the deadline for publication of the revised strategy (i.e. late 2018 at the latest). The opinion is forwarded to the Standing Committees of the National Assembly and the Senate responsible for energy and the environment.

As well as comparing the emissions figures against the carbon budgets and examining the reasons for any discrepancies, particularly in the transport, buildings and agriculture sectors, the opinion[9] dated 24 December 2018 outlines a number of avenues for future work on the SNBC, such as:

- use of the SNBC as a portfolio of public measures available to steer the transition at different regional levels and in different economic sectors;

[9] http://www.ecologique-solidaire.gouv.fr.vpn.e2.rie.gouv.fr/sites/default/files/CETE%20AVIS%20BUDGET%20CARBONE%202018.pdf

- accurate assessments of the factors that might contribute to success or failure of the transition;
- more systematic reliance on best practices from other countries;
- questioning of certain policies that are already in place.

The High Council for Climate established by the President of the Republic on 27 November 2018 was intended to take on certain tasks previously performed by the Expert Committee for Energy Transition, by carrying out assessments of France's climate measures and of the SNBC from 14 May 2019 onwards. The High Council for Climate is therefore responsible for assessing the revised version of the SNBC before it is published.

Consultations on the draft SNBC following the revision process

Once the revision process was complete, the draft strategy (published in December 2018) was submitted to the relevant bodies as part of a formal consultation:

- the **Environmental Authority**, which submitted its opinion on 6 March 2019. In this opinion, the Environmental Authority:
    - recommends 'raising the stakes' as regards the handling of technological risks and biodiversity in environmental assessment reports;
    - highlights the need for mechanisms and methodologies guaranteeing the alignment of the SNBC with plans, programmes and projects at regional level;
    - recommends that the principles governing carbon footprints and GHG emissions offsetting should be more stringent;
    - recommends that the state should undertake to carry out offsetting measures in the event that its 'carbon budgets' are exceeded;
    - highlights the lack of any detailed analysis of the impact of increased biomass use, and the challenge of ensuring that the mineral resources required for the energy transition are available;
    - more generally speaking, identifies a lack of concrete measures for implementing the planned guidelines in the various sectors and for quantifying the associated measures, for example mechanisms that compensate society for the cost of carbon or that promote a modal shift in the transport sector;
- the **National Council for Ecological Transition**, whose opinion of 18 April 2019 related mainly to the following points:
    - the need for consistency between the hypotheses underpinning the reference scenario and recent decisions by public authorities, in particular those relating to the carbon tax (including those taken in response to the findings that emerged from the 'Great Debate');
    - the importance of compliance with targets and robust monitoring, in view of the fact that the first carbon budgets were exceeded;
    - the need to align the SNBC with the MEP, and to align the SNBC with regional planning tools and strategies such as the regional plan for SRADDET and the regional energy and climate plans (PACET);

- the importance of the economic and social impacts of the guidelines outlined in the SNBC and the need for supporting measures;
- the need for everyone to get behind the goal of carbon neutrality;

- the **High Council for Climate**, whose annual report ('Acting in line with our ambitions', which was submitted to the Prime Minister on 25 June 2019) serves as an opinion on the draft SNBC and the draft carbon budgets, and contains the following recommendations in particular:
  - incorporation of the short-term effects of freezing the carbon component of taxation, by adopting additional measures to compensate for its effects on GHG emissions;
  - adjustment of the 2019–2023 carbon budget to the level set for the SNBC in 2015;
  - establishment of a link between emissions from international air and maritime transport on the one hand, and carbon budgets and the target of carbon neutrality on the other;
  - implementation of measures aimed at reducing the carbon footprint of consumption;
  - clarification of the reasons why international funding sources have not been utilised with a view to achieving carbon neutrality, and improved provision of information on the targets per sector and per gas;
- the **National Council for Standards Assessment** (favourable opinion of 11 July 2019);
- the **Corsican Assembly**, whose opinion dated 26 July 2019 contains the following recommendations in particular:
  - clarification of the precise relationship between the SNBC and the specific plans and programmes for non-interconnected areas, in particular Corsica;
  - explanation of the scope of the data set out in the strategy-related chapters (continental France, metropolitan France, non-interconnected areas, Corsica, etc.);
  - reiteration of the energy targets that have been set only for the interconnected areas;
  - further clarification in the document of the sections that apply only to continental metropolitan France;
- the **overseas authorities**, including opinions from:
  - the local authority of **Saint-Pierre-et-Miquelon** (favourable opinion of 29 July 2019);
  - the local authority of **La Réunion** (favourable opinion of 2 August 2019);
  - the local authority of **Martinique** (unfavourable opinion of 23 August 2019);
- the **public**, whose contributions (gathered via the Internet) were gathered together in a summary document.

Certain bodies submitted opinions on the draft SNBC on their own initiative. In particular, the following opinions were submitted:

- the opinion of the **Economic, Social and Environmental Council** of 9 April 2019;
- the opinion of the **High Council for Construction and Energy Efficiency** of 21 May 2019.

1.3.2. Consultations of other Member States

Other Member States were consulted in 2019 in accordance with Article 12 of the Regulation on the governance of the Energy Union.

A meeting with the countries that share borders with France (Germany, Belgium, Luxembourg, Italy, Spain and the United Kingdom), the countries whose energy systems are linked to France's energy system (the Netherlands, Austria, Ireland and Portugal) and the European Commission took place on 1 March 2019. Work was also stepped up within certain other bodies, in particular the Pentalateral Energy Form and the North Sea Wind Forum.

Finally, the countries that share borders with France were invited to take part in the public consultation launched on 20 January on the revised draft MEP.

1.3.3. Iterative process with the Commission

This process took place in 2019, as provided for in the Regulation on the governance of the Energy Union (Article 9).

2. NATIONAL OBJECTIVES AND TARGETS

2.1. Decarbonisation

2.1.1. GHG emissions and removals

2.1.1.1. The elements set out in point (a)(1) of Article 4

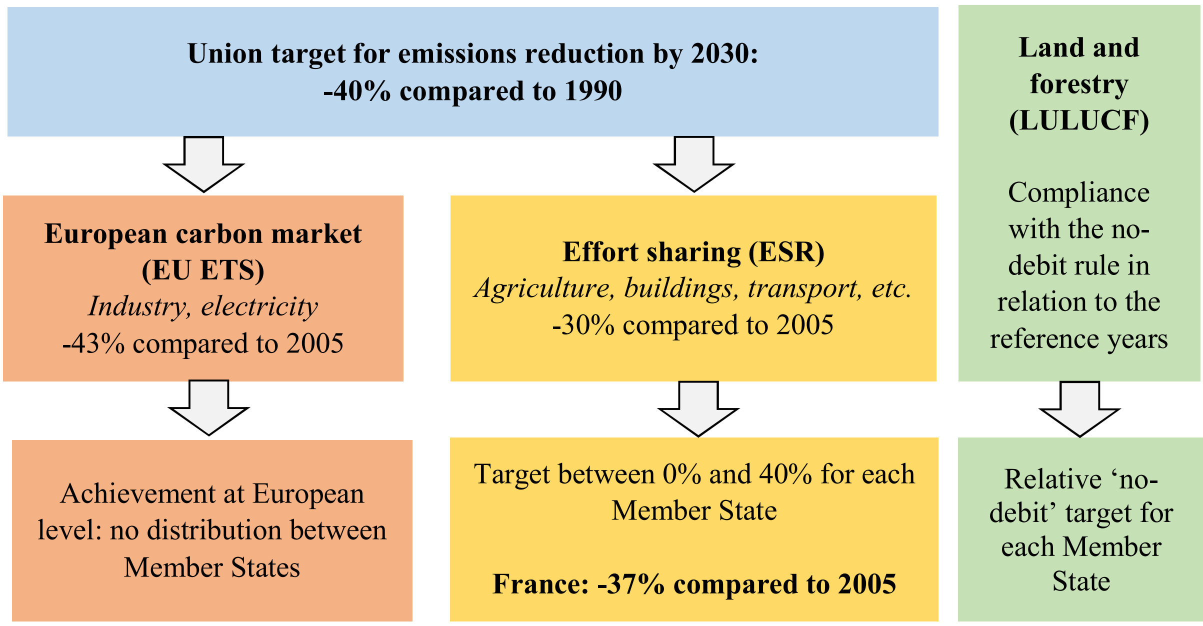
France's ESR and LULUCF targets for 2030

France's emissions target in respect of non-ETS and non-LULUCF sectors ('ESR target') under Regulation (EU) 2018/842 involves a **37% reduction in these emissions by 2030 compared to 2005**.

The European Commission will make known the budgets (annually binding national limits pursuant to Regulation (EU) 2018/842) allocated to each Member States in executing acts that will be published once the emissions data for 2016–2018 are available (probably in 2020).

According to Regulation (EU) 2018/841, each Member State (including France) must ensure that emissions in the land, land-use and forestry (LULUCF) sector do not exceed removals for the periods from 2021 to 2025 and from 2026 to 2030, compared to a reference period of 2005–2009 for the land sector and a projected forest reference level for forest management.

The diagram below outlines the European climate framework for the period 2021–2030 and France's targets in this context.



2.1.1.2. Other national objectives and targets consistent with the Paris Agreement and the existing long-term strategies. Where applicable for the contribution to the overall Union commitment of reducing the GHG emissions, other objectives and targets, including sector targets and adaptation goals, if available

France's mitigation targets

The targets set by France for the reduction of regional GHG emissions are consistent with its EU and international undertakings[10]. These targets are as follows:

- **achieving carbon neutrality by 2050, or in other words net zero emissions within the country; this target was set in the Government's Climate Plan published in July 2017, and is therefore enshrined in law;**
- **reducing greenhouse gas emissions by -40% by 2030 compared to 1990; this target was set in the Law on Energy Transition for Green Growth, which was adopted in 2015;**
- **in the short and medium term, to comply with the carbon budgets adopted by decree, i.e. the emissions caps that must not be exceeded for successive five-year periods (except for the first period which covers four years, from 2015 to 2018).**

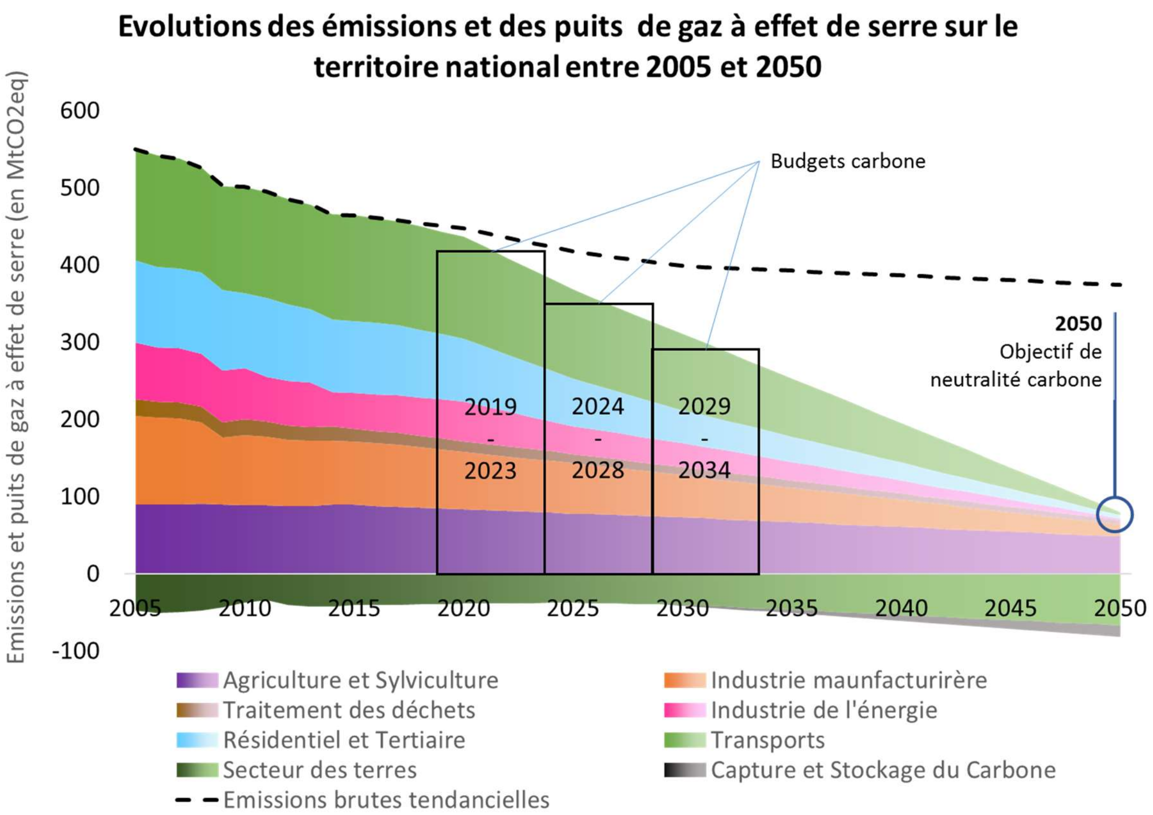
The carbon budgets are defined in the SNBC. The SNBC and the first three carbon budgets were adopted by Decree No 2015-1491 of 18 November 2015. The carbon budgets that have been adopted relate to the periods 2015–2018, 2019–2023 and 2024–2028. For reference purposes, they are broken down at the level of the following major sectors: transport, residential and tertiary buildings, industry, agriculture, energy generation and waste. Provisional adjustments were made to the carbon budgets in 2019 in response to developments in the field of GHG emissions accounting[11].

The draft SNBC 2 contains details of the fourth carbon budget for the period 2029–2033, which will be adopted by decree in 2019 in parallel to the adoption of the revised SNBC. The draft also revises the second carbon budget.

The graph below contains historical GHG emissions data for France since 1990, as well as the emissions for the period between now and 2050 modelled by the reference scenario used for the draft SNBC 2. It also shows the next three carbon budgets.

[10] Under the Paris Agreement and the UN Sustainable Development Goals.
[11] Final adjustments to the carbon budgets will be carried out in spring 2020 if necessary, when the outcomes of the GHG emissions inventory for the entire period between 2015 and 2018 are available.

Figure 13: Changes in GHG emissions and sinks in France between 2005 and 2050



Évolution des émissions et des puits de gaz à effet de serre sur le territoire national entre 2005 et 2050	Changes in GHG emissions and sinks within France between 2005 and 2050
Emissions et puits de gaz à effet de serre (en MtCO2eq)	GHG emissions and sinks (in MtCO2eq)
Budgets carbone	Carbon budgets
2050 Objectif de neutralité carbone	2050 Target of carbon neutrality
Agriculture et Sylviculture	Agriculture and silviculture
Traitement des déchets	Waste treatment
Résidentiel et Tertiaire	Residential and tertiary buildings
Secteur des terres	Land sector
Emissions brutes tendancielles	Gross emissions under the trend-based scenario
Industrie maunfacturirère	Manufacturing sector
Industrie de l'énergie	Energy sector
Transports	Transport
Capture et Stockage du Charbone	Carbon capture and storage

Based on the reference scenario used for the draft SNBC 2, a potential trajectory for GHG emissions reduction through to the achievement of carbon neutrality in 2050 can be modelled; this trajectory served as a starting point for the fourth carbon budget. The short-term and medium-term hypotheses used when developing the scenario were more accurate than those used when developing the scenario that was provided for under the SNBC adopted in 2015, and which was used as a basis for the first three carbon budgets. As a result, the second carbon budget that had been adopted in 2015 was adjusted upwards in the draft SNBC 2. The following finding has emerged from the provisional emissions forecasts for the periods 2019–2023 and 2024–2028, covered by the second and third carbon budgets:

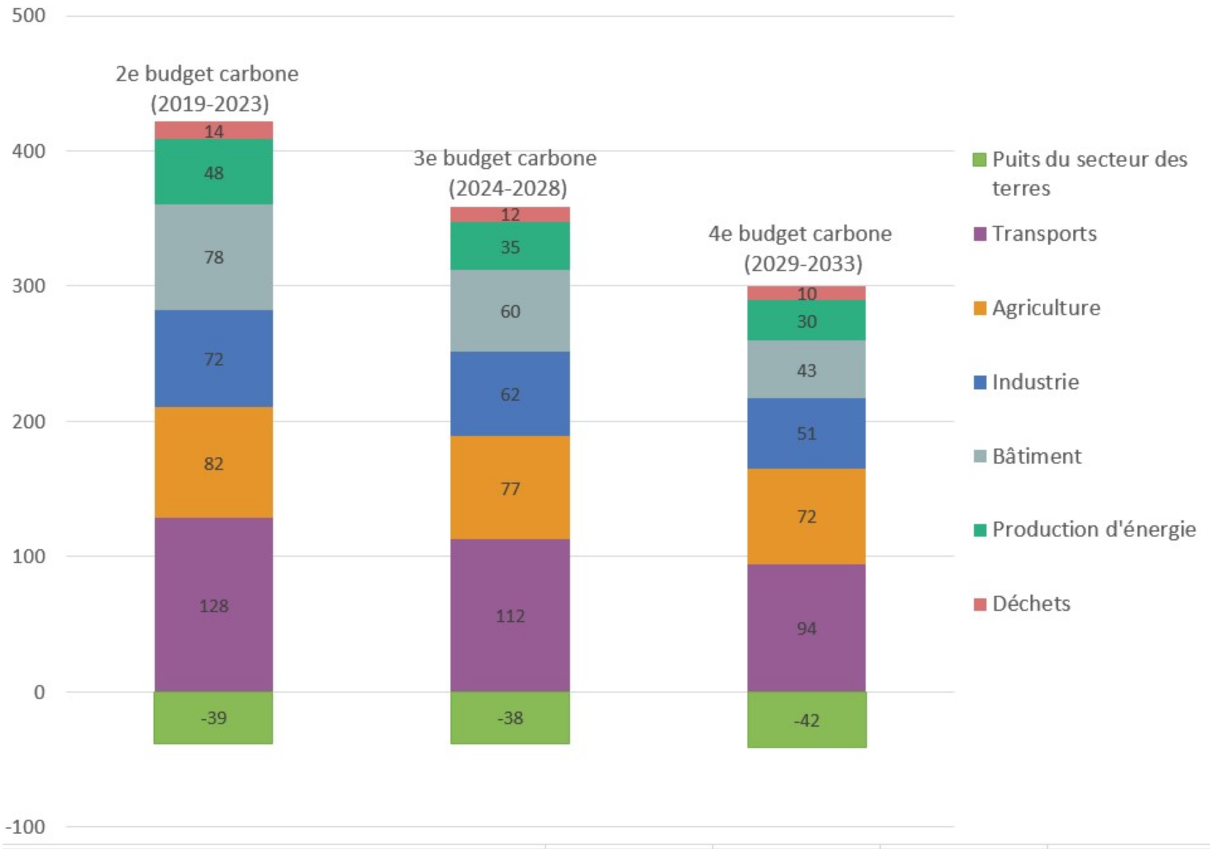
- **The second carbon budget set under the SNBC 1 will be exceeded, potentially by around 120 MtCO2eq for the entire period between 2019 and 2023, which is equivalent to 6% of the second budget. Reasons for this excess include the downward adjustment of hypothetical energy price trends and greater allowances for the challenges faced by the transport sector (lack of hoped-for improvements in the performance of new vehicles and absence of a modal shift in the fright transport sector) and buildings (lower-than-planned rate of renovation, and less substantial impact).**
- **The targets for the third carbon budget will only be missed by a very small amount (2 MtCO2eq) provided that all the measures already proposed are put in place, including all of the additional measures provided for in the reference scenario.**

The table and graph below show the next three carbon budgets under the draft SNBC 2, with a breakdown by sector:

Average annual emissions (in Mt CO_2eq)	Reference years			Second carbon budget	Third carbon budget	Fourth carbon budget
Period	1990	2005	2015	2019-2023	2024-2028	2029-2033
Transport	122	144	137	128	112	94
Buildings	91	109	88	78	60	43
Agriculture/ silviculture (excluding LULUCF)	94	90	89	82	77	72
Industry	144	115	81	72	62	51
Energy production	78	74	47	48	35	30
Waste	17	21	17	14	12	10
Total (excluding LULUCF)	546	553	458	422	359	300
Total (including LULUCF)	521	505	417	383	320	258
Carbon budgets adopted in 2015 – adjusted in 2018 (for reference)				*398*	*357*	

Emissions for the reference years are taken from the CITEPA inventory for April 2018, in CITEPA's SECTEN format. The figures that appear in the table above are rounded to the nearest unit, meaning that there may be slight discrepancies between the total emissions for the different sectors of industry and the overall total.

Figure 14: Mitigation targets set under the Effort Sharing Decision (ESD) for 2020 and under the Effort Sharing Regulation (ESR) for 2030, for sectors not covered by the EU's emissions trading system (ETS).



2e budget carbone (2019-2023)	Second carbon budget (2019–2023)
3e budget carbone (2024-2028)	Third carbon budget (2024–2028)
4e budget carbone (2029-2033)	Fourth carbon budget (2029–2033)
Puits du secteur des terres	Carbon sinks in the land sector
Transports	Transport
Agriculture	Agriculture
Industrie	Industry
Bâtiment	Buildings
Production d'énergie	Energy production
Déchets	Waste

The upward adjustment of the second and third carbon budgets does not call into question France's ability to meet its commitments at EU and international level. In application of the Effort Sharing Decision (ESD), France's ESD emissions must be lower than 342 MtCO2e by 2020. The trajectory of the draft SNBC 2 provides for a figure of around 330 MtCO2e of GHG emissions in the ESD sector by 2020, or in other words a reduction of -17% compared to the reference year of 2005, which exceeds the target set (a reduction of -14%), and will therefore allow France to comply with its ESD commitments with an estimated excess of 165 MtCO2e. The emissions-reducing trajectory based on a scenario with existing measures (WEM) would involve GHG emissions being stabilised at around 354 MtCO2e, which represents a reduction of only -11.6%. Since France recorded an excess of around 100 MtCO2e in 2020, however, it would still be able to comply with its commitments under the Effort Sharing Decision. France anticipates the accumulation of a significant excess under the Effort Sharing Decision; it has no concrete plans to transfer its excess allowances, but has not ruled out this possibility.

France's target for 2030 under the Effort Sharing Regulation (ESR) involves a reduction in emissions of 37% compared to 2005, which is equivalent to GHG emissions in the ESR sector of around 248 MtCO2e in 2030. The trajectory of the draft SNBC 2 provides for a figure of around 233 MtCO2e in 2030 in the ESR sector (equivalent to total GHG emissions of 310 MtCO2e), or in other words a reduction of -41.5% in GHG emissions by 2030 compared to the reference year of 2005. By following the trajectory for GHG emissions reduction outlined in the draft SNBC 2, France will therefore be able to comply easily with the provisions of the Effort Sharing Regulation (ESR).

The European Commission will be responsible for decisions on emission allowances under the Effort Sharing Regulation (ESR). An initial estimate based on GHG emissions in 2016, 2017 and 2018 can however be used as a starting point for the future trajectory of GHG emissions reductions in the ESR sectors.

Average GHG emissions in 2016, 2017 and 2018 in the ESR sectors were 349.267 MtCO2e. According to the provisions of Article 4 of Regulation (EU) No 842/2018, 'The linear trajectory of a Member State shall start either at five-twelfths of the distance from 2019 to 2020 or in 2020, whichever results in a lower allocation for that Member State.'

In France's case, average emissions in 2016, 2017 and 2018 are five twelfths of the distance from 2019 to 2020, which gives an estimated emission allowance ranging from 334.9 MtCO2e in 2021 to 250.7 MtCO2e in 2030, or a total allowance of 2,928 MtCO2e.

MtCO2e	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
ESR allowances	344.3	**334.9**	**325.6**	**316.2**	**306.9**	**297.5**	**288.2**	**278.8**	**269.5**	**260.1**	**250.7**
WAM	328.9	319.3	309.6	300.0	290.4	280.8	271.1	261.5	251.9	242.2	232.6
Accumulated surplus		*15.7*	*31.6*	*47.9*	*64.4*	*81.1*	*98.2*	*115.5*	*133.1*	*151.0*	*169.1*
WEM	345.4	340.4	335.4	330.4	325.4	320.4	317.1	313.8	310.5	307.2	303.9
Accumulated deficit		*- 5.5*	*- 15.3*	*- 29.6*	*- 48.1*	*- 71.0*	*-100.0*	*-135.0*	*-176.0*	*-223.1*	*-276.3*

Compared to this estimated emission allocation for France, the trajectory provided for under the SNBC 2 (scenario with additional measures, WAM), provides for a target of 319.3 MtCO2e by 2021 and 250.7 MtCO2e by 2030, which means that a quota excess of around 169 MtCO2e will be accumulated.

Conversely, the trajectory corresponding to a scenario with existing measures (WEM) provides for a target of 340.4 MtCO2e by 2021 and only 303.9 MtCO2e by 2030, or in other words a reduction in GHG emissions of 24%, compared to a target of -37%. In this situation, France would accumulate a total estimated allocation deficit of around -276 MtCO2e for the period 2021–2030.

The trajectory adopted by France for climate policy purposes corresponds to the SNBC 2, which means that the targets set under the Effort Sharing Regulation will be exceeded and a potential allocation excess of around 169 MtCO2e will be accumulated over the period 2021–2030. At this stage, France plans to make use of the flexibility option provided for in Article 5 of Regulation (EU) No 842/2018 and bank the excess part of the allocation, and has not ruled out the possibility of transferring them to a different Member State.

France is not eligible for the flexibility option provided for under Article 6 of Regulation (EU) No 842/2018 allowing the limited cancellation of EU ETS allowances, or the safety reserve provided for under Article 11.

Application of Regulation (EU) 2018/841 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry.

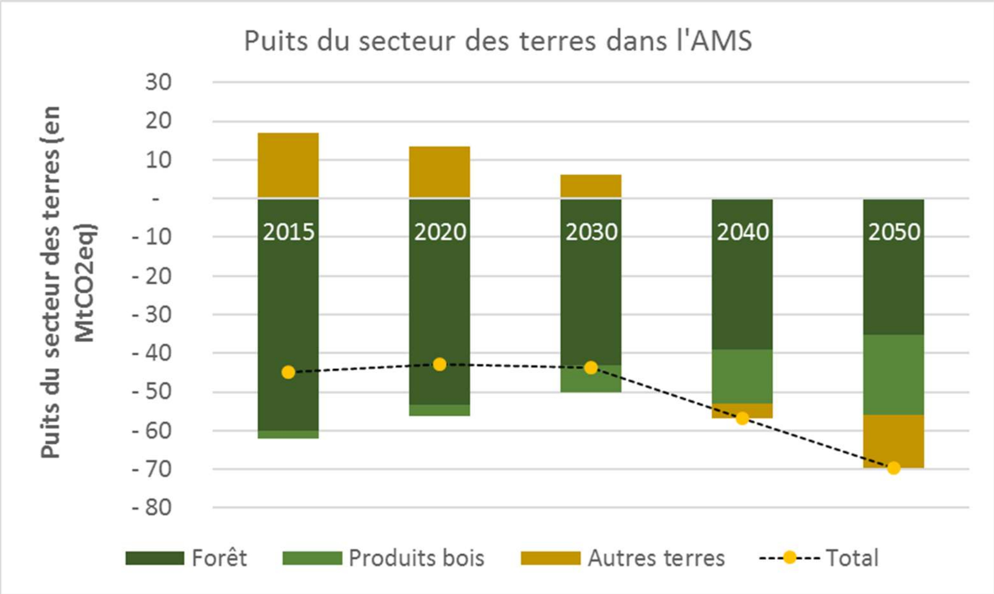
Regulation (EU) 2018/841 lays out rules for the accounting of emissions and removals in the forestry and land-use sectors and imposes commitments on the Member States with a view to ensuring that total emissions do not exceed total removals over the period 2021 to 2030, based on the accounting rules of the same Regulation. The rules in question are differentiated by land category. Emissions from forest management, including harvested wood products, are accounted for in relation to a reference level for forest management; emissions from the land-use sector (except forests) are accounted for in relation to an average for the period 2005–2009; and emissions and removals linked to deforestation and afforestation are accounted for in full.

Based on these accounting rules, each Member State must comply with a 'no-debit' rule, which entails an increase in removals or a reduction in emissions compared to an overall reference situation. This commitment is met through the production of a compliance report containing the total balance of emissions and removals and details of any intention to use the flexibility options, and rules guaranteeing the achievement of this target at EU level for the periods 2021–2025 and 2026–2030.

As regards forest management, France forwarded its Forestry Accounting Plan in January 2020 in keeping with the provisions of Article 8 of Regulation (EU) 2018/841, which included calculations of the reference level for managed forests (estimated at -55.40 MtCO2e for the period 2021–2025 and -57.29 MtCO2e for the period 2026–2030). Since removals stood at -46.817 MtCO2e in 2017, the calculated reference level means that it will be necessary to increase carbon sinks in the forest management sector; this can be achieved by continuing past management practices.

The trajectory under the SNBC 2 provides for smart and sustainable management of forests with a view to optimising their role as a carbon pump in the long term while improving their resilience to climate risks. This development is a vital step in ultimately achieving climate neutrality by fostering the parallel development of carbon sinks in standing forests and in bio-based products, particularly in the construction sector. The SNBC 2 therefore provides for an increase in carbon sinks across the entire sector by 2050, and also provides for an increase in the carbon stored in agricultural soils, a decrease in anthropogenic development and a sharp increase in the carbon stored in wood products.

Figure 15: Sinks in the land-use sector under the WAM scenario (diagram from France's Forestry Accounting Plan, Section 1.2.1)



Puits du secteur des terre dans l'AMS	Carbon sinks in the land sector under WAM scenario
Puits du secteur des terre (en MtCO2eq)	Carbon sinks in the land sector (in MtCo2eq)
Forêt	Forest
Produits bois	Wood products
Autres terres	Other land
Total	Total

Over the period 2021–2030, the projected developments will result in an overall stabilisation of sinks in the land-use sector; at the same time, however, carbon sinks associated with forest management will drop as a result of increasingly dynamic forest management aimed at upping the production of wood materials.

Removals within the managed forest sector will therefore fall over the period 2021–2030, resulting in a debit; this should nevertheless remain below the level of flexibility provided for in Article 13 of Regulation (EU) 2018/841 for managed forest land. The specific accounting rules provided for by the Regulation in respect of the other categories of land make it difficult to estimate accurate figures; nevertheless, the anticipated trajectory provides for a reduction in the rate of anthropogenic development and ploughing of grassland and an increase in forest cover, which should make it possible to achieve a positive balance for these categories of land.

Having regard to the above, France plans to make use of the general flexibility options provided for in Article 12(2) and (3), which make it possible to bank any quantity of removals remaining for the period 2021–2025 or to transfer them to or from another Member State. As noted above, the flexibility option provided for under Article 13 in respect of managed forest land could also be utilised if necessary, in accordance with the provisions of this Article.

Adaptation targets

France is currently implementing its second National Climate Change Adaptation Plan (PNACC), and a number of the adaptation policies and measures under this Plan may promote the achievement of objectives and targets under the Energy Union. The implementation of these policies and measures is aligned with the adaptation targets under the integrated national energy and climate plan.

The overall objective under the second National Climate Change Adaptation Plan (2018–2022) is to put in place, by 2050, the measures required to adapt the regions of metropolitan and overseas France to the regional climate changes that are anticipated. In keeping with its long-term targets under the Paris Agreement and relevant targets under other international agreements, France will need to adapt to the level of climate change made unavoidable by past GHG emissions that have accumulated in the atmosphere. France has chosen to base its work in this area on a hypothetical average global temperature increase of 2 °C compared to the pre-industrial era, despite its efforts at national and international level to limit this increase to 1.5 °C. The country's adaptation policy is therefore a vital complement to its climate change mitigation policy, which is aimed at achieving carbon neutrality.

By way of example, the **National Climate Change Adaptation Plan, which was adopted in December 2018,** provides for several measures promoting the adaptation of forests to climate change. Certain interactions between climate change and the energy system (in particular changing consumption levels in buildings) were taken into account when working on the MEP and the SNBC. Other topics currently being investigated include the impact of climate change on energy production and the security of supply, particularly within the framework of the provisional supply/demand balance sheet drawn up by RTE (the TSO). These topics will need to be examined in further depth when the national programmes are next updated.

Other policies and measures are outlined in Section 3.1.4.

2.1.2. Renewable energies

Targets relating to renewable energies are set under the Energy Code. It provides for an increase in the share of renewable energies to 23% of gross final energy consumption by 2020, and to 33% by 2030. By this date, renewable energies must account for at least 40% of electricity production, 38% of final heat consumption, 15% of final fuel consumption and 10% of gas consumption in order to achieve this target. The MEP 1 set targets by sectors.

Measures to promote renewable energies are determined to achieve the objectives set by law. Since these targets are expressed as percentages of renewable energies in relation to energy consumption, the target quantities of renewable energy depend on the amounts consumed. In turn, the amounts consumed depend on the macroeconomic context. The targets for 2028 are therefore expressed as a range (Scenario A and Scenario B) to ensure that the targets set by law can be achieved. Depending on the macroeconomic context, it may be necessary for the Government to step up its policy initiatives to maintain the same percentage use of renewable energies.

2.1.2.1. Renewable and recovered heating and cooling

The Energy Code sets a target of 38% for the share of renewable energies in final heat consumption by 2030. To achieve this target, it will be necessary to accelerate the increase in the share of renewable heating to an average of 1.2% per year, or in other words 1.5 times higher than the increase observed between 2010 and 2016. The Energy Code also sets the target of a five-fold increase in the amount of renewable and recovered heating and cooling supplied by district heating and cooling networks by 2030 (compared to the situation in 2012).

France also has European commitments, with a total target of 23% renewables by 2020, which means a target rate for renewable heat of 33% by 2020. This target does not seem attainable within the mandated deadline. The Renewable Energies Directive has recently been revised and published, and requires each Member State to increase its rate of renewable and recovered heat by at last 1.3 points each year between 2020 and 2030. This new target is compatible with the framework set by the LTECV and the targets imposed by the MEP.

The targets for renewable heating set by the MEP 2 can be seen in the table below.

	Target in MEP for 2023	Low target in MEP for 2028 Scenario A	High target in MEP for 2028 Scenario B
Renewable heat	196 TWh	219 TWh	247 TWh

Targets have also been set per sector.

Solid biomass

Targets for the increase in heat produced from solid biomass under the MEP 2:

	Target in MEP for 2023	Low target in MEP for 2028 Scenario A	High target in MEP for 2028, Scenario B
Solid biomass (TWh)	145	157	169

Heat pumps

Targets for the increase in heat produced from heat pumps under the MEP 2:

In single-family homes, Scenario B corresponds to a total of 6.8 million air source heat pumps (air/air and air/water heat pumps) by 2028, which represents an increase by a factor of 2.8 in the total for 2017, and a total of 315,000 geothermal heat pumps by 2028, which represents a doubling of the figure for 2017.

In multi-family dwellings, Scenario B corresponds to a total of 2.2 million air source heat pumps by 2028, which represents an increase by a factor of 2.9 in the total for 2017, with geothermal heat pumps being fitted in 1,000 multi-family dwellings per year.

In the tertiary sector, Scenario B corresponds to 114 million m² of floor area in tertiary buildings heated with air source heat pumps by 2028 (which represents a doubling of the figure for 2017).

	2017	2023	2028, Scenario A	2028, Scenario B
Air source heat pumps (TWh)	27.6	35	39	45
Geothermal heat pumps (TWh)	3.14	4.6	5	7

Deep geothermal

Target for increase in heat produced from geothermal sources under the MEP 2:

2017	2023	2028, Scenario A	2028, Scenario B
1.18 (TWh)	2.9 (TWh)	4 (TWh)	5.2 (TWh)

Solar thermal

Target for the increase in heat produced from solar thermal sources under the MEP 2:

The targets for 2023 are based on the installation of around 100,000 m^2 per year of solar thermal in the buildings sector (with half of this figure on privately owned buildings) and 150,000 m^2 in the industrial sector (around 50 solar power plants).

The targets for 2028 are based on the installation of between 150,000 m^2 and 350,000 m^2 per year in the buildings sector (with 70% of this figure on privately owned buildings, and assuming significant developments in the field of combined solar systems) and 300,000 m^2 in the industrial sector (around 100 solar power plants).

2017	2023	2028, Scenario A	2028, Scenario B
1.18	1.75	1.85	2.5

Recovered heat

Targets for the development of recovered heat under the MEP 2:

The MEP sets a target for the delivery of recovered heat (industrial, data centres and waste) through district heating and cooling networks. Achieving these targets will necessitate a five-fold or six-fold increase in the amount of lost industrial heat that is recovered by 2028, improved recovery of lost heat from household waste treatment facilities, and the recovery of combustion heat from other waste such as solid recovered fuel. Scenario B for 2028 would result in an increase in the average recovery rate within networks of 0.8% per year over the period 2016–2028.

- Lost industrial heat would account for 0.84 TWh by 2023 (which represents a doubling of the reference level for 2016) and between 2.3 TWh and 3 TWh by 2028 (which represents a five-fold or six-fold increase compared to the level for 2016);
- Improved recovery of lost heat from household waste treatment facilities and the recovery of combustion heat from other waste such as solid recovered fuel would contribute 3.6 TWh to the networks by 2023 and between 5.3 TWh and 6.9 TWh by 2028 (whereby 50% of this figure is already accounted for in the biomass target).

	2016	2023	2028 Scenario A	2028 Scenario B
Target (TWh) including renewable and recovered energies from domestic waste incineration plants (DWIP)	3	4.47	7.6	9.9

Recovery of energy from waste

There is no quantitative target for the production of energy from waste. The ranges of values are specified in the relevant paragraphs.

Targets for the development of district heating and cooling networks

The targets correspond to an average of 60% of renewable and recovered energies supplied through the networks in 2023, and 65% in 2030. By 2030, the delivery of renewable and recovered district cooling through networks is forecast to have tripled; in other words, around 5 million living quarters (or equivalent) will be connected to such networks in 2030.

	2018	2023	2028 Scenario A	2028 Scenario B
Delivery of renewable and recovered heat (TWh)	14.1	24.4	31	36
Delivery of renewable and recovered district cooling (TWh)	0.76	1.1	1.4	2.7

2.1.2.2. Biofuels

In 2015, Directive 2015/1513 (ILUC[12]) set a target of 10% renewable energies in the transport sector by 2020, with a ceiling of 7% for biofuels in which production competes with food production and an indicative target of 0.5% by 2020 for advanced biofuels. The Directive contains a list of the feedstock that can be used to develop advanced biofuels. The Energy Code sets a more ambitious target of 15% renewable energies in the figure for final fuel consumption by 2030. To achieve this target, it will be necessary not only to increase the rate at which biofuels are incorporated into fuels, but also to step up efforts to develop alternative fuels that emit less carbon dioxide than traditional fossil fuels.

France has reached the ceiling of 7% for the incorporation of conventional biofuels into liquid fuels. One of the priorities of the MEP is to develop second-generation 'advanced' fuels on the basis of waste and residues. This was a target set in the MEP adopted in 2016. The targets set in 2016 have been revised in the new MEP with a view to aligning them with the new definition of advanced biofuels in Directive (EU) 2018/2001 (RED II), i.e. 'biofuels that are produced from the feedstock listed in Part A of Annex IX'.

The target for the increase in biofuel consumption under the MEP 2:

To achieve the target for the incorporation of first-generation biofuels, it will be necessary to maintain and not exceed a level of 7% by 2023 and by 2028. An increase in the bio-based component of fuels must therefore be achieved exclusively through the development of advanced biofuels produced from the feedstock listed in Part A of Annex IX to Directive 2018/2001.

Heavy emphasis will be placed on compliance with the sustainability and traceability criteria for feedstocks while engaging in efforts to achieve the targets that have been set. In particular, France hopes to develop advanced biofuels for modes of transport that will be difficult to electrify, especially aviation.

Rate of incorporation of advanced biofuels into fuels released for consumption	2016	2023	2028
Target for the petrol sector (%)	nd	1.2	3.8
Target for the diesel sector (%)	nd	0.4	2.8

The table above shows the percentage share of fuels (in terms of energy) to be achieved by advanced biofuels. To ensure that this target can be achieved, the energy content of advanced biofuels will be eligible for double-counting. It will be possible to add advanced biofuels used in kerosene to the

12. Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources (Text with EEA relevance) **(ILUC)**.

numerator when calculating progress towards the achievement of the target for the heating oil sector, and they will be eligible for an additional multiplier of 1.2.

Targets for the development of recharging infrastructures for alternative fuels

Sector	State of play (late 2019)	Targets for 2023	Targets for 2028
Electricity	28,000 recharging points open to the public	100,000 recharging points open to the public	
LPG fuel	1,650 stations	Development of the vehicle fleet only: current infrastructures would be able to supply a vehicle fleet around 10 times larger than the fleet currently on the road	
Hydrogen	Around 30 stations	100 stations	400 to 1,000 stations
NGV (LNG and CNG)	110 CNG stations and 35 LNG stations	140 to 360 stations	330 to 840 stations
Maritime LNG	Le Havre Marseille Fos Dunkirk Nantes Saint-Nazaire	Development at all major ports	
Onshore power	Marseille (three stations)	On a case-by-case basis, use of onshore LNG to supply electricity to all vessels (greater flexibility, higher outputs)	

2.1.2.3. Renewable and recovered gas

The target for the increase in biomethane consumption under the MEP 2:

Based on the targets set under the MEP, biogas will account for 7% of gas consumption by 2030 if the cost reductions outlined in the reference trajectory are achieved, and up to 10% if greater cost reductions are achieved.

2016	2023	2028, Scenario A	2028, Scenario B
5.4 TWh HHV Of which 0.4 TWh injected	14 TWh HHV Of which 6 TWh injected	24 TWh HHV Of which 14 TWh injected	32 TWh HHV Of which 22 TWh injected

2.1.2.4. Hydrogen

The targets for the increase in hydrogen consumption under the MEP 2:

	2023	2028
Demonstrators for power-to-gas output (MW)	1 to 10	10 to 100
Rate of incorporation of decarbonised hydrogen into industrial hydrogen (%)	10%	20% to 40%
Hydrogen light commercial vehicles (number)	5000	20,000 to 50,000
Hydrogen heavy goods vehicles (number)	200	800 to 2,000

2.1.2.5. Electricity

The Law on Energy Transition for Green Growth set a target of 40% for the share of renewable energies in final electricity consumption by 2030. The electricity system will need to undergo a significant shift to achieve this target, with growth in all renewable energy segments. The specific nature of this growth will depend on the volume of energy available in each segment, its maturity and its competitiveness.

Hydropower

The target for the increase in installed hydropower generation capacities under the MEP 2:

the target that has been set involves increasing generation capacities by around 200 MW by 2023 and by between 900 and 1,200 MW by 2028, with an attendant rise in generation of approximately 3 to 4 TWh, around 60% of which will be achieved by optimising existing facilities.

2016	2023	2028, Scenario A	2028, Scenario B
25.3 GW	25.7 GW	26.4 GW	26.7 GW

Onshore wind

The target for the increase in installed wind generation capacity under the MEP 2:

The targets under the MEP (including repowering) are set out in the table. These correspond to a total of 14,200 to 15,500 wind turbines by 2028 (compared to around 8,000 at the end of 2018).

2016	2023	2028, Scenario A	2028, Scenario B
11.7GW	24.1GW	33.2GW	34.7GW

Photovoltaic

The target for the increase in installed photovoltaic generation capacities under the MEP 2:

The targets under the MEP are set out in the table. These correspond to installed photovoltaic capacity in France of between 330 and 400 km² of ground-mounted panels and between 150 and 200 km² of roof-mounted panels by 2028 (compared to 100 km² of ground-mounted and 50 km² of roof-mounted panels).

	2016	Target for 2018 under the 2016 MEP	2023	2028
Ground-mounted panels	3.8	5.6	11.6	20.6 - 25
Roof-mounted panels	3.2	4.6	8.5	14.5 - 19.0
Overall target (GW)	7	10.2	20.1	35.1 - 44.0

Electricity generation from bioenergy

The target for the increase in installed capacities for electricity generation from bioenergies under the MEP 2:

	2016	2023	2028
Biomass cogeneration target (GW)	0.59	0.8	0.8
Biogas cogeneration target (GW)	0.11	0.27	0.34 - 0.41
SRF cogeneration target (GW)		0.04	0.04

Offshore wind and renewable marine energies

The target for the increase in installed offshore wind capacities under the MEP 2:

	2016	Targets for 2018 under the 2016 MEP	2023	2028
Target for offshore wind (GW)		0.5	2.4	5.2 - 6.2

Geothermal electricity

The target for the increase in installed geothermal electricity capacities under the MEP 2:

	2016	2023	2028
Target (MW)	1	24	24

2.2. Energy efficiency

2.2.1. The elements set out in point (a)(1) of Article 4

2.2.1.1. National contribution to the EU target of 32.5% by 2030

Article 1 of the Regulation on the governance of the Energy Union and Article 3(4) of Directive 2012/27/EU on energy efficiency set a maximum figure for primary energy consumption in the EU of

1,273 Mtoe and for final energy consumption in the EU of 956 Mtoe by 2030, which is equivalent to a reduction of at least 32.5% compared to a trend-based reference scenario.

Articles L. 141-1 to L. 141-6 of the Energy Code, amended by the Law on Energy Transition for Green Growth of 17 August 2015, provide a framework for the MEP. The MEP sets priorities for government action in the field of energy within mainland France for the next 10 years, split into two periods of five years. The MEP that is currently being adopted covers two successive five-year periods: 2019–2023 and 2024–2028. It is linked to the SNBC, and uses the same scenarios.

According to the reference scenario used in the MEP and the SNBC, which incorporates all the measures resulting from the MEP and other future measures that have not yet been decided on, estimated final energy consumption in 2030 is **120.9 Mtoe**, and estimated primary energy consumption in 2030 is **202.2 Mtoe**.

	Target
Final energy consumption in 2030 (in Mtoe)	**120.9**
Primary energy consumption in 2030 (in Mtoe)	**202.2**

The main macroeconomic assumptions that are used in the scenario and that lead to these results are outlined in Section 4.1 of this report.

2.2.1.2. Total cumulative amount of end-use energy savings to be achieved in accordance with Article 7 of Directive 2012/27/EU

Under Article 7(1) of Directive 2012/27/EU, France must make annual savings equivalent to 0.8% of final energy consumption compared to the average for 2016–2018.

The amount of energy to be saved over the period 2021–2030, based on the average final energy consumption for 2016–2018, is indicated in the following table:

In ktoe	**2015**	**2016**	**2017**
Final energy consumption (non-HVAC*): total excluding international bunkers (source: energy balance sheet for 2017)	142,262	141,173	142,816
Average 2015–2017	**142,083**		

**non-HVAC: not adjusted for climate variations.*

The annual target is therefore 1,143.1 ktoe or **62,871 ktoe** (731 TWh) for the entire period 2021–2030.

The final energy consumption figures above are those that appear in France's energy balance for 2018, which is currently being drafted and which will be forwarded to Eurostat in December 2019.

The main action taken by France with a view to complying with its obligations under Article 7 of Directive 2012/27/EU will be to require energy sellers to provide evidence of their energy saving operations through a system of white certificates.

2.2.1.3. Indicative milestones of the long-term strategy for the renovation of the national

stock of buildings

The reference scenario under the MEP incorporates the gradual tightening up of the environmental regulations that apply to new builds, in particular through the introduction of a criterion for GHG emissions over the building's entire lifetime.

Over the period between 2015 and 2030, the average rate of renovation will be equivalent to around 370,000 complete renovations per year.

2.2.1.4. Total floor area to be renovated or equivalent annual energy savings to be achieved from 2021 to 2030 in relation to the exemplary role of public bodies' buildings

Since France introduced (in 2018 and 2019) an energy saving target of 40% by 2030 for tertiary buildings with a floor area exceeding 1,000 m², both public- and private-owned, the country chose to comply with the provisions of Article 5 of Directive 2012/27/EU on energy efficiency by opting for an alternative approach to reducing the energy consumption of the state's building stock.

The buildings covered by the scope of Article 5 are buildings owned and occupied by the Government: offices, buildings used for education or sport, buildings used for health or social welfare purposes, cultural buildings, businesses or living quarters. Agricultural buildings, technical buildings, Ministry of Defence buildings (excluding living quarters and offices), civil engineering structures for roadways and utilities, places of worship, and monuments and memorials are excluded from the scope of the Directive.

The savings that will be made by following this alternative approach are estimated at **7,200 GWh** of primary energy for the period 2021–2030, compared to **4,100 GWh** for a BaU approach. These savings will be achieved through a combination of various measures:

- **work on the building shell and building installations;**
- **measures relating to technical building services and the building's occupants;**
- **reductions in the floor area occupied by Government.**

The annex to this report contains details of the annual energy savings calculated for the period 2021–2030 in relation to the exemplary role of public bodies' buildings, with a view to transposing Article 5 of Directive 2012/27/EU.

2.2.2. Indicative milestones for 2030, 2040 and 2050, the domestically established measurable progress indicators and their contributions to the Union's energy efficiency targets as included in the roadmaps set out in the long-term renovation strategies for the national stock of residential and non-residential buildings, both public and private, in accordance with Article 2a of Directive 2010/31/EU

In keeping with Article 2a of Directive 2010/31/EU, France will forward the final version of its long-term strategy for the energy renovation of buildings by March 2020 at the latest. Certain elements of this strategy have not yet been finalised, in particular the calculations of expected energy savings. A preliminary version is annexed to this report.

2.2.3. Where applicable, other national objectives, including long-term targets or strategies and sectoral targets, and national objectives in areas such as energy efficiency in the transport sector and with regard to heating and cooling

The national objectives for energy demand management are specified in the Law on Energy Transition for Green Growth of 2015 and the Law on Energy and Climate of 2019:

- **reduction in final energy consumption of 7% by 2023 (compared to 2012), of 20% by 2030 and of 50% by 2050;**
- **reduction in the consumption of primary energy from fossil fuels of 40% by 2030 (compared to 2012); this target is broken down by fossil fuel according to the respective GHG emissions factor.**

2.2.3.1. Final energy consumption reduction targets

	2017	2023	2028
Final energy consumption (TWh)	1634	1525	1378
% reduction compared to 2012	0.9%	7.6%	16.5%

2.2.3.2. Final energy consumption reduction target in the buildings sector

	2016	2023	2028
Final energy consumption of buildings (TWh)	745	712	636

Decisions on the action to be taken in the buildings sector were adopted on the basis of the estimates in the reference scenario. If economic developments differed from the assumptions but the measures were still implemented in their present form, energy consumption might increase by an additional 12 TWh (7 TWh in the residential sector and 5 TWh in the tertiary sector). To maintain the same level of energy consumption in the buildings sector, the Government would need to introduce extra policy initiatives to achieve the target that has been set. Potential renovation figures are as follows:

- **an additional 25,000 living quarters per year, with 300,000 additional living quarters over the entire period, or in other words 1.5% of the park;**
- **an additional 1.25 Mm² of floor area per year in the tertiary sector, with 15 Mm² over the entire period, or in other words 1.5% of the park.**

2.2.3.3. Final energy consumption reduction target in the transport sector

	2016	2023	2028
Final energy consumption in the transport sector (TWh)	511	473	427

If economic developments differed from the assumptions in the reference scenario but the measures were still implemented in their present form, energy consumption might increase by an additional 8 TWh. To maintain the same level of energy consumption in the transport sector, the Government would need to introduce extra policy initiatives to achieve the target that has been set. The energy efficiency of all vehicles might need to be improved by as much as 17.5%, i.e. a target of 3.3 l/100 km in 2030 for personal-use internal combustion vehicles instead of a target of 4 l/100 km.

2.2.3.4. Final energy consumption reduction target in the industrial sector

	2016	2023	2028
Final energy consumption in industry (TWh)	319	291	269

Decisions on the action to be taken in the industrial sector were adopted on the basis of the estimates in the macroeconomic reference scenario. If economic developments differed from the assumptions but the measures were still implemented in their present form, energy consumption might increase by an additional 6 TWh. To maintain the same level of energy consumption in the industrial sector, the Government would need to introduce extra policy initiatives to achieve the target that has been set. Energy efficiency might need to be improved by as much as 2.5% to 3%, depending on the sector in question.

Final energy consumption reduction target in the agriculture sector

	2016	2023	2028
Final energy consumption in the agriculture sector (TWh)	51	49	46

2.2.3.5. Primary energy consumption reduction targets

	2017	2023	2028
Primary consumption of energy from fossil fuels (TWh)	1,394	1,149	942
Primary coal consumption	110	48	28
Primary oil consumption	824	700	569
Primary natural gas consumption	459	401	345

2.2.3.6. Primary coal consumption reduction target

	2017	2023	2028
Primary coal consumption (TWh)	110	48	28
Changes in primary coal consumption / 2012	-21%	-66%	-80%

2.2.3.7. Primary heating oil consumption reduction target

	2017	2023	2028
Primary heating oil consumption (TWh)	825	700	569
Changes in primary oil consumption / 2012	-5%	-19%	-34%

2.2.3.8. Primary natural gas consumption reduction target

	2017	2023	2028
Primary natural gas consumption (TWh – LHV)	459	401	345
Changes in primary gas consumption / 2012	+3%	-10%	-22%

2.3. Security of supply

Security of supply can be defined as the capacity of an energy system to meet market demand continuously and at a reasonable cost for the foreseeable future, by balancing supply and demand.

Confirmed targets and indicators are available in relation to the security of supply for electricity and gas. The underground storage infrastructures required for security of the gas supply are those that play a key role either by allowing natural gas to be conveyed within the transmission network or by safeguarding the capacity of the gas system to meet demand. Measures have only been taken (as outlined in Section 3) to ensure compliance with the policies in place, as outlined in Section 1.

2.4. Internal energy market

2.4.1. Electricity interconnectivity

The MEP provides for the roll-out of around 10 GW of additional interconnections by 2030, based on the Development Plan for the electricity transmission system. Plans have been made to establish interconnections of this kind with all countries that share borders with France, resulting in interconnectivity of around 26 GW by 2030. The indicators of the urgency of action provided for in Annex 1 to the Regulation on governance of the Energy Union would be around 30% for the nominal transmission capacity in relation to installed renewable generation capacity, and between 25% and 30% for the nominal transmission capacity in relation to peak load. The transmission system operator (RTE) is also carrying out prospective studies on the establishment of interconnections as part of the Ten-Year Network Development Plan (TYNDP), which takes into account the TYNDP drafted by ENTSO-E and which forms a coherent set with the MEP and the provisional balance sheet in terms of factors affecting the security of the electricity supply.

The main projects currently at the construction or planning stage are listed below:

Country – project (design capacity)		Project owner	State of progress	Project online date
Germany	Vigy Uchtelfangen (1.5 GW)	RTE & Amprion	At the planning stage – increase in existing capacity	By 2027
	Muhlbach Eichstetten (0.3 GW)	RTE & Amprion	At the planning stage – increase in existing capacity	2025
Belgium	Lonny Gramme	RTE & Elia	At the planning stage – increase in existing capacity	By 2025

Country – project (design capacity)		Project owner	State of progress	Project online date
	Avelin Mastaing-Horta	RTE & Elia	At the planning stage – increase in existing capacity	By 2022
Spain	Gascogne (2 GW)	RTE & REE	Consultation in progress	By 2025
	Navarre Landes (2 GW)	RTE & REE	Under investigation	-
	Aragón-Atlantic Pyrenees (2 GW)	RTE & REE	Under investigation	-
Ireland	Celtic (0.7 GW)	RTE & Eirgrid	Procedure launched	By 2025
Italy	Piedmont-Savoy (1 GW)	RTE & Terra	Work in progress	Between late 2020 and early 2021
Switzerland	Genissiat Verbois	RTE & Swissgrid	At the planning stage – increase in existing capacity	By 2023
	Cornier Chavalon	RTE & Swissgrid	At the planning stage – increase in existing capacity	By 2025
United Kingdom	IFA2 (1 GW)	RTE & National Grid	Work in progress	2021
	Eleclink (1 GW)	Eleclink	Work in progress	-
	FAB (1.4 GW)	RTE & Fablink	Procedure currently suspended	-
	Aquind (2 GW)	Aquind Ltd	Under investigation	-
	Gridlink (1.4 GW)	Elan Energy Ltd	Procedure launched	-

Electricity interconnectivity projects with France – Source: DGEC 2018

The MEP 2 reiterates the curtailment target of 6.5 GW by 2028, while adopting a more gradual approach by reducing the interim milestone target to 4.5 GW by 2023.

It sets a target of 200,000 photovoltaic systems for self-consumption by 2023 (including 50 collective self-consumption systems).

2.5. France’s strategy on research and innovation, the roll-out of new technologies and competitiveness

The Climate Plan presented in July 2017 by the Government reiterated France’s long-term aim of achieving carbon neutrality within the country by 2050. Carbon neutrality is an ambitious target. According to the latest studies by the IPCC, however, achieving this target as soon as possible and at global level is the only way to contain global warming at 1.5 °C.

The transition to a low-carbon economy (i.e. one which consumes small amounts of materials and energy and is highly circular and decarbonised) involves a stepping-up of energy-related research and innovation measures aimed at developing the technologies and behaviours that will promote reductions in emissions, while ensuring that France can compete on future markets for low-carbon goods and services.

Many specific research and innovation requirements have already been identified:

- in energy-related sectors: decarbonisation of energy, energy efficiency, energy storage, smart management of transmission and distribution systems and carbon capture, storage and reuse solutions;
- in non-energy-related sectors: process improvements relating to ‘carbon’ and environmental efficiency, optimisation, recycling and reuse of resources;
- in relation to social innovations (changes to behaviours and attitudes, ownership of change, etc.) and organisational innovations (public policies etc.).

The challenges involved in the ecological and energy transition will mobilise all stakeholders involved in low-carbon research and innovation measures at national, European and international levels.

2.5.1. National Energy Research Strategy

Article 183(II) of the LTECV (which was published in 2015 with the aim of ensuring that France can make a more effective contribution to the fight against climate change, to environmental conservation and to the strengthening of energy independence at the same time as allowing its businesses and citizens to access energy at a competitive price) provides for the drafting of a National Energy Research Strategy (SNRE). The aim of this strategy is to identify the R&D challenges and scientific obstacles along the innovation chain in the energy sector that must be overcome and the deadlines by which this must happen so that the targets set by law can be achieved; these challenges and obstacles are also placed in their broader international context.

This strategy was drafted jointly in 2016 by the Directorate-General for Energy and Climate and the Directorate-General for Research and Innovation (both of which operate under the aegis of the Ministry of Higher Education, Research and Innovation), and provides for the setting up of a monitoring committee that gathers together representatives of all energy research stakeholders.

The SNRE was approved by a joint decree of the ministers responsible for energy and research, and was published in the Official Journal on 27 December 2016.

The SNRE represents a new strategy tool for France’s research and innovation stakeholders in their efforts to facilitate the emergence of tomorrow’s energy system. Innovation will play a key role in the achievement of the targets set in the Paris Agreement, which was adopted with a view to strengthening the global response to the threat of climate change.

More specifically, the SNRE sets out four main guidelines, each with proposals for measures that can be taken to shape the future.

2.5.1.1. Guideline 1: focusing on key topics for the energy transition

Guideline 1 is intended to stimulate debate on the targets set in relation to diversification of the energy mix, growth in renewable energies, increased energy efficiency across all sectors of industry, reduced use of fossil fuels, etc., and lists the associated scientific and technological challenges (system flexibility with a view to the integration of renewable energies, decentralisation and multi-level governance of energy systems, enhanced role for consumers, continued improvements to nuclear energy in innovative fields (SMR technology) and nuclear competitiveness, the digital transition, safety and shut-downs and adaptation of the cycle to the development trajectory of electronuclear production, etc.)

To this end, the following is proposed:

- an increase in the multidisciplinary nature of R&D (link between the energy transition and the digital revolution, environmental challenges and incorporation into the circular economy, economic and social challenges in connection with consumer involvement and support for the decentralisation of systems);
- a systematic approach based on comparative analysis of the various flexibility solutions currently being developed (curtailment, production management, storage, coupling of networks and vectors, etc.) with a view to obtaining a detailed overview of short-term, medium-term and long-term technological options for future national programmes. This research will supplement the extensive work currently being carried out on various innovative means of production (e.g. renewable cooling) and demand management (e.g. materials and processes for the energy renovation of buildings).

2.5.1.2. Guideline 2: growing R&D&I capacities in tandem with the regions and the industrial base, particularly SMEs and intermediate-sized enterprises

Guideline 2 centres around the economic challenges involved in maintaining and improving the most competitive mature markets and developing new markets; these challenges should be viewed in a broader global context rather than simply in connection with the needs of the energy transition in France. A cooperative approach between the public and private sectors and an experimental approach are essential prerequisites for accelerating the transfer of technologies from R&D laboratories to the market. Proposals include the following:

- boosting support for projects demonstrating new technologies and solutions, particularly in the regions, with the involvement of local authorities and using all available financing tools (State aid or equity);
- supporting the development of SMEs and intermediate-sized enterprises, not only through financial backing but also by helping them to gain a foothold in the relevant markets;
- providing an organisational framework for individual sectors of French industry by strengthening initiatives already in place at national level, carrying out regular analyses of the positioning of French players on the global stage, and encouraging these players to become involved in European or global initiatives (such as the EU’s Horizon 2020 Programme or the Mission Innovation initiative launched during COP21).

2.5.1.3. Guideline 3: developing skills and knowledge for and by R&D&I

Guideline 3 centres around skills development, firstly with a view to building an energy research community and secondly with a view to providing training and informing to the various sectors of the public with an interest in the topic (professionals, civil society, decision-makers). The importance of a multi-disciplinary approach is emphasised heavily, as is the need to build a community of researchers working in energy-related areas of fundamental sciences, including humanities and social sciences. The following measures are therefore proposed:

- strengthening international collaboration and helping French entities involved in R&D in the field of energy to play a more prominent role on the global stage;
- building thematic networks of researchers as a means of building a critical mass around existing 'laboratories of excellence', for example in the field of advanced materials for energy; leveraging the potential of major research infrastructures as a basis for developing energy-related programmes;
- expanding modelling and forecasting capacities as a basis for developing scenarios that incorporate the various dimensions of energy systems and make it possible to identify and guide energy mix choices;
- developing new training courses for jobs associated with the energy transition;
- involving civil society in demonstration projects in the regions and in providing feedback on these projects as a basis for society-level debates and choices and the adoption of the best-performing technologies.

2.5.1.4. Guideline 4: creating a lightweight and high-performing governance that enables dynamic operational steering of the SNRE

The final guideline emphasises the need to coordinate implementation of the SNRE with initiatives already in place at various geographical levels, ranging from local (in particular at regional level) to international (in particular at European level, e.g. the Horizon 2020 Programme and the SET-Plan), and to strengthen governance with a view to guaranteeing efficient implementation beyond the drafting stage. The following are therefore proposed:

- convening an annual meeting by a committee of stakeholders to drive forward and monitor the implementation of the SNRE following its adoption, and to engage in preparations for its future revision on the basis of a five-year cycle;
- an ex-post evaluation of the SNRE;
- organising regular exchanges of views with the regions on R&D support measures, priorities and funding data, with a view to enabling coordinated development of the relevant strategies, harnessing synergies and consolidating feedback received in connection with demonstrations at regional level;
- monitoring compliance by France with its undertaking (made under the Mission Innovation initiative launched during COP21) to match R&D funding in the field of green energy;
- ensuring that R&D funding mechanisms at national and international level are complementary. For example, France will be able to campaign at EU level for an increase in funding under the Horizon 2020 Programme for upstream research (low TRL) and ensure that the future Innovation Support Fund established under the heading of carbon market reform (ETS Directive) incorporates an additional source of funding and adapted financing instruments for low-carbon innovation in large-scale projects.

The SNRE undergoes regular reviews; in particular, a Monitoring Committee is convened each year, with the latter's secretariat-related duties being carried out by the ministries responsible for research, innovation and energy, the National Research Agency, the ADEME and the National Alliance for the Coordination of Research Energy (ANCRE).

The stated goal of this Monitoring Committee, which is open to a wide range of national stakeholders in the field of energy, is to prove that the research measures implemented are consistent with the broad guidelines set out in the SNRE. If necessary, the Monitoring Committee can suggest any amendments that might need to be made to the SNRE in response to technological, economic and political developments.

A research and development strategy for France, based on an integrated and systemic vision of energy within the framework of the Energy Union

The European Commission regards energy as one of its priorities, and in February 2015 it published a communication presenting the 'Energy Union' (COM(2015)80) on the basis of five dimensions:

- **energy security;**
- **a fully integrated European energy market;**
- **energy efficiency contributing to moderation of demand;**
- **decarbonising the economy;**
- **research, innovation and competitiveness.**

R&D in the field of energy technologies is one of the five dimensions of the Energy Union and is also a vital prerequisite for implementing the four other dimensions.

The Member States have defined four common priorities for this fifth dimension in the EU's SET-Plan:

- **being the world leader in developing the next generation of renewable energy technologies;**
- **facilitating the participation of consumers in the energy transition through smart grids and home systems;**
- **efficient energy systems, and harnessing technology to make the building stock energy neutral;**
- **more sustainable transmission systems.**

In addition to these four common priorities, Member States that intend to make use of the relevant technologies can collaborate actively at European level on the following two optional priorities:

- **a forward-looking approach to carbon capture and storage (CCS) and carbon capture and use (CCU) for the power and industrial sectors;**
- **maintaining technological leadership in the nuclear domain (fission and fusion), including through ITER.**

The priorities that have been set are translated into a concrete action plan on the basis of 10 key actions.

R&D by French entities should therefore be viewed in this wider European context, which means adopting a system-wide perspective on tomorrow's energy challenges. These include new methods of production (variable and distributed renewable energy sources), new methods of consumption (proactive role for consumers, energy efficiency, etc.) and new methods of energy transport and storage (smart grids etc.). R&D activities will therefore help to overcome the systematic challenges associated with the European vision set out in the Energy Union package.

Aligning action by France with the EU's programmes

The European Union has earmarked substantial amounts of funding for R&D in the field of energy, particularly through its Horizon 2020 Programme; a pot of €5,931 million has been set up for (non-nuclear) energy research over the period 2014–2020. This substantial pool of R&D funding for new energy technologies will be implemented under the future Horizon Europe Programme, which provides in particular for the earmarking of €15 billion for Cluster 4 (energy/climate/transport).

France’s involvement in Horizon 2020 corresponds to its relative contribution to the EU budget, around 16%. Increasing the take-up rate of loans by project organisers based in France (from the current figure of 10%, which has remained stable for several years) therefore represents a major challenge, and steps are being taken to encourage the R&D community within France to work towards this goal, for example by organising national groups and points of contact to shape programme design and increase the level of response to calls for projects. These measures should be continued or strengthened.

R&I potential within France is equivalent to 14.6% of the R&D FTEs for the EU 28 and 16.1% of patent applications by the EU 28 to the European Patent Office. Increasing the take-up rate of loans by project organisers based in France (from the current figure of 10%, which has remained stable for several years) therefore represents a major challenge. Based on work that was carried out with the involvement of the research and innovation community (ministries, research bodies, universities, regional councils, BPI France (a public investment bank), business advisory organisations, Competitiveness Clusters, etc.), the Ministry of Higher Education, Research and Innovation has proposed an action plan structured under three headings: encouraging more stakeholders to take part in the Framework Research and Innovation Programme and coordinating projects, supporting these projects more effectively during their preparatory stages, submitting and executing projects and developing an effective strategy for shaping programmes. This national action plan for stepping up France’s involvement was adopted at interdepartmental level, and the Government views its implementation as a key priority.

2.5.2. Innovation as a means of increasing the competitiveness of French businesses

The Government intends to continue pursuing an ambitious national industrial policy centred around transformation capacity, while focusing in particular on potential relating to innovation and digital technologies (industry accounts for over 60% of private R&D within France).

Priorities identified in this connection include support for innovative projects and the ability of French companies to develop and market products that incorporate cutting-edge technologies; in addition, it is important for these products to allow novel uses or the provision of novel services, since this is regarded as a key differentiator and a key means of competing on the global stage.

2.5.2.1. Measures by the National Industry Council

With a view to achieving this goal, France set up a National Industry Council (CNI) in 2013. The aim of this Council is to provide information and advice to public authorities on the current state of French industry and industrial services at regional, national and international level, including export-related challenges. It is chaired by the Prime Minister, and serves as a platform for companies and employee representatives to discuss strategic topics such as training, innovation, funding for businesses, the circular economy and international development.

The National Industry Council is currently made up of 16 Strategic Sectoral Committees based on the major sectors of French industry, with two cross-disciplinary committees (National Industry Council Digital and National Industry Council International) and four thematic committees (Circular Economy, Jobs and Skills, Europe, Regulation and Simplification).

The Strategic Sectoral Committee for New Energy Systems was set up in 2018. It covers an industrial sector that accounts for 15,000 companies, 150,000 direct jobs and turnover of €23 billion. The industry-wide contract contains details of four large-scale thematic projects: energy efficiency, renewable energies (with a focus on biogas and offshore wind), storage (batteries and hydrogen) and micro-grids (scaling up of solutions). A strong focus is placed on innovation, particularly with regard to hydrogen, anaerobic digestion and digital technologies.

Several other Strategic Sectoral Committees have emphasised the need for innovation in connection with the energy transition; these include the Automotive Committee (electric vehicles), the Rail Committee (energy optimisation, new powertrains), the Maritime Industries Committee (renewable energies, storage), the Aerospace Committee (electrification, optimisation of internal combustion engines), the Mining and Metallurgy Committee (integration of renewable energies, recycling of batteries), the Chemistry and Materials Committee (thermal management, emergence of a batteries sector), the Construction Committee (energy renovation) and the Waste Committee (solid recovered fuel).

2.5.2.2. Establishment of the Innovation Council in July 2018

Last July, the French Government established an Innovation Council as a strategic body aimed at steering action by the public authorities towards breakthrough innovations. By doing so, the Government hoped to reiterate the priority status of innovation.

The Innovation Council is made up of the Minister of Ecological and Inclusive Transition, the Defence Minister, the Secretary of State for Digital Affairs and the Minister of Action and Public Accounts. BPI France and the National Research Agency attend the Innovation Council's meetings in their capacity as innovation funding bodies.

Six qualified professionals from the fields of research, industry, innovation capital, entrepreneurship and the innovation economy contribute their expertise and vision by assisting with the Innovation Council's work.

The Innovation Council's objectives include the following:

- adopting the major guidelines and priorities for the innovation policy, based on assessments and forecasts;
- developing a roadmap that contains measures likely to make innovation policy more cross-sectoral in nature and simplify the funding landscape for innovation players. In particular, this roadmap will ensure that the measures are properly aligned with regional and European frameworks, so that businesses and public research bodies can access the calls for projects that best fit their needs;
- drafting recommendations on funding tools for innovation policy, with the aim of promoting the emergence of breakthrough innovations and their mass production in France.

2.5.2.3. The Innovation Fund as a source of funding for the industrial policy

In 2018, the French Government established an Innovation Fund worth €10 billion and with an estimated annual return of between €200 million and €300 million. The aim of this Fund is to support the development of breakthrough innovations and their mass production in France.

In particular, it will be used as a source of funding (to the tune of approximately €160 million/year) for major social challenges in several areas regarded as strategic and requiring technological barriers to be overcome. Ultimately, overcoming these major challenges should make it possible to open up new markets in which France can play a leading position, with the parallel growth of an ecosystem of laboratories, start-ups, SMEs and large corporations.

The topics for the major challenges will be chosen by the Innovation Council, whose members represent the world of business, the research community and investors, and which is chaired by the Minister of the Economy and Finance and the Minister of Higher Education, Research and Innovation. One major challenge relating to energy storage was identified in December 2018.

All of these social challenges share the following features:

- a scientific and technological scope: each major challenge must address technological obstacles and explore areas that have hitherto been neglected;

- society-wide relevance: each major challenge must respond to French citizens' concerns in the fields of health, security, mobility and sustainable development;
- market prospects: the end goal of each major challenge is the bringing to market of an innovative product or service, which means that the project's technical and economic feasibility must be considered from the outset;
- pool of excellence for French businesses and laboratories: each major challenge must leverage France's unique advantages.

2.5.2.4. Competitiveness Clusters

The Competitiveness Clusters policy was launched in 2004 with a view to driving forward action in relation to the key factors in competitiveness, the most important of which include innovation capacity as well as growth and new jobs in lead markets.

A Competitiveness Cluster serves as a platform for large and small businesses, research laboratories and training institutions within a well-defined region to collaborate on work relating to a specific target. Public authorities at local and national level are closely involved in these measures.

A Competitiveness Cluster is aimed at supporting innovation. It promotes the development of collaborative and especially innovative research and development (R&D) projects. It also supports the evolution and growth of its member companies, in particular by bringing to market new products, services or processes that are developed as an offshoot of research projects. Competitiveness Clusters act as drivers of growth and jobs by allowing the businesses involved to become market leaders in France and abroad.

Many different parties are involved in Competitiveness Clusters. All are required for the development of dynamic, wealth-generating ecosystems.

Several Competitiveness Clusters relate directly to energy: Capénergies, Derbi, Tenerrdis, S2E2 and Energivie.

In 2018, the Competitiveness Clusters were rebranded in order to keep up momentum and encourage individual clusters to join together to achieve a critical size.

2.5.2.5. Macroeconomic assessment of the energy transition

France has assessed the macroeconomic impact of its energy transition policy for the period through to 2030. It calculates this impact by comparing the scenario currently backed by the Government against a scenario based on the continuation of current measures. The following percentage differences (between the WAM and WEM scenarios) are based on projections for jobs, the balance of trade, energy consumption and the government balance:

	2023	2028	2030
GDP (% difference between WAM and WEM)	1.3	2.1	2.5
Added value of market sector (% difference between WAM and WEM)	1.8	2.6	3.1
Household consumption (% difference between WAM and WEM)	0.6	1.3	3.3
Real disposable income of households (% difference between WAM and WEM)	1	2.2	2.9

Jobs (number)	238,000	440,000	540,000
Balance of trade (% of nominal GDP)	0.1	-0.4	-0.6
Energy consumption (% of nominal GDP)	-0.5	-0.9	-1
Government balance (% of nominal GDP)	0.6	1.1	1.3

3. POLICIES AND MEASURES

3.1. Decarbonisation

3.1.1. GHG emissions and removals

3.1.1.1. Policies and measures to achieve the target set under Regulation (EU) 2018/842 as referred in point 2.1.1 and policies and measures to comply with Regulation (EU) 2018/841, covering all key emitting sectors and sectors for the enhancement of removals, with an outlook to the long-term vision and goal to become a low emission economy and achieving a balance between emissions and removals in accordance with the Paris Agreement

Planned policies and measures aimed at achieving France's ESR target for 2030

The following section describes the policies and measures planned for each CO_2-emitting sector, or in other words the options that are currently being examined and that have a realistic chance of being adopted and implemented after the submission date of the integrated national energy and climate plan, in line with the definition provided in the Regulation on the governance of the Energy Union.

It also outlines the sectoral and cross-cutting guidelines laid down in the draft SNBC 2, which was published in December 2018. These guidelines underwent extensive stakeholder consultations, and were designed to supplement existing measures and promote the achievement of France's GHG emissions reduction targets (see Section 2.1.1). Once the strategy has been adopted, the guidelines will be legally enforceable against the public sector, and they must serve as a basis for the drafting of future public policies.

Transport

The planned policies and measures and the SNBC guidelines in the transport sector are described in Sector 3.1.3.(iii) *Policies and measures to achieve low carbon emission mobility.*

Residential and tertiary

- **Planned policies and measures**

The majority of planned policies and measures aimed at reducing GHG emissions in the residential and tertiary buildings sector involve improvements to the energy efficiency of buildings (detailed in Section 3.2. *Energy efficiency*) and the development of renewable energies (detailed in Section 3.1.2 *Renewable energies*).

The **environmental regulations** that will apply to new builds and that are expected to come into force in 2020 will be relevant under two dimensions: energy efficiency and decarbonisation. They will introduce an innovative environmental standard for new builds that combines requirements relating not only to energy consumption and the growth of renewable energies, but also to GHG emissions throughout the building's entire lifecycle (from construction through to demolition, including use). It will be possible to use feedback from the pilot scheme for the 'Positive-Energy and Low-Carbon Buildings (E+C-)' label, launched in late 2016, as a basis for agreements on the methodologies to be followed under future environmental regulations. This voluntary label will combine requirements relating to both energy and GHG emissions. It will allow developers to choose the solution that best fits the geography of the region, the nature of the buildings and the costs incurred. The pilot scheme approach is intended to test solutions 'in the field' to ensure that there is a good balance between their environmental impact, the associated construction costs, and the capacity of businesses and their equipment to achieve the intended impact. Through these measures, France hopes to encourage players in the buildings sector to construct positive-energy and low-carbon buildings.

- **Guidelines laid down in the SNBC**

The draft SNBC 2 outlines the following strategic guidelines for the residential/tertiary buildings sector:

- ✓ **steer energy mix choices towards zero-carbon energy consumption in existing buildings and new builds;**
- ✓ **encourage the renovation of all existing residential and tertiary buildings with a view to achieving the target of 'low-energy building' standards on average across the entire building stock;**
- ✓ **increasing energy and carbon performance levels in new builds under future environmental regulations;**
- ✓ **improving the energy efficiency of appliances and encouraging citizens to be moderate in their use of such appliances.**

Industry (non-ETS)

- **Planned policies and measures**

The majority of mitigation measures implemented in the industrial sector (non-ETS) are accounted for by energy efficiency measures (detailed in Section 3.2. *Energy efficiency*) and measures aimed at developing renewable energies (detailed in Section 3.1.2 *Renewable energies*).

- **Guidelines laid down in the SNBC**

The draft SNBC 2 outlines the following strategic guidelines for the industrial sector:

- ✓ **helping businesses to transition to low-carbon production systems and tap into new markets;**
- ✓ **promoting the early development and roll-out of breakthrough technologies with a view to reducing residual emissions and eliminating them if possible;**
- ✓ **providing a framework that encourages energy demand management and resource conservation, by prioritising carbon-free energies and the circular economy.**

Waste treatment

- **Planned policies and measures**

The **Roadmap for the Circular Economy**[13] published in 2018 is targeted at better manufacturing (ecodesign, use of recycled materials), better consumption (increase in rates of reuse and repair, lengthening of product lifespans), better waste management (optimised sorting of waste, increase in recycling and recovery) and better mobilisation of all stakeholders.

Its main targets are as follows:

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13 https://www.ecologique-solidaire.gouv.fr/sites/default/files/Feuille-de-route-Economie-circulaire-50-mesures-pour-economie-100-circulaire.pdf

- achieving a 30% reduction in resource consumption in relation to GDP by 2030 compared to 2010;

- achieving a 50% reduction in volumes of non-hazardous waste placed in landfill by 2025 compared to 2010 (target under the LTECV);

- achieving a recycling rate of almost 100% for plastics by 2025;

- reducing greenhouse gas emissions: preventing the emission of an additional 8 million tonnes of CO_2 each year through the recycling of plastics.

The Roadmap proposes 50 measures aimed at fostering the circular economy. The measures outlined in the Roadmap will be adopted at legislative level by 2019 in the law transposing the new EU Directive on waste, as well as in future Finance Laws. Over the next few months, the Roadmap's measures will also be implemented by means of regulatory measures, initiatives by local authorities (particularly in the case of measures aimed at significantly increasing the collection of recyclable waste) and voluntary commitments by companies.

The measures under the Roadmap that will have the greatest impact on GHG emissions include the following:

- increasing the use of recycled materials as raw materials for manufacturing, based on voluntary commitments and support for industry players;

- stepping up the fight against food waste;

- broadening the scope of schemes for collecting recyclable packaging, plastic bottles and cans;

- making it easier for citizens to sort their waste;

- introducing economic incentives to recycle waste rather than send it to landfill;

- making it easier for local authorities to sort and recycle biowaste at source;

- increasing the sorting, reuse and recycling rates for construction waste.

The draft Law on the Fight against Waste and the Circular Economy, which was adopted by Parliament in early January 2020, is aimed at addressing the challenges associated with combating different forms of waste and making our economy more circular. It is structured around four major areas:

- **stopping waste in its various forms with a view to conserving natural resources;**
- **providing more information to consumers so that they can make informed decisions;**
- **encouraging economic players to transform their methods of production and distribution;**

  improving the collection and sorting of waste with a view to promoting reuse and recycling and preventing fly tipping.

▪ **Guidelines laid down in the SNBC**

The draft SNBC 2 outlines the following strategic guidelines for the waste treatment sector:

✓ **encouraging all stakeholders to reduce waste;**
✓ **encouraging producers to combat waste generation from the product design stage onwards;**
✓ **improving waste collection and management by increasing recovery rates and improving the efficiency of treatment operations.**

Agriculture

- **Planned policies and measures**

The Agri-Environmental Plan for France sets out a holistic vision of the transformation of agricultural practices in France. Its underlying aim is to ensure that French agriculture moves to production systems that are highly efficient in all respects, particularly in economic and environmental terms. It incorporates several separate plans, some of which have recently been revised, are currently being revised or will shortly be revised: these include the Vegetable Protein Plan, the Organic Plan and the Teaching to Produce Alternatives Plan.

The **Vegetable Protein Plan** is aimed at developing pulse crops, in particular through the integrated management of inputs and the consolidation of markets. It covers the period between 2014 and 2020, with plans to increase the target for the post-2020 period. A further target of achieving protein self-sufficiency by 2030 has been set; in particular, this will involve the growth of the country's vegetable protein sector to a point where it can cover the country's needs (announced by the President of the Republic on 25 January 2018: strategic project aimed at achieving sovereignty in the protein sector over the next five years, broken down at CAP level).

The **Organic Plan 2022** was presented in June 2018. Its underlying aim is to ensure that 15% of utilised agricultural land is used for organic crops by 2022. The plan has a pot of €1.1 billion and is structured around seven major areas, with funding to be awarded mainly via three tools that promote organic farming:

- **increase in the amount of funding available for conversion aid: €200 million in state loans, €630 million under the EU's EAFRD scheme topped up with other state funding and, from 2020, €50 million per year from the tax on non-point pollution;**
- **doubling of the pot for the 'Organic Future' Fund (managed by the Organic Agency), which will gradually be topped up from €4 million to €8 million per year;**
- **extension of the 'organic tax credit' scheme and an increase in its value, from €2,500 to €3,500 by 2020 (enshrined in the 2018 Finance Law).**

In addition to conversion aid and the Organic Future Fund, support for individual and group projects will be provided via the agricultural pillar of the Major Investment Plan (see below).

The **'Teaching to Produce Alternatives Plan'**, which forms one of the building blocks of the Agri-Environmental Plan, is currently being revised. Its aim is to promote the provision of agriculture-related training that supports the transition towards new and more sustainable production systems. Teaching resources designed to be used when providing training to future generations of farmers are being revised to ensure that they cover the latest agri-environmental developments, in particular climate-related matters.

Within the framework of the current negotiations on the future CAP and the 2021–2027 Multiannual Financial Framework, France has also campaigned for a **stronger environmental component for the common agricultural policy (CAP)**, in particular through payments for ecosystem services.

During a speech given in Rungis on 11 October 2017, the President of the Republic asked the inter-branch organisations to produce **plans for the development and transformation of the agricultural and agri-food sectors**. In particular, these sector-specific contracts must include targets relating to growth in organic and high-quality products, environmental targets and targets relating to agricultural research programmes. The plans were forwarded to the Minister for Agriculture and Food by the inter-branch organisations in December 2017.

Finally, the Government's **Major Investment Plan**, worth €57 billion over the five-year period between 2017 and 2022, incorporates an **agricultural pillar** aimed at accelerating changes to tools and practices in the agriculture, fisheries, agri-food and forestry/wood sectors. The agricultural pillar of the Major Investment Plan diversifies and boosts the range of financing tools available to operators in these sectors wishing to carry out transformation-related measures, including guarantee funds, non-guaranteed loans and equity investments, in addition to grants or repayable advances. It is based on nine measures gathered together under three axes:

- **Axis 1 'Transforming sectors upstream of agriculture and forestry', which contains four measures: support for investments into agricultural holdings, support for changes in agricultural practices, support for agricultural anaerobic digestion and support for investments into forestry;**
- **Axis 2 'Increasing the competitiveness of sectors downstream of agriculture and forestry', which contains two measures: support for upgrading of the sectors downstream of agriculture and modernisation of the sectors downstream of forestry;**
- **Axis 3 'Innovation and sectoral organisation', which contains three measures: innovation competition, support for regional innovative projects based on cooperation and for structural investments in these sectors.**

The measures are aimed not only at promoting changes to agricultural practices, but also at influencing demand and consumption in agri-food sectors. Between 20 July and 30 November 2017, the Government organised a National Foodstuffs Meeting. Several of the recommendations that emerged from this Meeting, and that were incorporated into Law No 2018-938 of 30 October 2018 on equitable commercial relations in the agricultural and food sector, and a healthy, sustainable and accessible food system, make a direct contribution to GHG mitigation as follows:

- **support for organic production systems**, in particular through the adoption of regulations obliging operators in the food service industry to use a minimum proportion (50%) of locally sourced or quality-certified (including organic) agricultural products from 1 January 2022;
- the introduction of mandatory **preliminary food waste assessments** (including sustainable sourcing) for all operators in the food service industry.

- **Guidelines laid down in the SNBC**

The draft SNBC 2 outlines the following strategic guidelines for the agriculture sector:

- ✓ **reducing direct and indirect emissions of N_2O and CH_4 by applying the principles of agroecology and high-precision agriculture;**
- ✓ **reducing CO_2 emissions linked to the consumption of fossil fuels and increasing the use of renewable energies;**
- ✓ **boosting the production of carbon-free energy and the bioeconomy with a view to reducing France's CO_2 emissions, and increasing the value added by the agricultural sector;**
- ✓ **reversing the current trend for carbon stored in agricultural soils to be removed, in keeping with the initiative '4p1000, soils for food security and the climate';**
- ✓ **influencing demand and consumption in the agri-food sectors via the National Food and Nutrition Programme (PNAN);**
- ✓ **improving inventory and evaluation methodologies.**

Cross-sector measures

- **Planned policies and measures**

Carbon pricing

In 2014, changes were made to the energy consumption tax with the result that a share of this tax is now calculated in proportion to CO_2 emissions from energy products. The rate was set at €44.6/tCO_2 in 2018 and was expected to reach €86.2/tCO_2 in 2022. The planned increases were delayed from 2019 onwards in response to the 'Grand National Debate', which focused in particular on the ecological transition and its consequences for French citizens.

In addition, the trajectory for the shadow price of carbon has been updated by the Commissariat-General for Strategy and Foresight (report published in February 2019). The shadow price of carbon is the cost of all the efforts required to avoid the emission of one tonne-equivalent of CO_2. It is used to assess the socioeconomic impact of public investment projects in order to steer choices towards pro-decarbonisation projects. It is also intended to be used as a basis for developing and assessing the various measures that promote carbon-free choices and private investments (explicit carbon pricing, investment subsidies, regulations, etc.), without setting a level or a rate on a case-by-case basis. The shadow price of carbon serves as a point of reference for comparing the cost of different public policies per tonne of greenhouse gas avoided, which is one of the factors to be taken into consideration when designing measures.

- **Plans to tax HFCs and ratification of the Kigali Amendment**

The Climate Plan published by the Government in July 2017 provides for an expansion of the carbon pricing mechanisms to include other greenhouse gases and, as a first step, the introduction of tax incentives for avoiding HFCs. The details of the tax were outlined in the 2019 Finance Law, which provides for the introduction of a tax on HFCs from 2021 based on progressive rate increases as follows: €15 per tonne-equivalent of CO_2 in 2021, €18 in 2022, €22 in 2023, €26 in 2024 and €30 from 2025 onwards. The entry into force of the tax has been set for 1 January 2021, so that assessments can be carried out prior to this date to determine whether industry professionals have delivered on their commitments to reduce consumption of these gases. The outcomes will determine whether these gases are still a relevant tax base that will generate adequate returns in view of the Government's belief that higher taxes should be levied on polluting operations than on work or economic activities.

On 29 March 2018, France also ratified the Kigali Amendment to the Montreal Protocol. Although the Kigali Amendment shares the same overall objectives as the EU's F-Gas II Regulation, its reporting period is longer (through to 2036, while the F-Gas II Regulation only covers the period until 2030).

- **Introduction of a low-carbon label for the certification of emissions-reducing projects**

Through the introduction of a framework for monitoring, notifying and verifying GHG emissions, the low-carbon label is aimed at promoting the emergence of additional GHG emission-reducing projects within France and placing a value on any additional reductions achieved voluntarily by natural or legal persons in a range of different industrial sectors. In this context, the term 'emission-reducing' refers both to projects that prevent GHG emissions in the first place and GHG sequestration projects. The label has been introduced in response to calls for a GHG emissions offsetting scheme that is both local and voluntary. Voluntary partners (from the public or private sector) will make payments to project organisers and then seek recognition for their contributions to the additional emissions reductions achieved through the relevant projects. Checks are carried out before the emissions reductions are recognised. Once they have been recognised, the emissions reductions cannot be transferred or exchanged either in private arrangements or on any voluntary or mandatory market. Emissions reductions can only be used for the voluntary offsetting of emissions by non-state players (companies, local authorities, individuals, etc.).

The regulations governing implementation of the scheme were published in November 2018. The first details of methods that must be followed in order for projects to be granted the label have already been validated.

- **Cross-sector guidelines of the SNBC**

The draft SNBC 2 lays down cross-sector guidelines on carbon footprints; economic policy; research and innovation policy; and urban design, land-use planning and regional dynamics.

Carbon footprint:

- ✓ improving control of the carbon content of imported products;
- ✓ encouraging all economic players to reduce their carbon footprints;
- ✓ encouraging citizens to reduce their carbon footprints.

Economic policy:

- ✓ **sending the right signals to investors, particularly in respect of carbon prices, and giving them a clear, long-term view of climate policies;**
- ✓ **ensuring a fair transition for everyone;**
- ✓ **supporting EU and international action on funding and carbon prices in line with the Paris Agreement;**
- ✓ **promoting investment into projects that foster the low-carbon transition, by developing funding tools that limit the risks incurred by investors and by adopting stringent criteria for identifying appropriate projects;**
- ✓ **analysing in more depth the climate impacts of measures implemented with public funding or under public policies, and using this information as a decision-making criterion; ensuring that measures that would run counter to efforts to meet our climate targets do not benefit from public funding.**

Research and innovation policy:

- ✓ developing low-carbon innovations and facilitating their timely diffusion, based on basic and applied research.

Urban design, land-use planning and regional dynamics:

- ✓ placing limits on anthropogenic soil development and reducing carbon emissions in connection with urban design.

3.1.1.2. Policies and measures to comply with Regulation (EU) 2018/841

The first SNBC, which was adopted in 2015, lays down strict guidelines aimed at developing a more sustainable approach to land management with a view to limiting anthropogenic development of land (in particular agricultural land), storing and maintaining carbon in soils and biomass and increasing the amount of carbon removed from the atmosphere by the forestry and timber sector.

These guidelines involve firstly action under the Agri-Environmental Plan for France, and secondly the revitalisation of forestry management. In particular, four mutually reinforcing tools have been identified in the forestry and timber sector:

- **use of bio-based products as substitutes for energy-intensive materials;**
- **recovery of energy from bio-based products or from the waste generated from these products as a substitute for fossil fuels;**
- **storage of carbon in wood and waste wood products;**
- **carbon sequestration in the forestry ecosystem.**

Planned policies and measures

- The **National Bioeconomy Strategy** (adopted in 2017) and the associated Action Plan for 2018–2020 combine within a single framework all the public policies relating to biomass, with a view to positioning renewable carbon and biological resources at the centre of the economy by substituting bio-based products for fossil and mined products.
- The **National Forestry and Timber Plan**, which provides a framework for forestry policy over the period 2016–2026, is aimed in particular at expanding the role played by forests in the fight against climate change, and sets a target of mobilising an additional 12 million m^3 of marketed wood. Regional Forestry and Timber Programmes are currently being developed on the basis of the National Forestry and Timber Programme.
- The **National Biomass Mobilisation Strategy**, which was adopted in 2018, estimates the potential of different types of biomass and lays down broad guidelines for mobilising them as effectively as possible, in particular with a view to achieving the targets under the MEP as regards heating and biomass electricity production capacity in line with the target set under the National Forestry and Timber Programme for forestry biomass.
- The **National Climate Change Adaptation Plan**, which was adopted in December 2018, provides for several measures that will help make forests 'climate change ready', in particular by making them more resilient to the heightened risk of forest fires, which would have a negative impact on stores of carbon in forests.
- The **Strategic Wood Sector Contract** (2018–2022), signed by industry professionals and the Government, is aimed at promoting the use of wood and boosting the sector's competitiveness. The Strategic Wood Sector Contract represents a building block in the implementation of a circular economy; its objectives include sustainable production, reduced raw material waste and higher rates of wood waste recycling and recovery (Challenge 3). It also provides for the increased use of wood for construction, resulting in long-term carbon storage (Challenge 4).
- The **Interdepartmental Plan for Stimulating the Forestry and Wood Sector**, launched in November 2018, is structured around three axes: sustainably renewing and mobilising forests as a resource, developing end markets, supporting innovation and investment, improving the sector's environmental performance and expanding the sector's development in the regions.
- The **Biodiversity Plan**, published in 2018, which aims to reduce net biodiversity loss to zero, and which in particular proposes a set of measures that limit use of natural areas, agricultural land and forests with a view to achieving a target of net zero anthropogenic development.
- The **City Centre Action Plan**, which was launched in 2018, and which has a pot of €5 billion over five years for revitalising city centres. Priority objectives under this plan include limiting urban sprawl and reducing anthropogenic soil development.

Strategy implementation in the forestry and wood sector

A more dynamic approach to forest management requires a case-by-case assessment of existing stands with a view to identifying local potential and circumstances. It also requires research, development and innovation. It takes into account all the relevant economic, social and environmental challenges, including carbon storage in soil compartments, above-ground and below-ground biomass, litter, dead wood and harvested wood products, the maintenance of other ecosystem services, the preservation of landscapes and biodiversity, protection against natural risks, citizens' expectations and research into the creation of economic value and jobs.

An approach of this kind can be implemented in a number of different ways: Introducing species that are better adapted to climate change and/or those originating from more appropriate geographical regions, diversifying species and management practices within forests, reduction in forest rotation times in high-risk situations, thinning of high forests in the interests of producing high-quality timber, natural regeneration, maintaining small patches of old trees to preserve the biodiversity associated with senescence in trees, improving coppiced forests or coppices with standards by fencing off and selecting natural seedlings, restoring through planting forests that are in decline, dying or at an impasse, and improving afforestation processes that occur spontaneously on fallow agricultural land. These forestry-related measures fall under the heading of Improved Forestry Management (IFM) strategies that contribute to the strengthening and resilience of forest-based carbon sinks and stores in the long term.

Wood production and yield will increase as a result of measures aimed firstly at encouraging increasingly dynamic and sustainable forest management by forest owners, secondly at discouraging the consumption of fossil or mineral materials with a large environmental footprint, and thirdly at promoting the use of bio-based products throughout the entire economy. This quantitative increase in production and yield will be accompanied by a qualitative improvement in use, with a shift towards products with a long service life and high substitution potential, a reduction in material and energy losses at all stages of processing, and improvements to the collection and recycling of end-of-life wood products.

The entire forestry and wood industry, including upstream and downstream sectors, will be encouraged to follow this approach. By means of public policies and career development strategies, the silviculture and wood production sector will gradually but consistently be shifted towards markets with a high added value and high environmental value. Sectors and uses to be promoted include:

- uses of materials: under-valued links of the production chain, in particular deciduous woods, construction and bio-based chemistry.
- energy uses: in the long term, a small number of large carbon use and capture (CUC) or carbon storage and capture (CSC) facilities; in particular, however, small or medium-sized facilities distributed across the regions (heat production, cogeneration, advanced biofuels, gasification) using small-diameter wood, poor-quality wood and certain silviculture residues, by-products of first- and second-stage wood processing activities and recycled wood waste.

Afforestation is not necessarily incompatible with agricultural production. The priority must be to support and enrich afforestation processes that occur or will occur spontaneously on fallow farmlands. Research will also be carried out into the afforestation potential of certain types of land upon which spontaneous afforestation processes will not take place, such as degraded land, and the renaturalisation of anthropogenically developed land such as derelict land, industrial wasteland or artificially grassed areas.

- **Guidelines laid down in the SNBC**

The draft SNBC 2 outlines strategic guidelines for the land sector:

- for the forestry and wood sector:

  - ✓ **implementing upstream measures to guarantee the timely preservation and strengthening of carbon sinks and stores in the forestry and wood sector, and their resilience to climate stresses;**
  - ✓ **maximising the effects of carbon substitution and storage in wood products by leveraging supply and demand;**
  - ✓ **monitoring the implementation of policies adopted on this basis and adjusting them regularly in response to any findings, in order to guarantee the achievement of targets and the expected attendant benefits.**

- for the agricultural sector:

- ✓ **reversing the current trend for carbon stored in agricultural soils to be removed, in keeping with the initiative '4p1000, soils for food security and the climate'.**

- for the land-use change sector:

- ✓ **placing limits on anthropogenic soil development and reducing carbon emissions caused by urbanisation.**

Long-term vision and goal of moving to a low-emissions economy and achieving a balance between emissions and removals in line with the Paris Agreement

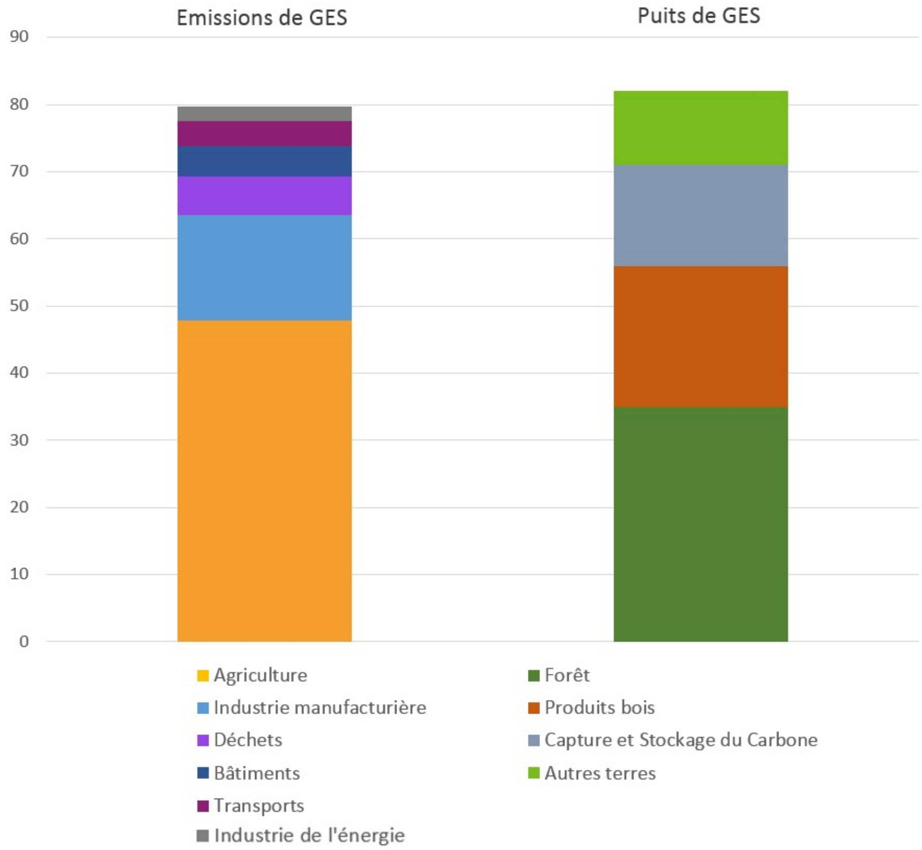
The Climate Plan presented in July 2017 reiterated France's long-term objective of achieving carbon neutrality within the country by 2050. Carbon neutrality is an ambitious target. According to recent research carried out by the IPCC, however, achieving this target as soon as possible and at global level is essential to contain global warming at 1.5 °C.

The revised version of the SNBC is France's roadmap for achieving carbon neutrality by 2050. It is based on a reference scenario that outlines future public policy directions (presented in the sections above) in addition to the measures already in place today, thereby allowing France to meet its climate and energy targets in the short, medium and long term.

The reference scenario is designed to be both ambitious as regards its targets and feasible as regards the means by which these targets are achieved, without gambling on significant technological breakthroughs. At the same time, however, a number of new technologies are included on the basis of reasonable assumptions (carbon capture, storage and use (CCSU), power-to-gas, energy storage, etc.).

It appears that a proportion of CO_2 emissions will still be unavoidable in 2050, particularly in non-energy sectors (agriculture and industrial processes). Achieving carbon neutrality therefore involves using carbon sinks to compensate for these emissions. It is estimated that the sinks provided by an optimised and sustainable land sector (forests and agricultural land) plus carbon capture and storage will only compensate for residual non-energy emissions and the residual emissions from fossil fuels that are still used for certain means of transport (aviation).

Figure 16: GHG emissions and sinks in France in 2050, based on the reference scenario



Emissions de GES	GHG emissions
Puits de GES	GHG sinks
Agriculture	Agriculture
Industrie manufacturière	Manufacturing sector
Transports	Transport
Agriculture	Agriculture
Industrie	Industry
Bâtiment	Buildings
Industrie de l’énergie	Energy sector
Déchets	Waste
Forêt	Forest
Produits bois	Wood products
Autres terres	Other land
Capture et Stockage du Carbone	Carbon capture and storage

The following steps must be taken to achieve carbon neutrality:

- **total decarbonisation**[14] **of energy production by 2050**, with exclusive use of the following energy sources: biomass resources (waste from agriculture and wood products, wood energy, etc.), heat from the environment (geothermal, heat pumps, etc.) and carbon-free electricity;
- **sharp reduction in energy consumption across all sectors,** based on a significant increase in energy efficiency and a moderation of demand (the scenario is based on a slight drop in public demand across all sectors compared to the trend-based scenario coupled with major changes in consumption patterns, without any compromises in terms of convenience);
- **minimisation of emissions that are not linked to energy consumption** (for example emissions from agriculture or industrial processes);
- **increase in carbon sinks (natural and technological)** to absorb unavoidable residual emissions by 2050 while promoting biomass production. Problems may arise in connection with biomass resources, since the structure of the system is predominantly geared towards liquid and gaseous fuels at present.

3.1.1.3. Regional cooperation in this area, where applicable

France is not currently involved in regional cooperation in this area.

3.1.1.4. Without prejudice to the applicability of State aid rules, financing measures, including Union support and the use of Union funds, in this area and at national level, where applicable

A variety of different types of financing measures are implemented in this area, some of which are cross-cutting in nature. No provision has been made for specific financing measures in this area.

3.1.2. Renewable energies

Measures to promote renewable energies are determined to achieve the objectives set by law. Since these targets are expressed as percentages of renewable energies in relation to energy consumption, the target quantities of renewable energy depend on the amounts consumed. In turn, the amounts consumed depend on the macroeconomic context. The targets for 2028 are therefore expressed as a range (Scenario A and Scenario B) to ensure that the targets set by law can be achieved. Depending on the macroeconomic context, it may be necessary for the Government to step up its policy initiatives to maintain the same percentage use of renewable energies.

3.1.2.1. Renewable and recovered heating and cooling

Measures applicable across all sectors will be adopted to boost the generation of renewable heat. For some sectors, these measures will be sufficient to support the penetration of renewable heat, while for others they will need to be supplemented with specific measures, which will be described in the corresponding paragraph.

14 In reality, decarbonisation will be 'near-total', firstly because certain unavoidable residual leakages of renewable gases will remain, and secondly because fossil fuels will still be used in part for air transport.

The following table shows the final consumption target for renewable heat that can be achieved through the implementation of the measures.

Cross-sector measures for the development of renewable heat:

Technical measures:

- Ensure that the future environmental regulation on new buildings (ER 2020) imposes a minimum level of renewable heat in all new buildings (individual, collective and tertiary) as soon as it is implemented.
- Generate feedback from the calculation engine in RT2012 (the French thermal buildings regulation, amended in 2012) and on the E+C- trial to enable better use of thermal renewable energies, especially solar thermal energy, in the future environmental regulation ER 2020.
- Facilitate recourse to the ranking of high-performing district heating and cooling systems (the ranking of a district heating and cooling system is a procedure that makes it possible to determine the areas within which any new installation must be connected to the system).

Financial measures:

- Continue the strengthening of the Heat Fund from 2019 with an annual budget of €307 million in 2019 and then €350 million from 2020 onwards. The amount committed to the Heat Fund from ADEME will be stabilised at €350 million from 2022 unless there is a change to carbon taxation before that year.
- Simplify the rules of the Heat Fund: the obligation to make repayable advances for Heat Fund projects was eliminated in 2019 and replaced by subsidies, and the rules governing grants within ADEME were reconciled with the EU guidelines in 2019 by aligning them with the maximum levels of support for heat networks, which are more favourable for non-economic activities; develop local, financial contracts for the development of renewable energies, which make it possible to subsidise clusters of small projects.
- Make the energy transition tax credit (CITE) and its replacement MaPrimeRénov' more effective by setting a flat-rate amount, differentiated according to technologies and giving specific consideration to the renewable heat generation enabled by each equipment type.
- Keep VAT at 5.5% for renewable heat equipment eligible for the CITE, and related works (for example: smoke extraction chimney, granulate silo).
- Provide better coordination of White Certificates (WC) and Heat Fund grants according to conditions that comply with the EU guidelines.
- Since mid-2019, zero-rate eco-loans have applied for works eligible for the CITE without any conditions based on series of works projects.
- Make the eligibility criteria for reduced VAT of 5.5% more ambitious, with an increase in the 50% threshold for renewable or recovered energy within a sustainable timetable (60% in 2030).

Information/communication/awareness-raising measures:

- Undertake a collective campaign for local authorities with more than 10,000 inhabitants to initiate projects for construction of a district heating and/or cooling system.
- Ensure that all public stakeholders are familiar with the monitoring centre's website for heating and cooling networks and the Via Seva website for the general public.
- Make it possible for private individuals to obtain information through their energy bills about their heating and cooling consumption twice a year from October 2020 in accordance with the provisions of the European package in order to comply with the standards relating to metering and the provision of information for customers.

- Make available the list of Government buildings and associated heating methods.

Solid biomass

Measures to supplement cross-sector measures:

- Promote heat recovery from biomass before high-yield cogeneration. Heat will clearly be a priority for energy recovery from biomass.
- Ensure the rapid replacement of inefficient independent wood-burning appliances (fireplaces, stoves, heating inserts) with more efficient equipment in terms of yield and air quality (Green Flame-labelled, pellets, etc.).
- Organise a campaign to raise awareness about the correct use of domestic wood.
- Develop local analyses of biomass on a regional basis (as part of the drafting of regional biomass plans) in order to mobilise available but underexploited biomass resources, with the updating of inventory data (work in progress by the IGN).
- Continue support for boilers in collective and industrial heating systems through the Heat Fund.

Heat pumps

Measures to supplement cross-sector measures:

- Maintain the support provided by means of the CITE/MaPrimeRénov' for air/water and geothermal heat pumps, with the same size contribution required from the recipient for each of these two solutions.
- Support heat pump-assisted geothermal heating and geothermal renewable cooling projects through the Heat Fund.

Deep geothermal energy

Measures to supplement cross-sector measures:

- Implement a local coordination structure, with at least one geothermal specialist coordinator per region, with the support of ADEME.
- Support investment in geothermal energy, geothermal district heating and cooling systems, and heat storage solutions using geothermal energy, through the Heat Fund.
- Maintain the Auxiliary Finance Company (SAF) guarantee fund and adapt it where necessary to develop the potential of new little known aquifers on the basis of the conclusions of the dimensioning study being conducted by ADEME.
- Enable participation by the Heat Fund in funding regional mapping for Geothermal installations of Minimal Importance (GMI), and where necessary in funding support for decision-making on the economic profitability of surface geothermal resources.
- Modify the Mining Code to explicitly mention the generation of cooling through geothermal energy.

Solar thermal

Measures to supplement cross-sector measures:

- For individuals:

    - Maintain support through the CITE for solar thermal systems (combined solar heating system, individual solar water heater, etc.) as part of the realignment of the CITE on the most effective works.
    - Develop a communication pack for FAIRE advisers on the value of solar thermal energy for individual systems, to encourage them to promote this solution more widely.
- For the collective, tertiary and industrial sectors:
    - Extend the call for Heat Fund project proposals for large solar thermal units for at least three years. The associated project evaluation criteria were reviewed in 2019.
    - Enable grants from the Heat Fund for the repair of faulty installations. sizing audit, performance instrumentation, operator training, grants subject to conditions (for example, if no grant has so far been awarded for the installation or if an energy performance contract (CPE) is planned).
    - Since 2019, the supply of district heating systems through solar thermal energy has been taken into account for the application of reduced-rate VAT for heat delivered by renewable and recovered energy networks.
    - Integrate a technical and financial assessment of solar or geothermal heat generation into energy audits on large and medium-sized enterprises.
    - Develop a communication about the value of solar thermal energy for the agriculture sector.
    - Diversify the role of wood energy promoters to include other technologies such as solar thermal and geothermal energy.

Recovered heat

Measures to supplement cross-sector measures:

- Make it mandatory to recover the energy from biogas captured in waste storage facilities, where relevant.
- Organise an action to stimulate domestic waste incineration plants (DWIP) and energy recovery units (ERU) to recover more residual heat. this action will be planned in conjunction with the publication of the *BREF - Best available techniques REFerence documents* for this sector (the BREF documents provide a description by sector of the best available techniques and the performance levels associated with these techniques: an inspection of classified installations can be required to examine the energy efficiency ratio of each energy recovery unit to ensure that it achieves the best possible ratio within the admissible range).
- Provide feedback on the cost/benefit analysis of heat recovery introduced in 2015 and develop this scheme if necessary.
- Develop a coordination network for industrial residual heat, for example by providing operator training for existing local ‘industrial ecology’ coordination networks, or by providing information to and supporting highly industrial areas (e.g. port zones, chemical platforms).
- Evaluate the potential to recover heat from waste water using a regional plan for spatial planning, sustainable development and territorial equality (SRADDET) and the updating of the ADEME study on residual heat.

3.1.2.2. Energy recovery from waste

Measures:

- Organise an action to stimulate domestic waste incineration plants (DWIP) and energy recovery units (ERU) to recover more residual heat. This action will be planned in conjunction with the publication of the BREF for this sector (the BREF documents provide a description by sector of the best available techniques and the performance levels associated with these techniques: an inspection of classified installations can be required to examine the energy efficiency ratio of each energy recovery unit to ensure that it achieves the best possible ratio within the admissible range), and may be based on an inventory prepared by the SN2E union and the National Union of Treatment and Recovery of Urban and Similar Waste (SVDU) and on expert information provided by ADEME.
- Maintain the grants paid by the Waste Fund to improve the energy efficiency of DWIP and by the Heat Fund for the connection to recovered district heating systems.
- Extend the call for projects on recovered solid fuels, with ADEME's Waste Fund.

3.1.2.3. Biofuels

Support measures for biofuels:

- Continue national support for the development of biofuels through an incentive to incorporate biofuels for operators that release fuels for consumption.
- Above the existing ceiling for conventional biofuels, limit the incorporation of biofuels produced from raw materials with a high risk of causing indirect land-use change (e.g. certain palm or soybean oils), as stipulated in the new EU Directive on renewable energies (RED II).
- Reinforce the sustainability and traceability criteria for raw materials.

3.1.2.4. Renewable and recovered gas

Support measures for biogas:

- Provide visibility by adopting a tender timetable for injected biomethane: two tenders, for an annual generation target of 350 GWh HHV/year each, will be launched each year.
- Consolidate the obligation to purchase biogas at a regulated tariff and launch tenders that make it possible to achieve the generation targets at a reasonable cost thanks to substantial cost reductions.
  - The tenders will be based on a reference feed-in tariff, used to dimension the total budget, with a target of €75/MWh HHV for injected biomethane projects selected in 2023 and €60/MWh HHV in 2028. If this average tariff is not reached, the volumes allocated will be reduced to ensure that the target public expenditure level is not exceeded. A maximum feed-in tariff of €90/MWh HHV for injected biomethane in 2023 and €80/MWh HHV in 2028 will also be introduced.
  - The volume of the tender will be increased if the average tariff requested in the bids is lower than the reference feed-in tariff. The feed-in tariff proposed on an open-window basis for small-sized facilities will be adjusted downwards if biogas generation capacity is contracted in excess of the target value of 800 GWh HHV per year for all recovery sectors.
- Put in place an appropriate support mechanism for biomethane not injected into natural gas networks (in particular biomethane used directly for bioNGV vehicles).
- Promote NGV and bioNGV, in particular thanks to the additional depreciation on the purchase of compatible vehicles.
- Accelerate the roll-out of NGV: support the generation of biomethane for methanisers supplying vehicles (buses, lorries) to develop direct local use, in particular those further away from the gas network.

- Facilitate the supply and connection of NGV stations to the natural gas networks.
- The following timetable shows the quarters when a tender will be launched up to 350 GWh/year.

2019				2020				2021				2022				2023				2024			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	350 GWh		350 GWh		350 GWh		350 GWh		350 GWh		350 GWh		350 GWh		350 GWh		350 GWh		350 GWh		350 GWh		350 GWh

Gasification of organic matter

Gasification corresponds to a thermochemical decomposition of organic matter into a synthesis gas (syngas) composed primarily of methane, hydrogen, carbon monoxide and carbon dioxide. This synthesis gas is then recovered in various ways. Gasification for heat generation constitutes one of the technologies in the wood energy sector. Synthesis gas can also be converted using a methanation process and then purified for injection into the natural gas networks.

Unlike anaerobic digestion, gasification can use wood fibre material. This use of wood fibre material could bring gasification for injection into the gas networks into competition with the wood energy sector, where development requires more limited public support. Given this more limited need for public support, priority will be given to the development of the wood energy sector, which includes gasification for heat generation, rather than to support for gasification for injection.

Feedback is planned on the demonstrators for gasification for injection into the gas networks in order to analyse the role that could potentially be played by this sector. In particular, this will involve an analysis of the energy efficiency level of this biomass recovery method, and of the environmental issues affecting the installations.

The possibility of developing gasification for injection without creating competition with the wood energy sector will be studied. Where applicable, the tenders relating to the biomethane purchase obligation described above may be extended to cover, under the same conditions, projects involving gasification for injection into the natural gas networks.

Measures:

- Generate feedback on the demonstrators for gasification for injection into the gas networks.
- Study the possibility of developing gasification for injection without creating competition with the wood energy sector and, where applicable, authorise projects involving gasification for injection into the natural gas networks to take part in tenders relating to the biomethane purchase obligation.

Hydrogen and power-to-gas

Measures:

- Put in place a support mechanism for the development of decarbonised hydrogen up to €50 million per year and launch calls for projects on hydrogen mobility and generation using electrolysers.
- Put in place a traceability system for decarbonised hydrogen in 2020.
- Extend the measure providing additional depreciation for the purchase of hydrogen vehicles at least under the same conditions as for NGV (heavy goods vehicles > 3.5 t).
- Mobilise financial institutions (public and private finance, including CDC, BPI) and standardise the cofinancing models for ecosystem deployment projects that pool different usages locally (mobility, industry, etc.) in the regions.
- Organise in-depth reflection among all stakeholders concerned with simplifying and harmonising procedures for the authorisation and accreditation of vessels and associated hydrogen refuelling solutions.
- Continue to provide support for innovation, in particular to support the industrial development and scaling-up of French industry players.

Recovered gas, pyrogasification

Measures:

- Generate feedback on the demonstrators for gasification for injection into the gas networks and for heat generation.

3.1.2.6. Electricity

Cross-sector measures to increase capacity to generate renewable electricity

- Provide visibility for tender schedules.
- Continue the administrative simplification measures introduced to decrease development periods and reduce costs.
- Support the development of crowdfunding investment in projects by citizens and local authorities.
- **Prepare large-scale recycling of end-of-life installations.**

Hydroelectricity

Measures to supplement cross-sector measures

- Optimise the generation and flexibility of the hydroelectricity system, in particular through over-equipping and installation of hydroelectric power plants on existing, non-equipped dams.
- Put in place a mechanism to support the refurbishment of authorised plants between 1 MW and 4–5 MW.
- Launch the granting of new concessions on certain sites where potential has been identified.
- Launch tenders for small hydroelectricity according to the following table.

2019				2020				2021				2022				2023				2024			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
35 MW				35 MW				35 MW				35 MW				35 MW				35 MW			

The objectives and issues associated with pumped-energy transfer stations (STEP) are discussed in the section on storage.

Onshore wind farms

Measures to supplement cross-sector measures

- Prioritise the use of tenders to support the sector by reducing the scope of the open-window system to small-size equipment stocks developed in restricted areas and citizen stocks.
- Maintain a stable regulatory framework for the authorisation of equipment stocks, simplify this framework if possible and enable reasonable development periods for project drivers, while ensuring that the environmental stakes are appropriately considered and the impacts on the environment and neighbouring populations are managed.
- Make it mandatory by 2023 to recycle materials used in producing wind farm components once they are decommissioned.
- Promote the reuse of wind farm sites at end-of-life for the installation of more efficient machines.
- Launch the trialling of innovative solutions to reduce light pollution while protecting the safety of aircraft, and make it possible to plan for new systems that could be approved in early 2021.
- Draft a protocol to measure the level of noise generated by wind farms precisely and indisputably.
- Ensure the general application of the principle of total excavation of the turbine foundations during decommissioning and increase the amount of financial guarantees to take account of new technologies.
- Introduce a mechanism to ensure that the development of wind power is more balanced nationally and avoid the risks of saturation. Proposals will be made in 2020.

Tenders will be launched up to 1,850 GW/year (excluding repowering) according to the following schedule, up to 500 MW to 925 MW per period.

2019				2020				2021				2022				2023				2024			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0.5 GW	0.5 GW	0.6 GW		0.75 GW		0.925 GW		0.925 GW		0.925 GW		0.925 GW		0.925 GW		0.925 GW		0.925 GW		0.925 GW		0.925 GW

Photovoltaic power

Measures to supplement cross-sector measures:

- Promote ground installations on urbanised or degraded land, or parking areas, to enable the emergence of less costly projects while continuing to apply the strict requirements in relation to agricultural land and the absence of deforestation.
- Preserve the reclamation of degraded land, which makes it possible to limit the usage of natural areas.
- Implement the measures adopted on 28 June 2018 following the outcomes of the solar working group, including the following in particular:
    - Facilitate the development of photovoltaic power for the Ministries, public institutions (SNCF, ports, etc.) and owners of developed sites (large-scale distributors, logistics, etc.).
    - Facilitate the development of photovoltaic power on parking lots (simplification of urban planning measures for parking shelters).
    - Support local authorities, in particular through the 'Villes solaires' network.
    - Enable a better integration of solar power into the French landscape.
- Adopt the following tender schedule corresponding to 2 GW per year for photovoltaic plants on the ground and 0.9 GW per year for installations on large roof areas.
- Maintain a target of 300 MW installed per year for installations on small and medium-sized roofs (smaller than 100 kWp), guiding projects towards self-consumption; boost the development of projects over the 100–300 kWp tranche by making them eligible for the open-window system; and accelerate the development of projects on large roof areas (> 300 kWp).
- Support innovation in the sector through tenders, to encourage the emergence of innovative solutions, in particular agrivoltaic projects that generate real synergies between agricultural production and photovoltaic energy, maintaining current tender volumes (140 MW/year).

The following schedule shows the quarters when a tender will be launched for ground plants up to 1,000 MW per period.

2019				2020				2021				2022				2023				2024			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	850 MW		850 MW	850 MW	1000 MW		1000 MW		1000 MW		1000 MW		1000 MW		1000 MW		1000 MW		1000 MW		1000 MW		1000 MW

The following schedule shows the quarters when a tender will be launched for large roof installations up to 300 MW per period.

2019				2020				2021				2022				2023				2024			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

300 MW	300 MW		300 MW	300 MW	300 MW	300 MW		300 MW	300 MW	300 MW		300 MW	300 MW	300 MW		300 MW	300 MW	300 MW		300 MW	300 MW	300 MW			

Generation of electricity from bioenergy

Measures to supplement cross-sector measures

- Given the cost of generating electricity from biomass, to optimise the total cost of achieving the targets for renewable energies and to promote the greatest possible energy efficiency, support to these sectors will be reserved for heat generation. No biomass cogeneration tenders will be launched over the Multiannual Energy Plan (MEP) period.
- Open a tariff window for anaerobic digestion installations between 0.5 MW and 1 MW for which injection into the network is not possible or is too costly. Above that value, anaerobic digestion installations must focus on injecting biomethane into the network.
- Intensify improvements in the energy efficiency of energy recovery units for domestic waste, undertake a specific action on a dozen or so incinerators without energy recovery and go beyond the energy efficiency criterion applied to the existing units.
- Extend the call for projects on recovered solid fuels for ADEME.

Offshore wind farms and renewable marine energy

Measure: launch the following tenders corresponding to offshore wind farms with ceiling prices €10 to €20/MWh above the target prices.

Date of award of the tender	**2019**	**2020**	**2021**	**2022**	**2023**	**> 2024**
Floating wind turbine 750MW			250 MW *Southern Brittany* (€120/MWh)	2 x 250 MW *Mediterranean* (€ 110/MWh)		1,000 MW per year, fixed-foundation and/or floating, depending on the prices and bearing, with target tariffs converging towards the market price for fixed-foundation turbines.
Fixed-foundation wind turbine 2.5 to 3 GW	600 MW *Dunkirk* (€ 45/MWh)	1,000 MW *Eastern Channel - North Sea* (€60/MWh)*	500–1,000 MW *Southern Atlantic*** (€ 60/MWh)		1,000 MW (€ 50/MWh)	

Schedule of tenders for offshore wind farms (the dates indicated are the dates on which a winner will be selected, at the end of the competitive dialogue procedure).

When a new project is launched, the Government will plan in all cases for the implementation of an extension and the introduction of a pooled connection. The projects awarded from 2024 onwards will relate in particular to extensions to previous offshore wind farms, with a pooled connection.

In terms of tidal turbines, no financial support is planned within the period covered by the MEP, but the Government will nonetheless be watching progress in the sector.

Geothermal electricity

Given the cost of generating electricity from geothermal energy, to optimise the total cost of achieving the targets for development of renewable energies, support to the geothermal sector will be focused on heat generation. Electricity generation projects for which an eligible request for additional remuneration has been made will be supported. Innovative projects, especially those coupled with the production of lithium, will be supported where applicable as part of R&D mechanisms.

3.1.2.7. Cost for supporting renewable energies

Support for renewable heat generation

The costs for supporting the Heat Fund and the CITE already take into account the changes announced in relation to the carbon component. This has already been taken into account in estimating the budgetary requirements.

Heat Fund

The Heat Fund has been allocated an amount of €1.9 billion for the 2009–2017 period in legal commitments. As highlighted by the Court of Auditors, this is an efficient mechanism with an average grant rate of €4/MWh generated, thus approximately €16/tCO_2 avoided, and a significant leverage effect (€1 of the Heat Fund for €3 of investment).

In 2017, Heat Fund grants corresponded to budgetary support of:

- €1/MWh for residual heat recovery;
- €4/MWh for wood support;
- €7/MWh for geothermal energy;
- €8/MWh for heating networks;
- €11/MWh for regional, financial renewable energy contracts (clusters of small projects concerning a single owner or a single area);
- €33/MWh for solar thermal (roofs and major surfaces).

On the basis of the targets set in Scenario B of the 2028 MEP, the budget for the Heat Fund was reviewed for 2019, resulting in an annual budget of €307 million, and then €350 million from 2020. The trajectory of the Heat Fund may be reviewed from 2021 to offset the freezing of the carbon tax (Contribution Climat Energie, CCE). As an indication, if the annual budget for the Fund had been kept at €350 million for the period after 2020, the cumulated requirement for the 2018-2028 period would be €3.46 billion.

Energy transition tax credit (CITE)

To achieve the objectives laid down in the MEP, the CITE and the MaPrimeRénov' will contribute up to €800 million per year earmarked as support for equipment used to generate renewable heat.

Reduced VAT rate for heating networks

The following table shows the cost for the public purse of the reduced VAT rate for district heating and cooling systems where the 50% renewable energy threshold is reached. This estimation takes into account the targets set for the networks at the deadlines set in the MEP:

2016 base year	2017-2023	2023-2028 low option	2023-2028 high option
55	65	70	75

Cost for the public purse of the reduced VAT rate for heating networks (€ millions)

Support for renewable electricity generation

The Government pays the differential between the sales price for electricity and the cost borne by the various sectors. The budgetary cost must therefore be assessed on the basis of the forecast costs for the various sectors and the projected changes in the sale price for electricity generated by renewable energies. For each sector, the prospects for cost changes expected are presented and followed by an assessment of the budget amount for support. That amount can be broken down into costs incurred for prior government commitments and new costs for supporting new capacity.

The public support costs have been calculated on the basis of the targets stated in Scenario A of the MEP. This is the budget that will be allocated by the Government to the development of renewable energies in order to achieve these targets. In the case of a higher reduction in costs, the budget allocated will make it possible to achieve the targets stated in Scenario B of the MEP.

The costs already incurred correspond to tenders awarded, contracts signed before 31 December 2018 and projects with the right to a purchase obligation that have submitted a request to an obligated purchaser. This does not therefore relate to the systems and equipment installed as at 31 December 2018, but to a broader series of installations: indeed, depending on the technologies, installations begin to generate between two and four years after the contract is signed.

Two electricity price scenarios have been analysed to estimate the costs for public support for the development of renewable electricity. These two prices reach €56/MWh and €42/MWh respectively in 2028 for the average market price, and are stable after 2030. The average sale prices for electricity generated by renewable electricity generation facilities are the following, for the principal pathways:

	2023	2028
Market price	€44/MWh	€ 56/MWh
Sale price for wind power	€ 38/MWh	€ 46/MWh
Sale price for photovoltaic power	€ 37/MWh	€ 43/MWh
Sale price for offshore wind power	€ 40/MWh	€ 48/MWh

Assumptions for average sale prices for electricity generated by the principal renewable energy pathways, for a scenario at €56/MWh in 2028

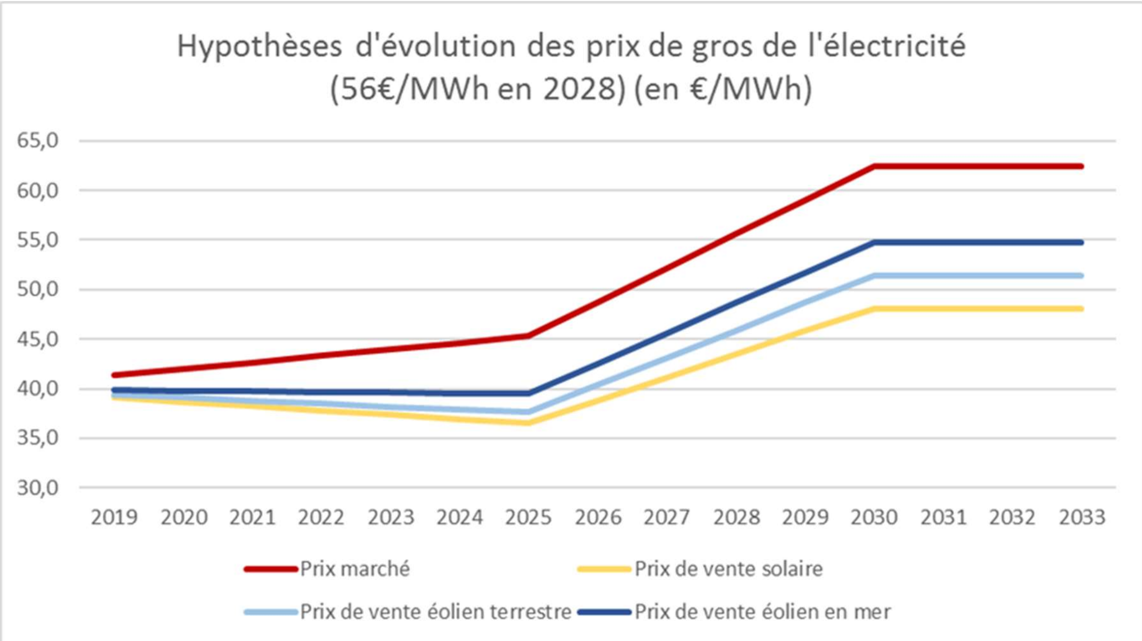
	2023	2028
Market price	€ 40/MWh	€ 42/MWh
Sale price for wind power	€ 34/MWh	€ 33/MWh

Sale price for photovoltaic power	€ 34/MWh	€ 30/MWh
Sale price for offshore wind power	€ 36/MWh	€ 36/MWh

Assumptions for average sale prices for electricity generated by the principal renewable energy pathways, for a scenario at € 42/MWh in 2028

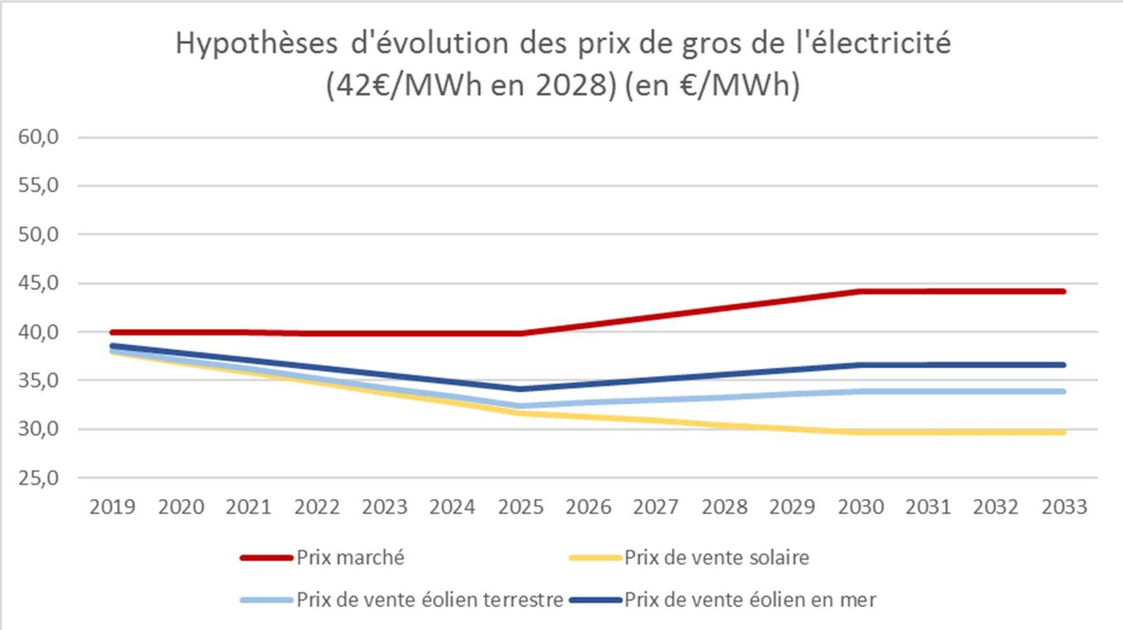
The average sale prices for electricity generated by renewable electricity generating installations for the above-mentioned pathways are lower than the average prices for electricity on the markets, because of the correlation of electricity generation for installations within a given pathway. For example, solar electricity generation occurs at the same time of day for all installations, and the increase in installed capacity by 2028 will result in a drop in the market price for electricity over those hours, reducing the average price received by the installations. A haircut has therefore been applied in relation to the average market price, to calculate the public support for generation installations. These evaluations therefore result in the following price trajectories in the two scenarios above:

Figure 17: Assumptions for average sale prices for electricity generated by the principal renewable energy pathways, for a scenario at €56/MWh in 2028



Hypothèses d'évolution des prix de gros de l'electricité (56 €/MWh en 2028) (en €/MWh)	Assumptions for changes in wholesale electricity prices (€56/MWh in 2028) (in €/MWh)
Prix marché	Market price
Prix de vente solaire	Solar sale price
Prix de vente éolien terrestre	Onshore wind sale price
Prix de vente éolien en mer	Offshore wind sale price

Figure 18: Assumptions for average sale prices for electricity generated by the principal renewable energy pathways, for a scenario at € 42/MWh in 2028



Hypothèses d'évolution des prix de gros de l'electricité (42 €/MWh en 2028) (en €/MWh)	Assumptions for changes in wholesale electricity prices (€ 42/MWh in 2028) (in €/MWh)
Prix marché	Market price
Prix de vente solaire	Solar sale price
Prix de vente éolien terrestre	Onshore wind sale price
Prix de vente éolien en mer	Offshore wind sale price

The estimations made have been approved by the Management Committee for Public Electricity Service Charges, which decided to add some variants, in particular based on the feed-in tariffs to be obtained in the tenders.

Onshore wind

	2023	2028
Generation cost for new installations	€ 68/MWh	€ 58/MWh
Cost already committed	€21.3 billion	
Additional cost linked to the targets set in this MEP	€3.9 to 4.0 billion	€3.6 to 9.0 billion
Total	€28.7 to 34.2 billion	

Assumptions and budget costs linked to support for wind power (€ billion) for an electricity price of €56/MWh in 2028

It should be noted that for this pathway, a certain number of installations will cease to be subject to the purchase obligation during the period of application of the MEP. It is assumed that these installations will continue to generate for some years (at least five) without support.

Photovoltaic

	2023	2028
Generation cost for new PV ground installations	€ 60/MWh	€ 50/MWh
Generation cost for new PV installations on large roofs	€ 73/MWh	€ 60/MWh
Cost already committed	€39.1 billion	
Additional cost linked to the targets set in this MEP	€4.5 to 5.1 billion	€1.7 to 6.7 billion
Total	€45.3 to 51.1 billion	

Assumptions and budget costs linked to support for photovoltaic power (€ billion) for an electricity price of €56/MWh in 2028

The support costs for this pathway depend to a large extent on how they are distributed among the various segments: ground, large roof, small roof. The assumption applied in the modelling corresponds to the assumption used in the tender schedule provided in the section on renewable electricity. In particular, 60% of capacity will be developed on the ground.

Bioenergy: biomass and anaerobic digestion

	2023	2028
Cost already committed	€6.8 billion	
Additional cost linked to the targets set in this MEP	€ 0	€ 0
Total	€6.8 billion	

Budget costs linked to support for biomass (€ billion) for an electricity price of €56/MWh in 2028

	2023	*2028*
Generation cost for new installations	*€ 200/MWh*	*€ 200/MWh*

Cost already committed	*€4.6 billion*	
Additional cost linked to the targets set in this MEP	*€0.7 billion*	*€1.2 billion*
Total	*€6.5 billion*	

Budget costs linked to support for anaerobic digestion (€ billion) for an electricity price of €56/MWh in 2028

Offshore wind farms and renewable marine energy

	2023	2028
Cost already committed	€21.9 billion	
Additional cost linked to the targets set in this MEP	€0 billion	€3.0 to 5.9 billion
Total	€24.9 to 27.7 billion	

Budget costs linked to support for offshore wind farms and renewable marine energy (€ billion) for an electricity price of €56/MWh in 2028

Geothermal electricity

	2023	2028
Cost already committed	€0.5 billion	
Additional cost linked to the targets set in this MEP	€ 0	€ 0
Total	€0.5 billion	

Budget costs linked to support for geothermal energy (€ billion) for an electricity price of €56/MWh in 2028

Support for the generation of injected biogas

The support costs for injected biogas have been calculated on the basis of the generation costs indicated in the following table, making it possible to achieve 7% renewable gas in 2030. A higher decrease would make it possible to reach 10%. If generation costs do not fall as much as expected, the rate of construction of new generating capacity will be adapted.

	2023	2028
Generation cost for new installations	€ 75/MWh	€ 60/MWh
Cost already committed	€2.8 billion	
Additional cost linked to the targets set in this MEP	€2.5 billion	€4.4 billion
Total	€9.7 billion	

Budgetary costs linked to support for injected biogas (€ billion)

3.1.3. Other elements of the dimension

3.1.3.1. Where applicable, national policies and measures affecting the EU ETS sector and assessment of the complementarity and impacts on the EU ETS

The national policies and measures affecting the EU ETS sector are the following:

- **measures to support renewable energies (in particular: tenders from the Energy Regulatory Commission, Heat Fund);**
- **measures promoting energy efficiency (in particular: energy transition tax credit, white certificates).**

These measures contribute to reducing electricity consumption by private individuals (especially during winter, when the most carbon-intensive production methods are used) and by industry, and to reducing emissions in the sectors subject to the ETS. They may be complementary to the ETS to the extent that the sale of allowances saved because of a reduction in emissions is not always enough to ensure that low-carbon investments are profitable. It is for this reason, for example, that the white certificates mechanism was extended to cover installations subject to the ETS in 2019.

However, the measures could accentuate the allowances surplus in the EU ETS. The introduction of the market stability reserve in 2019 will make it possible to limit this effect.

3.1.4. Policies and measures to achieve other national targets, where applicable

The following policies and measures may also contribute to achieving the EU's objectives and the targets of the Energy Union.

3.1.4.1. Consistency between attenuation and adaptation

In areas where adaptation and attenuation are strongly interlinked (such as forestry, energy consumption and generation), the possible co-benefits and compromises must be identified. This process is scheduled to be completed in 2019-2021, with the aim of providing information for the review of the next National Low-Carbon Strategy (SNBC) and the National Adaptation Strategy.

3.1.4.2. Regional coordination of the adaptation policy in Metropolitan France and in

overseas territories

The planning tools such as the convergence plans, Government-Region planning contracts, the blue book for overseas territories and the regional forest and wood programmes, but also the local planning documents specific to each overseas territory, will include actions to promote adaptation to climate change. Through the mobilisation of appropriate financial tools, the aim of these actions will be to strengthen the development and maintenance of infrastructures, the search for and improvement in knowledge regionally and across borders, and the preservation of natural environments and resources and the ecosystems they contain.

3.1.4.3. Forest and brush fires

The Government and public institutions such as the National Forests Office will ensure, by mobilising all stakeholders involved in forest management and in particular the competent local authorities, that forest management is adapted gradually in line with the foreseeable increase in fire risks in terms of the frequency of occurrences and the surface areas concerned in Metropolitan France and in overseas territories.

Consistency will be guaranteed between the potential for attenuation and adaptation of forest management and conservation policies and policies for the recovery and recycling of wood and biomass. The aim is to contribute to reducing the risk of fires and to increasing resilience to that risk, as fires have a very negative effect on the carbon footprint of forests and the resilience of ecosystems.

3.1.4.4. Soils

Soils contribute to atmospheric carbon sequestration. As part of the Biodiversity Plan, the Ministry for Ecological and Inclusive Transition (MTES) will limit anthropogenic development and soil sealing, seeking ultimately to stop these phenomena, using the various tools that can be mobilised nationally as part of land-use planning (e.g. regional consistency plans, local intermunicipal development plan) or a project (e.g. modification of practices, reuse of wastelands after recovery), and will study the possibilities for returning to nature, or indeed recultivating, developed lands (e.g. pollution clean-up, recovery of industrial wastelands).

3.1.4.5. Forest

The MTES and the Ministry of Agriculture and Food (MAA) will promote sustainable forestry management, taking into account changes in local climate parameters, impacts already recorded and studies of vulnerability and giving forests the greatest possible chance to cope with those factors and to continue to stand in the long term. The entire diversified range of silviculture techniques and tree species in the forests, such as free development or active management, will be used in the light of the expertise and forecasts, to guarantee genetic diversity in the long term and thus preserve future options.

3.1.4.6. Laws, codes, standards and technical regulations

The technical references will be reviewed by the competent departments and adapted as necessary, giving priority to the sectors of infrastructures and transmission system equipment (reliability and climate comfort), energy infrastructures and construction. Once new references are established, such as the cross-sector standard relating to adaptation currently being drafted internationally, they will be incorporated into the existing labels and considered in the technical or legal standards and regulations, applying the approach based on simplification and predictability initiated by the Government in order to establish a context favourable to adaptation.

The framework will be adapted gradually to climate change to promote resilience to natural and health risks within an urban planning context that incorporates such change, in particular by using existing labels or indeed regulatory methods.

3.1.5. Policies and measures to achieve low carbon emission mobility (including electrification of transport)

3.1.5.1. Policies and measures planned

The **Clean Mobility Development Strategy (SDMP)** is an annex to the Multiannual Energy Plan (MEP). It falls within the context of the framework law on mobility, adopted on 19 November 2019, which radically reformed the general system governing mobility policies. The first strategy, published in 2015, covered the 2016–2018 period. The second strategy will be published with the revised MEP in 2019. It describes the guidelines and actions planned in the 2019–2023 and 2024–2028 periods for the development of clean mobility, with the aim of complying with France's targets and commitments in preventing global warming and reducing energy consumption.

The guidelines and avenues for action described in the SDMP result primarily from the national dialogue taking place during the National Conference on Mobility held from September to December 2017. The draft framework law on mobility will be the preferred vector for implementation of these actions. Other strategies and action plans have also been used to draft this document, in particular the Climate Plan, the Hydrogen Plan, the Strategic Contract for the Automobile Sector for 2018–2022, the Bicycle and Active Mobility Plan and the commitment for the deployment of low-emission zones.

The principal guidelines and avenues for action covered in the SDMP are the following:

Enabling all regions to have access to alternative mobility services other than the individual use of a car and to unleash innovation

- Making clean mobility accessible to everyone, providing each area with a mobility authority (AOM) and expanding the role of the AOMs to cover active or shared mobility and social mobility services. This means giving everyone their choice of mobility, offering our fellow citizens a more diversified, more effective, more connected and more shared range of services throughout the nation.
- Facilitating the trialling and roll-out in sparsely populated areas of new mobility solutions, and the circulation on public roads of autonomous vehicles on the basis of an appropriate legislative and regulatory framework.

Managing demand for mobility

- Encouraging the optimisation of travel by reinforcing the role of employers and coordination of the actions of local authorities using mobility plans.
- Promoting more virtuous behaviour, in particular through the deployment of low-emission zones in conurbations and valleys where air quality is a concern.

Developing low-emission vehicles (including river and sea vessels and aircraft) and improving the energy efficiency of equipment stocks, relying on the alternative fuels market

- Relying on purchase and tax incentives to achieve the ambitious targets set for the low-emission vehicle market (bonus/penalty, conversion bonus), supporting all communities.
- Setting minimum incorporation rates for low-emission vehicles for upgrading public (in accordance with the European Directive on clean vehicles in public procurement) and private fleets and ensuring that these targets are met.
- Supporting this development through the deployment of alternative fuel distribution infrastructures: roll-out of electric recharging stations (including the 'right to plug') and gas stations (NGV) and hydrogen stations.

- Promoting energy efficiency of domestic river and sea transport and achieving carbon neutrality, enabling the distribution of low-carbon energy in all French ports and facilitating the switch to other low-carbon technologies (batteries, biofuels, hydrogen, sail, etc.).
- Limiting the impact of air transport on climate change by targeting substantial energy efficiency improvements and a very significant switchover from fossil fuels to biofuels (50% in 2050).

Promoting modal shifts for passenger transport

- Developing multi-modal mobility as a result of the accelerated opening of data and the possibility for the stakeholders to offer a journey planning and ticket payment service integrating all links for the same journey.
- Boosting the share of active modes in daily mobility by implementing the bicycle and active mobility plan, including: creating an active mobility fund of €350 million over seven years, making cycling safer (secure parking, anti-theft tagging of bicycles, bike box at traffic lights, etc.), creating incentives (grants for sustainable mobility) and making it more accessible (cycling proficiency).
- Developing public, shared and cooperative modes of transport by investing in rail infrastructures, in public transport, in clean mobility through calls for projects and by encouraging the use of shared transport modes thanks to a sustainable mobility grant and dedicated lanes.

Promoting efficiency in freight transport and modal shifts towards river routes and railways

- Streamlining urban logistics by taking this into account in planning documents and by overseeing the activity of digital platforms.
- Developing mass modes for freight by increasing investment in mass transport infrastructures (railways, river routes and ports).

Adopted in December 2019, the Mobility Law15 (LOM) introduces several measures and targets intended to realise these various targets.

3.1.5.2. SNBC guidelines

The SDMP lays down the guidelines for the transport sector up to 2028. In the longer term, SNBC 2 defines the following guidelines for this sector:

- ✓ **providing the sector with incentivising price signals;**
- ✓ **setting clear, consistent targets with targeted objectives for the energy transition of equipment stocks;**
- ✓ **supporting fleet changes for all transport modes;**
- ✓ **supporting local authorities and companies in implementing innovative initiatives;**
- ✓ **encouraging modal shifts by supporting active mobilities and mass public transport modes (freight and passengers) and developing intermodality;**
- ✓ **controlling the increase in transport demand.**

[15] https://www.ecologique-solidaire.gouv.fr/loi-mobilites-0

3.1.6. Where applicable, national policies, schedules and measures planned to phase out energy subsidies, in particular for fossil fuels

There are no subsidies for fossil energies in France in the true sense of the term. The carbon component in the energy taxation system currently in place (see Section 3.1.1) increases the prices of fossil energies on the basis of their carbon content.

However, certain sectors are subject to reductions in rates for the energy consumption tax (TICPE). This is the case in particular for road freight transport, agriculture and fisheries, and energy-intensive industries otherwise subject to the ETS system. Aviation and international maritime transport are also subject to exemptions on the basis of international agreements. These 'tax loopholes' are considered to be fossil energy subsidies according to the definition applied by the OECD.

The identification of these tax expenditures is monitored as part of the preparation of finance laws (report relating to the interministerial task force on 'Energy Transition' for the draft financial law[16]). Furthermore, a recent report from the Compulsory Levies Board[17] carried out a detailed review of this subject.

The following table shows the primary tax expenditures that are environmentally harmful:

Tax expenditures relating to reduced tax rates for fossil energies	**€ million**
Road haulage	1361
Road passenger transport	219
Internal waterways transport	48
Transport by taxi	58
Non-road diesel (other than for agricultural use)	1000
LPG used as non-road fuel	75
Non-road diesel, heavy fuel oil, natural gas and agricultural LPG	1057
Energy-intensive installations subject to the ETS system	903
Energy-intensive installations performing an activity considered to be exposed to a significant risk of carbon leakage	49
Companies recovering biomass	32
Fuels used for aircraft and ship test engines	27

The tax loopholes are subject to reductions under the most recent finance law. The TICPE rate for road freight transport has therefore been increased by €0.02/l (from €00.4319 to €00.4519/l). The TICPE on non-road diesel used in particular by construction machinery, which is currently €00.1882/l, will match the tax rate on ordinary gas oil by 2022 (€00.5940/l). Because it is not possible to directly increase the tax rate on jet fuel for international flights because of the applicable international aviation agreements, France has instead chosen to introduce a tax on airline tickets based on the distance travelled.

Continued elimination of tax loopholes is desirable, but for sectors subject to international competition, it would seem more appropriate for carbon pricing to be handled effectively at European and

[16] https://www.performance-publique.budget.gouv.fr/sites/performance_publique/files/farandole/ressources/2020/pap/pdf/jaunes/Jaune2020_transition_ecologique.pdf

[17] https://www.ccomptes.fr/fr/publications/la-fiscalite-environnemental-au-defi-de-lurgence-climatique

international level for certain sectors. Indeed, tax convergence in Europe would make it possible to remedy this problem.

France also supports international actions within the ICAO and the IMO in favour of increased carbon taxation in the aviation and maritime sectors.

3.2. Energy efficiency

3.2.1. National energy efficiency obligation scheme and alternative policy measures in accordance with Articles 7-bis and 7-ter of Directive 2012/27/EU, to be prepared in accordance with Annex II

In accordance with Article 7(1) of Directive 2012/27/EU, France will use the White Certificates (WC) mechanism to fulfil its energy efficiency obligation for the period from 1 January 2021 to 31 December 2030.

3.2.1.1. Description of the energy efficiency obligation scheme

The White Certificates (WC) mechanism, created in 2005 and governed by Articles L. 221-1 et seq. of the Energy Code, is a key tool in French policy relating to the management of energy demand.

WCs (1 WC = 1 kWh cumac[18] final energy) are awarded by the Ministry of Energy to eligible stakeholders (obligated entities but also other non-obligated legal persons, such as local authorities, housing associations, etc.) that have undertaken energy-saving operations in line with certain criteria set by decree. These WCs can be freely exchanged.

There are two methods for obtaining WCs: standardised operations and specific operations.

Fact sheets on standardised operations, defined by decree, are prepared for the most common operations, to facilitate implementation of energy saving actions. These are classified by sector (residential, tertiary, industrial, agricultural, transport, networks) and set out the lump-sum energy saving amounts in kWh cumac and the life cycle of the operations. These operations correspond to 'expected savings' and are updated regularly. The list of standardised operation fact sheets is available online.

These standardised operation fact sheets are developed by groups of thematic experts, coordinated by the Technical Association for Energy and the Environment (ATEE) and bringing together the various stakeholders. The fact sheets are then appraised by ADEME, and validated by the Ministry of Energy.

The specific operations make it possible to recognise energy savings achieved in non-standardised operations. These correspond to infrequent operations that cannot be standardised, in particular as regards defining a lump sum value for the volume of WCs to be issued. This concerns 'estimated savings'.

The applicant must follow six steps for a specific operation:

[18] The term 'cumac' is an abbreviation for 'cumulative' and 'recalculated' in French. Thus, for example, the number of kWh cumac saved following the installation of an energy efficient appliance corresponds to the cumulative total of the energy saved each year during the appliance's life cycle. In addition, the energy savings each year after the first are recalculated by dividing the previous year's savings by 1.04 (4% recalculation rate).

- carry out an energy audit;
- establish the situation before the operation;
- determine the baseline situation and justify the choice made;
- determine the projected situation after the operation, including theoretical before-and-after energy balance sheets;
- justify the amount of certificates requested and in particular the choice of the equipment life cycle;
- justify the calculation of the timeline for return on investment (TRI).

ADEME and the National White Certificates Office ensure that the energy savings requested are valid and accurate.

The White Certificates mechanism is described in detail in the National Energy Efficiency Action Plan (PNAEE) sent to the European Commission in 2017[19].

3.2.1.2. Expected cumulative and annual volume of savings and duration of the obligation period(s)

The first three periods have been marked by a significant ramping-up of the targets: 54 TWhc for 2006–2009 and then 447 TWhc for 2011–2014 and lastly 850 TWhc for 2015–2017, including 150 for households experiencing fuel poverty (this new obligation was introduced from 1 January 2016 by the Law on Energy Transition for Green Growth. The mechanism is currently in its fourth period. The Decree of 9 December 2019 amending the provisions of the regulatory section of the Energy Code relating to White Certificates extended the current period of one year (now 2018–2021) and increased the WC target for the fourth period to 2,133 TWh cumac, including 533 TWh for households experiencing fuel poverty.

The cumulative volume of energy savings expected by the WC mechanism for the 2021–2030 period will be at least equal to the volume of the energy savings obligation as stated in Section 2.2.2 of this report for the 2021–2030 period under Article 7 of Directive 2012/27/EU. The periods covered by the obligations will have a term of three to four years.

3.2.1.3. Obligated parties and their responsibilities

The WC mechanism is based on a three-year obligation imposed by the public powers on energy sellers (electricity, gas, fuel oil, fuel, etc.), classified as ‘obligated’, where their energy sales exceed certain thresholds set by the regulatory provisions.

When requesting certificates, obligated sellers must show that they have played an active and encouraging role. To prove this, they must be able to produce the following, if checks are required:

- a description of the applicant’s active and encouraging role;
- evidence that the contribution is direct and was made before the operation started;
- a sworn declaration signed by the beneficiary of the energy efficient operation stating the applicant’s active and encouraging role in its execution.

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[19]Website: https://www.ecologique-solidaire.gouv.fr/sites/default/files/PNAEE%202017.pdf

At the end of the obligation period, obligated energy sellers must prove that they have fulfilled their obligations, demonstrating that they hold certificates in an amount equivalent to those obligations. If they fail to do so, a deterrent penalty must be paid.

3.2.1.4. Target sectors

The aim of the WC mechanism is to mobilise potential energy savings, in particular in sectors where these are the most widespread. The WC mechanism therefore concerns all sectors: residential, tertiary, industry, transport and agriculture.

3.2.1.5. Eligible actions provided for under the measure

In accordance with Section 2 of Chapter I of Title II of Book II of the Energy Code, the awarding of WCs complies with two broad principles in order to ensure that the mechanism does indeed represent an additional tool:

- White certificates may only be issued for actions that go further than the rules in force at the beginning of the period.
- The baseline situation for calculation of the lump-sum energy savings corresponds to the technical and economic state of the market for the product or service on the most recent date for which data are available, integrating the effect of regulatory changes (in particular EU regulations on the ecodesign of energy-related products). In the case of work to improve the heat performance of the outer walls of an existing building or its in-built heating system, the baseline situation for energy performance takes into account the general state of buildings of the same type and the level of performance of the material or equipment used on the most recent date for which data are available.

When a person undertakes action under a specific operation aimed at saving energy, that action may only be taken into account for the issuing of white certificates if the savings made take longer than a minimum period of return (three years) to offset the cost of the investment.

3.2.1.6. Alternative policy measures in accordance with Articles 7-bis and 7-ter of Directive 2012/27/EU

At this stage, France is not planning to use alternative policy measures as permitted by Articles 7-bis and 7-ter of Directive 2012/27/EU for the 2021–2030 period.

3.2.2. Decrease in final energy consumption – General approach

Cross-sector measures to reduce final energy consumption:

- Set the target in 2020 for the next five years of the White Certificates (WC) mechanism on the basis of an analysis of potential energy savings.
- Support an ambitious, effective European policy on the ecodesign of energy-related products, and energy labelling of these products.
- Promote a European floor price for carbon, the setting of a carbon price for all sectors outside the European carbon allowance system, which is a single price at the borders of the European Union (carbon inclusion mechanism), compatible with the rules of the World Trade Organisation, intended to prevent carbon leakage effectively.

- Supplementary measures must be put in place, relying in particular on the activities of the new governance bodies introduced in 2019 to obtain similar effects to the carbon component.

The measures have been adopted on the basis of the estimates used in the baseline scenario. If the economic situation develops differently, with those measures unchanged, total final energy consumption could increase up to 24 TWh in 2028, thus an increase of 1.7% in consumption (compared to the baseline scenario). The Government will monitor changes in consumption and will assess whether the expected targets are being met. It will supplement the measures in place as required with additional policy measures in order to achieve the target set.

3.2.2.1. Building sector: residential and tertiary

Measures to reduce energy consumption in buildings:

- Implementation of the Building Energy Renovation Plan.
- Undertake actions to eradicate inefficient homes (energy sieves) (diagnosed as having F or G performance) in three phases (Law No 2019-1147 of 8 November 2019 on energy and climate):
    - A first incentive phase in anticipation of a mandatory energy audit prior to the sale or lease of an inefficient home beginning in 2022. This audit will contain renovation proposals and estimated costs, and will inform the prospective buyer or lessee of future energy costs.
    - A second phase will take effect before 2028 requiring owners of inefficient homes to undertake renovations that will improve their home's energy performance.
    - A third phase will be implemented in 2028 to fine property owners if they do not comply with the obligations to renovate inefficient homes.

For public buildings:

- Set up a task force aimed at accelerating the renovation of school buildings. Educational buildings (school, middle school, high school) represent around 50% of the building stock of local authorities. Public action on this segment of the stock also involves raising awareness of the energy savings implications for new generations.
- As part of the 2018–2022 Major Investment Plan, the following financing tools, up to €3 billion, are available to local authorities for the energy renovation of their buildings:
    - €2 billion in subsidised loans from Caisse des Dépôts;
    - €0.5 billion invested in equity by Caisse des Dépôts in large capital projects or to support innovative economic models;
    - €0.5 billion from the local investment support budget (DSIL).
- Starting from 1 January 2020, forbid the purchase or heavy repair of fuel oil boilers in Government buildings, and plan the end of all fuel oil use in Government buildings (excluding operational issues) by 2029.
- Release as open data the list and/or map of buildings belonging to the Government, including specifications of floor area and type of energy used for heating. All willing public bodies (local authorities, hospitals, etc.) could also be invited to join in this measure.
- Implement a building renovation plan for 39 administrative units in France.

For professionals:

- Work with building and real estate professionals, NGOs, local authorities and energy companies, under the FAIRE banner, to better identify the relevant renovation solutions for households, to trigger more action by enhancing household knowledge and confidence, and to better coordinate the existing grants and financing.

- Finalise and implement the new environmental regulations for buildings, in particular by:
    - making a minimum renewable heating rate obligatory;
    - incorporating a criterion on greenhouse gas emissions in operation and over the entire life cycle of the building;
    - reinforcing standards in terms of energy performance, with the inclusion of stipulations for comfort in the summertime.

  The new regulations will result in a suitable updating of the conversion factors for converting electricity into primary energy and the emission coefficient for electricity for heating currently used in regulations governing new buildings (RT2012, Label E+C-, RE2020):
    - The conversion factor for converting final energy into primary energy for electricity will be fixed at 2.3, a value calculated by averaging values over 50 years, taking into account the electric mix diversification targets set by law.
    - The electricity emission factor will be determined using the monthly usage method, which results in a value of 79 gCO_2/kWh for electric heating.
- For tertiary buildings, monitor the application of energy efficiency obligations for existing tertiary buildings, which aim to achieve a 40% reduction in their energy consumption by 2030 compared with 2010, focusing on buildings over 1,000 m² in all business sectors.

For private individuals:

- Make the energy transition tax credit (CITE) and its replacement MaPrimeRénov' more effective through:
    - a new fixed-rate scale in 2020, which will take into account the energy efficiency of actions;
    - payment of the corresponding benefits by the ANAH when the renovation work is performed; the grant rate will be increased for low-income households, so that public support really triggers the actions needed to escape fuel poverty;
    - extension of these payments to cover owners-lessors in 2021, and the simplification of the request process for multiunit collective renovation projects.
- Expand the use of the recently simplified ecoPTZ (zero-rate eco-loan), which can now apply, using a flat-rate grant, to single-action projects (e.g. installation of a central heating system powered by renewable energy without requiring a series of work projects).
- Keep the VAT rate at 5.5% for energy renovation work eligible for the CITE and related works.
- Provide more information for households about the energy performance of their homes and renovation work to be undertaken. In this regard, cofinance, by means of the MaPrimeRénov' and the SARE programme (service to support energy-efficiency works), the provision of advice and home diagnosis in particular for low-income households owning 'thermal sieve' dwellings (diagnosed as having F or G performance), and support comprehensive renovations of dwellings (Habiter Mieux Sérénité programme).

Box 3: Building Energy Renovation Plan

The Building Energy Renovation Plan makes energy renovation a national public priority. In particular, it authorises or provides for the following:

- creation of a guarantee fund of up to €50 million to help 35,000 low-income households each year;
- simplification of the incentives for all French people, making the tax credit a lump-sum payment and adapting the existing zero-rate eco-loan;
- increased reliability of energy labels for homes and energy efficiency diagnosis, to increase confidence;
- better training for professionals and better monitoring of the quality of works, with a review of the RGE label (French environmental sustainability label);
- promotion of a large-scale renovation programme in public buildings managed by the Government and local authorities, with a budget of €4.8 billion.

3.2.2.2. Transport sector

Principal measures to supplement cross-sector measures:

- Maintain the conversion bonus to continue the replacement of a large number of old vehicles with new or used vehicles with much lower emissions: the bonus is doubled in 2019 for lower income households and working people under the taxation ceiling who have long journeys to and from work, and it is higher to make conversion to a rechargeable hybrid or electric vehicle more attractive. The objective is to reach one million people by 2022.
- Meet the European target for greenhouse gas emissions of 95 gCO_2/km on average for cars by 2021.
- Achieve, as efficiently as possible, the European target for 2030: a drop of at least 37.5% in CO_2 emissions for private vehicles sold (compared to 2021).
- End sales of new private and light commercial vehicles powered by fossil fuels by 2040 (LOM).
- Remove barriers to the development of electric vehicles: total additional cost of ownership (in particular costs in addition to purchase), usage constraints (battery life, charging infrastructure).
- Balance the total cost of ownership: maintain subsidy mechanisms and/or taxes; introduce regulatory measures (development of low-emission zones, usage benefits such as dedicated lanes or parking spaces); support investment in clean heavy-goods vehicles through a strengthened additional depreciation scheme: extend the additional depreciation scheme for NGV heavy-goods vehicles until 2021; reinforce the scheme for heavy-goods vehicles weighing less than 16 tonnes and establish technological neutrality for this measure (extension to hydrogen and electricity); extend it to cover other modes of transport; e.g. maritime.
- Increase the reduced diesel tax rate for the transport of goods by road by €00.02/l.
- Remove the tax advantage for non-road diesel over three years (excluding agriculture and rail and river transport).
- Increase the solidarity tax on airline tickets in order to contribute to the financing of sustainable transport infrastructure.
- Promote carpooling and all forms of mobility alternatives to personal cars.
- Reinforce the bonus/penalty system to encourage the purchase of less polluting vehicles and promote the sale of electric vehicles. Lower the threshold for penalties by -3 gCO_2/km in 2019 and continue to lower it after the new WLTP standard has been passed. Maintain the bonus at a high rate while gradually incorporating technological and in-use gains.

- Implement regulatory measures or expand the use of existing incentive tools to develop urban spaces planning (development of low-emission zones, usage benefits such as dedicated lanes or parking spaces).
- Promote clean mobility for 2/3-wheeled vehicles:
  - focus on four greening charter initiatives for 2/3-wheeled vehicles and quadricycles:
    - build awareness within the sector and among buyers of the environmental issues linked to 2/3-wheeled vehicles and quadricycles;
    - increase the supply of low-emission 2/3-wheeled vehicles and quadricycles;
    - facilitate the use of low-emission 2/3-wheeled vehicles and quadricycles, as well as the proliferation of electric recharging points;
    - combat noise pollution from 2/3-wheeled vehicles and quadricycles;
  - adapt all greening tools for light vehicles to the specificities of 2/3-wheeled vehicles (energy label, public sector minimum quota for the purchase of low-emission 2/3-wheeled vehicles, etc.).
- Deploy a recharging infrastructure network and support the targeted growth of the number of electrical vehicles: mobilise financing tools (PIA, CITE, WC ADVENIR scheme; increased coverage of connection costs by network tariffs); remove the barriers to installation (changes in co-ownership right, terminals on demand); facilitate recharging in companies (reform of benefits in kind in 2019).
- Exempt all river navigation (except private pleasure craft) from energy consumption tax (TICPE) in order to promote multimodal mobility. This exemption was previously reserved for the inland transport of goods.
- Reduce the final electricity consumption tax (TICFE) rate for boats and ships that use electricity directly when docking. The objective is to make the use of electric recharging stations more competitive with regard to other modes of energy supply (engine and generator) when ships and boats are docked.
- Create a sustainable mobility package up to €400/year to encourage the use of bikes and carpooling for commuters.
- Implement a bike and active mobility plan: create a €350 million bike fund to ensure bike path continuity and user safety, gradually implement markings for bikes and secure parking to combat theft and fencing, promote learning about bikes and a bike culture in schools so younger generations will include this eco-friendly mode of transportation in their way of life.
- Develop carpooling: reserved lanes and parking, public carpooling department and calculation of cost sharing between driver and passengers.
- Develop a new framework for self-service solutions.

3.2.2.3. Industrial sector

Measures to supplement cross-sector measures:

- Trial a managed release of white certificates for energy saving operations carried out in facilities covered by the European CO_2 emissions trading system.
- Identify new methods to support decarbonisation or energy efficiency actions in industry, within the framework of the 2025 Production Agreement.
- Integrate a technical and financial assessment of solar or geothermal heat generation into energy audits on large and medium-sized enterprises.
- Continue to increase applications for the eco-energy loans (PEE) made available by BPI France, for SMEs and very small enterprises engaged in work that qualifies for white certificates. Extend the PEE scheme until 2025.

- Promote the deployment of energy management systems (ISO 50 001 type) and energy benchmarks in industry.

3.2.3. Decrease in primary consumption of fossil fuels

3.2.3.1. Measures complementing the energy control measures to reduce coal consumption

For professionals, a 75% reduction in coal consumption in industrial sectors, excluding steel between now and 2028:

- As part of the Heat Fund, prioritise the substitution of biomass instead of coal in industry and continue the Waste Fund's call for solid recovered fuel projects to make the necessary adaptations.
- For district heating systems, as part of the Heat Fund, prioritise the substitution of renewable and recovered energies instead of coal and increase the Heat Fund's resources. The aim is to make system operators and leaders within the 10 networks that are totally or partially reliant on coal commit to transitioning away from coal in the next five years. This effort is facilitated by the fact that in early 2019 the ADEME Board decided to align the rules of the Heat Fund to those defined within the EU framework on State aid.

In the iron and steel sector:

- Continue trials to set up processes that emit less CO_2 in blast furnaces through the use of loans from the Investments for the Future Programme.
- Over the period covered by the MEP, establish demonstrators of innovative processes that enable the complete replacement of coal.
- Continue Heat Fund support for actions to recover industrial residual heat.

In the energy sector:

- Shut down the last electric power stations running solely on coal between now and 2022. In accordance with the guidelines prioritising projects that develop biomass in heat form, the Government will not grant any financial support for those focusing on generating electricity using biomass.
- The Government will no longer authorise new power stations generating electricity exclusively from coal.

For private individuals, eradication of coal heating by 2028:

- Maintain CITE grants for the installation of renewable heating. Renewable heating is heating provided by heat pumps, biomass boilers, hybrid solar systems or by connection to a renewable district heating system.
- Mobilise the National agency for the protection of miners' rights (ANGDM) as a vector of information.

3.2.3.2. Specific MEP measures to reduce primary oil consumption

- The Government will no longer authorise new power stations generating electricity exclusively from fuel oil.
- **Maintain CITE grants for the installation of renewable heating. Renewable heating is heating provided by heat pumps, biomass boilers, hybrid solar systems or by connection to a renewable district heating system.**

- Plan for abandoning fuel oil by 2028 in public buildings, with a flyer to be published in 2020, and cycled renovations between 2020 and 2028. The projected investment is €600 million over nine years.

3.2.4. Cost of supporting energy control

3.2.4.1. In buildings

Tax credit and reduced VAT

To achieve the MEP goals, two tax benefits are currently available:

- **CITE tax credit covering up to 30% of the cost of renewable heat generation equipment and work to reduce energy consumption in primary properties completed more than two years ago;**
- **VAT rate reduced to 5.5% for renewable heat generation equipment and work to reduce energy consumption in residential properties completed more than two years ago, as well as inextricably linked ancillary work.**

ANAH grants

The National Housing Agency (ANAH) is financing works in particular to improve the energy performance of the private homes of low and very low-income households. The ANAH budget for 2020 is in excess of €1 billion.

Eco-loans for social housing

The main incentive measure for energy renovation in social housing is the social housing eco-loan (eco-PLS), a subsidised-rate loan distributed by the Caisse des Dépôts et Consignations (CDC). A new Government-CDC agreement entered into force in August 2019, drawn up with the Social Housing Union (USH), in order to make the eco-PLS plan more ambitious and attractive while simplifying the application process. In particular, this involves an increase in the loan-per-home cap to €22,000 (previously €16,000) and a new bonus of €3,000 per home if asbestos is present in the building. The following progression of eco-PLS taken out over the last three years has been observed:

- in 2016: 41,397 homes for a sum of €512 million;
- in 2017: 64,137 homes for a sum of €845 million;
- in 2018: 43,409 homes for a sum of €563 million.

On average over the period, the provision per home is about €13,000, with a maximum grant amount of €16,000 and €18,000 for a renovation achieving low-energy building status (Bâtiment Basse Consommation, BBC).

In the context of the Major Investment Plan (GPI), the decision has been made to devote a total of €4 billion over five years to the renovation of energy sieves (inefficient homes) in social housing. The Investment Pact (25 April 2019) has set an annual target of 125,000 energy renovations (for one step of at least one DPE label) and an acceleration in the rate of renovation of energy sieves.

Relief on energy-saving works for low-income housing (Habitation à loyer modéré, HLM) and semi-public companies (Société d'économie mixte, SEM)

This tax expenditure entitled 'Relief totalling one quarter of expenditure on energy-saving works, on property tax contributions for properties built for HLM organisations and SEMs' is intended to help to fund energy-saving works undertaken by social housing owners to renovate their social housing stock. This mechanism amounted to €31 million in 2014, €59 million in 2015, €80 million in 2016 and €70 million in 2017.

In 2016, more than 6,000 property owners benefited from this scheme.

It is proposed that the total budget be determined on the basis of the progression of eco-PLS loans (scheme for social housing energy renovations, see above). The result would be an average budget allocation of around €350 million over the period.

Heavy building work – upgrading and restoration of Government buildings

The 'State-owned Assets: Energy Efficiency' guideline covers the renovation of Government buildings that do not comply with heating regulations. It has been evaluated quantitatively so as to renovate 3% of the Government building stock per year over the 2015–2020 period. When establishing the scenarios, the SNBC applied the following floor areas of renovated public building stock (in Mm^2):

	2016	2017	2018	2019	2020
Renovated floor areas of Government building stock (Mm^2)	1.559	1.514	1.460	1.522	1.563

Renovated floor areas of building stock by 2020 (Mm^2)

The renovation of Government buildings involves several budgetary vectors, and in particular programme 723, which contributes to the financing of real estate projects and owner's maintenance as part of the property special allocation account and the specific support programmes of the Ministries. Since 1 January 2018, a new programme 348, 'Renovation of administrative units and other multi-occupant public sites', endowed with a budget of €1 billion, has been specifically participating in reducing the Government's energy consumption. This forms part of initiative 2 of the Major Investment Plan, 'Reducing the energy footprint of public buildings'.

3.2.4.2. In transport

Contribution to financing the acquisition of clean vehicles

Programmes 797 and 798 finance grants for purchasing clean vehicles ('bonus/penalty'). The committed amounts were €207.5 million in 2016, €265.6 million in 2017, €266 million in 2018, €264 million in 2019 and €395 million in 2020, reflecting a rise of about 50%. These amounts are covered by income from the penalty.

The Climate Plan sets the goal of ending sales of new cars that emit greenhouse gases by 2040.

Contribution for taking polluting vehicles off the road

Programme 792 finances the aid scheme for taking polluting vehicles off the road ('conversion premium').

At the end of 2019, over 600,000 applications had been accepted and about €1.2 billion had been paid. The goal is to eliminate one million vehicles by 2022.

3.3. Energy supply security

Supply security can be defined as the capacity of the energy system to meet foreseeable market demand continuously at a reasonable cost by balancing supply and demand.

3.3.1. Supply security of liquid fuels

Measures:

- Launch studies to obtain a forward-looking vision of the necessary network of depots for oil storage and the minimum number required to guarantee supply security.
- Monitor the number and location of petrol stations to determine the quality of service for all fuel consumers.
- Examine the appropriateness of introducing tools to guarantee the continuity of service in oil logistics in order to ensure that the essential needs of the country are met.

3.3.2. Supply security of gas products

Measures:

- Maintain the current criterion for supply security.
- Convert the low-calorific-value gas system as soon as possible, and by 2029 at the latest.
- Keep the 11 sites currently operational until at least 2023 (volume of 138.5 TWh and extraction capacity of 2,376 GWh/day).
- Do not develop new storage sites within the scope of the regulation.
- In 2023, confirm the assessment of the storage capacity necessary for post-2026 supply security and, in the next MEP, identify the underground natural gas storage facilities that would no longer be necessary to ensure the security of natural gas supply. By 2026, the list of the essential storage facilities could be reduced by an extraction capacity of at least 140 GWh/day (6%).
- Develop the interruptibility of natural gas consumption by at least 200 GWh/day by 2023.
- Clarify the legislative and regulatory framework for natural gas consumption load shedding.

3.3.3. Security of electricity supply

The measures introduced by the MEP make it possible to clarify the definition of supply security criteria, while awaiting the future discussions to take place at European level on a possible harmonisation of supply security criteria.

- Defer the prospect of increasing the nuclear share in the electricity generation mix to 50% until 2035.
- Confirm the current supply security criterion and clarify its content by specifying that:
    - ‘disruption’ means the use of exceptional contractual and non-contractual resources and that the duration of the disruption must not exceed three hours per year on average;
    - in these disruptions, the expectation of cuts in supply to end consumers, due to supply-demand imbalances, must not exceed two hours per year.
- Continue the work to ensure more comprehensive consideration in these criteria of the number of customers cut and not merely the duration of the cut.

- Contribute to harmonising the procedures for establishing the criteria used by the Member States to define their objectives for electricity supply security.
- Accelerate the decrease in peak electricity consumption:
  - by encouraging heating methods that do not contribute (or contribute less) to this;
  - by developing flexibility of demand.
- Solicit feedback on the mechanism's first years of operation so as to assess the potential need for reforms.
- Consolidate the European integration of the capacity mechanism via cooperation agreements between RTE and border grid operators and on the basis of the new European regulations on capacity mechanisms introduced through adoption of the 4th package.

Increase cooperation among gas and electricity transmission system operators on the risks for the electrical system during periods of tension in the gas system, and put in place procedures to manage these common fault modes.

3.4. Internal energy market

3.4.1. Electricity infrastructure

Measures:

- Continue the development of interconnectors on the basis of positive cost-benefit analyses.
- Optimise and reinforce the electricity transmission system in order to exploit interconnectors as much as possible.
- Continue regional cooperation for the development of interconnectors within the High Level Group with Spain and Portugal.
- Continue active regional cooperation in the area of supply security, particularly through participation in the Energy Pentalateral Forum and discussions with the Iberian peninsula.
- Implement the network code on security and the restoration of the electrical system.
- Ensure that power supply security is covered in the coming years (particularly in 2022–2023) and implement additional measures if necessary to enable the shutting down of coal-based power generation by 2022.
- Prepare and implement a dimensioning of electricity networks that make it possible to accommodate new sources of electricity generation planned in the Multiannual Energy Plan.
- **Conduct studies, with the AIE and RTE, on the technical feasibility of an electrical system with a significant level of variable renewable energies.**
- Refine the economic assessment of smart grid solutions on the basis of recipients (system operators, producers, consumers), in order to target Government support in the most effective way.
- Make the best use of the potential of services provided by smart meters, in particular by providing more information about their functionalities.

Measures concerning curtailment:

- Promote the use of such flexibilities, particularly in industry and tertiary sectors.
- Change the rules for estimating curtailments, to increase reliability in the sector, in particular the methods used to monitor curtailments.
- Improve and simplify the support framework for curtailments to best meet the needs of the sector, in accordance with EU law on State aid.
- With ENEDIS and ADEeF, increase the options for use of demand modulation to manage local problems with the operation of distribution systems.
- Encourage suppliers to develop deals promoting flexibility, by taking advantage of the new potential offered by smart meters.

Measures concerning electricity storage:

- During the first period of the MEP, launch the procedures for the development of pumped-energy transfer stations (STEP) for a potential of 1.5 GW identified with a view to commissioning the installations between 2030 and 2035.
- During the first MEP period, set up the framework for rolling out the development of virtual lines using battery storage facilities, to avoid grid reinforcements and the capping of renewable energies, by 2028.
- Continue upstream R&D or demonstration efforts (e.g. a programme of future investments for demonstrators, a single interministerial fund for collaborative research projects, ANR support for research and development projects, innovation competition for small businesses, but also demonstrators of grid services such as the Ringo project led by RTE) in order to develop competitive electricity storage solutions, which, in the medium term, could allow the share of renewable energy in the electric mix to continue increasing.
- In conjunction with committees within the sector, explore the possibilities for developing a French production sector for batteries and provide an ambitious plan, incorporating all storage parameters, by mid-2019.
- Given the existing possibilities, study the potential of reusing saline cavities for the storage of hydrogen.

Measures concerning self-consumption:

- A total of 200,000 photovoltaic generation sites for self-consumption in 2023, including 50 collective self-consumption operations.

The development of self-consumption in particular involves a need for visibility for the players about the context applying to them, and about the various factors that could have an influence on the level of profitability of self-consumption operations:

- open new possibilities for collective self-consumption and facilitate their funding;
- establish the legal and regulatory framework applicable to renewable energy communities and citizen energy communities.

3.4.2. Energy poverty

Measures:

- **Evaluation and monitoring of fuel poverty in France**: the National Observatory for Fuel Poverty (Observatoire National de la Précarité Energétique, ONPE) has become a reliable, shared reference tool for addressing energy poverty in France, for understanding, monitoring and analysing this phenomenon, along with the mechanisms put in place to prevent energy poverty. A group of indicators has therefore been defined to characterise and quantify the fuel poverty linked to housing and mobility, and the changes in the indicators are monitored each year and published as part of a trend chart. Two indicators can therefore be used to evaluate fuel poverty:

◦ the indicator based on the energy effort rate, now estimated each year by the Commissioner-General for Sustainable Development using the Prometheus micro-simulation model; this indicator considers a household to be in a situation of fuel poverty where its expenditure on energy in the home exceeds 8% of revenue, where revenue by consumption unit (CU) is below the third decile of revenue per CU;

◦ the indicator of feeling cold, taken from the energy-info barometer produced by the National Energy Ombudsman using a sample of 1,500 people. This declarative indicator makes it possible to quantify self-restriction phenomena not captured by the economic indicator. This indicator considers a household to be in a situation of fuel poverty if it declares that it feels cold because of at least one of the following five reasons: poor insulation, insufficient heating, heating breakdown, heating restriction because of cost or energy shutdown because of non-payment.

Thus, according to the 2019 trend chart developed by the ONPE, 11.6% of French people (thus 3.3 million households representing 6.7 million individuals) spend more than 8% of their revenue on paying their home energy bills, and 15% of French people declared that they experienced cold during the winter of 2017.

Regular monitoring of these fuel poverty indicators, along with analysis of the impacts of the various mechanisms put in place to address this phenomenon, make it possible for France to steer its actions aimed at reducing fuel poverty.

- **A varied group of measures is deployed to prevent fuel poverty:**

◦ Increase the value of energy allowances (chèque énergie): the amounts were increased by €50 for eligible households in 2018. The eligibility criteria for energy allowances have been widened, so as to benefit the 20% of households with the lowest incomes. This will extend the allocation of energy allowances to 2.2 million additional households, or 5.8 million households in total.

◦ Make the energy transition tax credit (CITE) and its replacement MaPrimeRénov' more effective through:

▪ a new fixed-rate scale in 2020, which will take into account the energy efficiency of actions;

▪ payment of the corresponding benefits by the ANAH when the renovation work is performed; The grant rate will be increased for low-income households, so that public support really triggers the actions needed to escape fuel poverty.

▪ extension of these payments to cover owners-lessors in 2021, and the simplification of the request process for multiunit collective renovation projects.

◦ Expand the recently simplified ecoPTZ (zero-rate eco-loan), which can now apply, using a flat-rate grant, to single-action projects (e.g. installation of a central heating system powered by renewable energy without requiring a series of work projects).

◦ Cofinance, through the CITE and the SARE programme, an energy audit for low income households that are thermal sieve owners (diagnosed as performance F or G).

◦ Deploy innovative solutions allowing the industrial application of renovation solutions by taking advantage of effects of scale.

◦ Strengthen the conversion bonus for old vehicles for low-income households by increasing the old vehicle replacement target from 500,000 to 1,000,000 over the five-year period, with a doubled bonus for very low-income households (as well as tax-free long-distance vehicles), while working on attractive loans to finance the balance to be paid.

- Develop the offer for public transport, car sharing and more generally the alternatives to individual car use across France when this is possible, targeting the most vulnerable communities.
- Mobilise white certificates for the benefit of low-income households, both to reduce consumption by buildings (reinforcement and extension of the energy saving boost) and for mobility (support for carpooling, the development of bike use instead of thermal vehicles, handling the mobility needs of households in situations of fuel poverty).

3.5. The legislative framework and the measures implemented by France to promote an innovation policy for decarbonised energy nationally and within Europe

The energy problem falls within a complex landscape that must address several major challenges: guaranteeing and securing access to energy for populations and organisations at an affordable, competitive cost, avoiding fuel poverty, participating in mitigating climate change and adaptation to such change, protecting human health and the environment, and offering a sustainable energy mix.

To meet these challenges, France has made a firm political commitment, through the implementation of a range of key legislative, regulatory and strategic tools, both to guiding technological and societal choices and to supporting the research and development (R&D) effort necessary to ensure a continuous improvement in existing pathways and the emergence of new pathways.

3.5.1. The national regulatory framework

3.5.1.1. The Law on Energy Transition for Green Growth

The aim of the Law on Energy Transition for Green Growth (LTECV) adopted in 2015 is to enable France to contribute more effectively to preventing climate disruption and to protecting the environment, and to strengthen the country's energy independence while offering French companies and citizens access to energy at a competitive cost.

To provide a framework for joint action by citizens, companies, territories and the Government, the law sets medium- and long-term targets for reducing GHG emissions, reducing energy consumption, energy performance and the share of renewable energies.

The LTECV is also intended to promote sustainable economic growth and the creation of sustainable jobs that cannot be relocated.

The LTECV therefore constitutes the foundation on which the policy of innovation for ecological and energy transition can be built. The law also provides for the drafting of the above-mentioned National Energy Research Strategy (SNRE).

3.5.1.2. The Climate Plan – Accelerating action to prevent climate change in France and internationally

In keeping with the LTECV, the Government presented the Climate Plan in 2017. This document is intended to project France into the post-carbon world, reducing its dependence on fossil energies and mobilising ecosystems in terms of their capacity to store carbon and to provide protection from the consequences of climate change. The Climate Plan set an objective of carbon neutrality by 2050 and intends to be the marker for mobilisation by the French Government and all stakeholders.

The fight against climate change, driven by the Climate Plan, requires substantial economic changes. Reducing greenhouse gas emissions in a growing world requires innovation in means of production, in particular energy, in order to separate economic performance from emissions. In that context, the Climate Plan reiterates the absolute need to rely on research and innovation, along with investment in new technologies. It provides, inter alia, as follows:

- Betting on talent to find tomorrow's solutions: France is reinforcing henceforth its mechanisms for attracting talent and for scientific cooperation in key areas to combat climate change. It is therefore putting in place a programme to attract experienced high-quality researchers, along with chairs for excellence for young researchers and a selected programme for doctoral students. As an illustration, since its launch on 1 June 2017 by President Macron, the *Make Our Planet Great Again* initiative has welcomed several hundred top-level applications for long-term research projects in France.

- Making the Paris stock exchange the international hub for green finance: Paris, which has quality experience applied during COP21, aims to become the capital of green and responsible finance. France must promote green and responsible finance labels and must be at the centre of discussions considering climate-related risks in international financial regulations (Article 173 of the Law on Energy Transition for Green Growth). It is therefore the first country to ask investors to publish information about the impact of their activities on the climate, encouraging them to invest in the green economy rather than in fossil energies.

3.5.1.3. Implementation of the French strategy for energy and climate – The Multiannual Energy Plan and the National Low-Carbon Strategy

Achieving carbon neutrality by 2050 in French territory will require changes to the energy system to ensure that the energies consumed within France no longer release greenhouse gases. In taking action, the Government relies on:

- **The National Low-Carbon Strategy (SNBC)**, which describes the roadmap to 2050 for France for the implementation of its climate change mitigation policy, and the measures that make it possible to achieve carbon neutrality, including in innovation.

- **The Multiannual Energy Plan (MEP)** to 2028, which sets the priorities for action by the public powers in relation to energy in order to ensure a successful transition towards a more effective and more simple energy system that is more diversified and therefore more resilient, with a focus on innovation.

3.5.1.4. The Law on Energy and Climate

The Law on Energy and Climate (LEC), promulgated on 9 November 2019, amends the targets that France has set itself and the tools required to verify that it is on the right track. It also puts in place specific measures designed to reduce greenhouse gas emissions.

First, this text enshrines the concept of ecological and climatic emergency in the law. To respond to this emergency, it introduces into the law the notion of achieving carbon neutrality for France by 2050. It then creates new tools for the management, governance and assessment of our climate policy that will make it possible to better understand whether the country is following the right path. One of the key features of the law is the creation of the 'High Council on Climate'. This Council is made up of recognised figures in the climate sphere, and will provide a fully independent assessment of France's climate strategy and of the policies implemented to achieve the nation's goals. The law also introduces (from 2023) additional carbon budgets for the French carbon footprint and international transport enabling the determination of targets and tools for monitoring of these two central indicators. It introduces a five-yearly programming law for the nation's energy and climate targets, which will encourage democratic debate on these targets.

Lastly, concrete measures are introduced. France is committed to ending coal-based electricity generation, through the introduction of a cap on the operational life of coal-fired power stations from 1 January 2022, at a level that will lead to a shutdown in their use. It has also committed to preventing thermal sieves, setting a target for the renovation of the buildings concerned by 2028.

3.5.1.5. The Mobility Law

The aim of the Mobility Law (LOM) adopted in December 2019 is to:

- invest more in existing infrastructures to enable improvements in everyday transport services (maintenance of existing rail networks, desaturation of major rail hubs): Government financial support for these infrastructures, which are essential in encouraging a switch from the use of cars to trains, is increasing significantly;
- provide everyone everywhere with alternative solutions to individual car use;
- develop innovation and new mobility solutions for the benefit of everyone;
- reduce the environmental footprint of transport services;
- adapt the regulations governing road, maritime, river and rail transport.

The LOM is the first legal text to enshrine the target of full decarbonisation of land-based transport by 2050. An immediate trajectory has been identified to achieve this, in accordance with European targets, the Climate Plan and the National Low-Carbon Strategy:

- development of low-emission vehicles according to the European targets for reducing CO_2 emissions for 2030 (see above);
- end of the sale of new light vehicles that use fossil fuels by 2040.

To follow this trajectory, binding progressive targets have been set for the annual replacement of vehicle fleets owned or used by public sectors, integrating an increasing minimum quota of low-emission vehicles.

To support vehicle energy transition, the development of recharging facilities for electrical vehicles is being encouraged: mandatory installation in car parks with more than 10 spaces in new or renovated buildings, facilitation of the 'right to plug' in multi-occupied buildings, rate of coverage of the connection cost by the tariff for the use of public electricity networks (TURPE) increased from 40% to a maximum of 75%.

To encourage citizens to adapt the transport modes to their movements, the LOM promotes shared, eco-friendly transport modes: wording encouraging the use of shared, active mobility options or public transport in car ads; possibility for local authorities to subsidise carpooling solutions and to be able to reserve traffic lanes around city axes for carpooling and low-emission vehicles; implementation of the bike plan to triple its modal share by 2024 (from 3% to 9%), in particular by creating a national bike fund of €350 million to fund cycling infrastructures; creation of the sustainable mobility package to enable employers to pay up to €400/year to employees travelling to work by bike or using carpooling.

Local authorities will be provided with monitoring tools to enable the roll-out of low-emission zones and zones where entry is forbidden for the most polluting vehicles.

3.5.1.6. The Finance Law for 2020

This law has enabled a partial reduction in tax expenditures that adversely affect the climate: it has increased the reduced rate on diesel used for road freight transport by €00.02/l and will eradicate the reduced rate on non-road diesel within three years (excluding agriculture and rail and river transportation). A certain number of support measures are planned for the sectors most affected. Regarding fuels for the aviation sector, discussions must be held within Europe and internationally, taking into account existing instruments such as the aviation ETS. However, an increase on the solidarity tax on airline tickets has also been introduced by the 2020 Finance Law to contribute to funding sustainable transport infrastructures.

This law also provides for an end to Government export guarantees granted for operations associated with coal exploration, mining and production and for coal-based energy generation, and for certain operations associated with hydrocarbon exploration, mining and production (projects using methods prohibited within French territory, projects to produce liquid hydrocarbons that involve routine flaring operations).

Lastly, it should be noted that this law has made it possible to initiate the green budget approach, which will be consolidated in the next finance law, and provides a clear assessment of budget programming in terms of environmental targets (broader than climate).

3.5.1.7. Implementation of major Government policy objectives – thematic plans and roadmaps

The major policy objectives laid down in the various legislative texts are implemented in a variety of ways, and in particular in the form of thematic plans or roadmaps stipulating the measures necessary to ensure a successful ecological and energy transition. Thus since 2017, France has published the following:

The biodiversity plan

The aim of this biodiversity plan is to implement the target of reducing net biodiversity loss to zero. To achieve this, the plan is based around six strategic areas for which numerous innovation requirements have been identified, in particular in terms of biodiversity, ecological engineering and biomimetics, and the reinforcement of presence in urban spaces.

The Roadmap for the Circular Economy

The transition towards a circular economy is a key part of ecological and inclusive transition. The Roadmap for the Circular Economy has set ambitious targets, which will require increased research and innovation efforts:

- reduce consumption of resources linked to French consumption: reduce consumption of resources in terms of GDP by 30% by 2030 compared to 2010;
- reduce quantities of non-hazardous waste disposed of in landfills by 50% by 2025 compared to 2010;
- move towards 100% recycled plastics in 2025.

This roadmap lays down 50 measures, with innovation playing a full role. In particular, these measures cover the development of solutions to support the circular economy by incorporating more recycled raw materials in manufacturing and biowaste recovery.

Generally speaking, the objective is to mobilise the scientific community using a multidisciplinary approach, especially by launching calls for projects funded by ADEME and by encouraging the filing of European projects to bring about essential technological innovations in the deployment of the circular economy and mobilise experts across all sectors (urban planning, development, management, sociology, design, fashion, communication, economics, etc.).

Innovation linked to the implementation of the Building Energy Renovation Plan

In national terms, the building sector represents close to 45% of final energy consumption and 25% of greenhouse gas emissions: its contribution to transforming our development model for energy saving is crucial and was included in a Government plan in 2018.

The issue of the energy renovation of existing buildings remains a major challenge that must find a way to marry the substantial requirements in terms of the quantity of homes to be renovated with the level of quality required of the works performed and the need to control costs. Current and future transformations of the economic fabric have few recent equivalents. Their success is based primarily on the ability to modernise the entire building sector by supporting and disseminating innovations, enabling simpler, less costly and more effective renovation works.

The requirements demonstrated therefore assume the use of the most environmentally high-performance products and support for the emergence of innovative sectors that could enable large-scale production of those products. Support for innovation will focus primarily on:

- the development of eco-materials sectors (bio-based materials, use of wood resources, etc.);
- the development of innovative business plans for energy renovation that make it possible to address this coming challenge;
- the spread and use of digital tools across the entire sector;
- the development of capabilities for measuring and managing energy efficiency that enable a better understanding of the building stock and associated consumption;
- active management services for buildings and groups of buildings.

Deployment of H2 technologies through support for research and innovation

The Hydrogen Plan announced by the Government in July 2018 shows the potential of this energy vector for various uses, with a desire to focus as a priority on the decarbonisation of existing uses.

The sustainable competitiveness of the various sectors will be achieved through the emergence of strong R&D players working on two levels.

- The acceleration of the industrial development of hydrogen-based technologies by supporting research and the transfer of technologies resulting from research, for which support actions such as demonstrators of the Investments for the Future Programme (PIA), in particular equity, are valuable.
- The implementation of disruptions in accordance with international roadmaps in order to reduce component costs and dependence on critical materials, and to work on their substitution. This element, which is fundamental in ensuring the sustainability of France's technological assets, could be covered by dedicated ongoing programming by the National Research Agency (ANR).

3.5.2 European cooperation actions implemented by France

3.5.2.1. A national research and innovation strategy consistent with the targets set by the SET-Plan

Active French involvement in the SET-Plan since its inception

Since the launch of the Energy Union by EC President Juncker in 2008, the Strategic Energy Technology Plan (SET-Plan) has played an enhanced role in the programming of Societal Challenge 3 'Secure, Clean and Efficient Energy'.

Starting from the premise whereby companies provide 70% of total investments in research and innovation in the area of energy technologies, Members States 20% and the European Union 10% (source JRC: COM(2013)253), the Member States have set a target through the introduction of the SET-Plan to maximise the impact of national, private and European resources by strengthening joint projects and coordination of national R&I programmes and budgets for energy technologies.

Through Government, academic and industrial stakeholders, France has participated actively in all actions undertaken as part of the SET-Plan, namely the creation of the integrated roadmap in 2013–2014; the drafting in 2015–2016 of 10 declarations of intent defining the targets to be achieved in terms of costs and performance of new technologies; and lastly, the drafting of 14 action plans summarising the initiatives to be implemented to enable the achievement of the targets set by the declarations of intent.

France has also coordinated the activities of the working groups responsible for drafting the battery action plans for static or mobility options and nuclear safety.

In this general context, France has been able to drive its vision of the actions to be undertaken to ensure energy transition within the wider European context.

National guidelines for research and innovation in line with the recommendations of the SET-Plan action plans

In general terms, the French and European targets in relation to the fight against climate change and the related required energy transition are in agreement.

This therefore means that there is a consistent overall vision of the resources to be implemented and, more specifically in relation to research and innovation, the recommendations contained in the 14 SET-Plan action plans are essentially shared at national level. To illustrate this fact, the plans covering photovoltaic energy and batteries are used as examples below.

The SET-Plan photovoltaic action plan:

This action plan describes the technological and non-technological research and innovation activities to be implemented to rebuild EU leadership in the high-performance photovoltaic technologies sector and the integration of those technologies into the EU energy system, proposing competitive, sustainable solutions for the European electricity market. To meet these targets, the following challenges should be addressed:

1. developing technologies (silicon and films) and new concepts to increase the PV efficiency compared to 2015 by at least 20% by 2020 and 35% by 2030;
2. reducing the costs of technologies compared to 2015 by at least 20% by 2020 and 50% by 2030;
3. increasing the quality, environmental impact and life cycle of the proposed technologies;
4. enabling the construction of zero-emission buildings by integrating PV technologies (building-integrated photovoltaics, BIPV) directly into the infrastructure design;
5. developing GW-competitive PV module production lines.

France's positioning consistent with the PV action plan:

The MEP published in November 2018 stipulates a very ambitious schedule for the deployment of PV solutions to 2028, increasing from the 8.3 GW installed in 2018 to 20.6 GW in 2023 and then around 40 GW in 2028.

To achieve this massive deployment, France believes that there is a need to support research and innovation in this area, and the strategic themes proposed in the SET-Plan action plan discussed above are fully integrated into this national approach.

Thus, the SNRE states that: *'the French, and more broadly the European, photovoltaic industry suffers from a lack of competition vis-à-vis its Asian competitors. In this regard, research and innovation have a major role to play in order to increase the competitiveness of French and European products.*

An initial lever for action is to reduce the production costs of these products, in particular by improving industrial production methods (more automation, time saved in manufacturing processes) or through savings on the cost of raw materials (savings on the quantities of Si and In required). Another lever for action is to increase the quality and durability of the products by extending system life cycles and improving recyclability levels.

Lastly, it is also appropriate to continue research and development efforts aimed at improving the performance of cells and modules and, more upstream, exploring disruptive concepts, such as perovskites, which could become the technologies of tomorrow.

France has a dynamic ecosystem of laboratories and innovative companies that is able to meet these challenges. In particular, the works of the IPVF (thin layer) and INES2 (silicon) Energy Transition Institutes could prove to be crucial in responding to these issues.'

The Batteries and Storage action plan:

This action plan is intended to cover batteries, a key technology for applications involving electric mobility and fixed energy storage. It is therefore crucial for the European industry to ultimately control the entire value chain, namely design, development, manufacture, application and recycling of future generations of batteries, while becoming competitive in the global market.

The recommendations presented in the action plan have been developed in the context of the research and innovation component of the European Battery Alliance. Three broad spheres of action to be addressed by 2030 have been identified:

1. Materials/Chemistry/Design and Recycling;
2. Production;
3. Applications and Integration.

The working group for application of the action plan is chaired by France and has identified the following priority areas for implementation:

1. advanced materials for batteries
2. eco-efficient production
3. quick-charge batteries
4. battery second life
5. recycling
6. application and integration.

France's positioning consistent with the Batteries and Storage action plan

To develop a structure that could potentially meet the major challenges associated with energy storage, France introduced the 'Electrochemical Energy Storage Network' (RS2E) in 2011. The RS2E was created with the support of the Ministry of Higher Education, Research and Innovation, in conjunction with the National Centre for Scientific Research (CNRS), research bodies and industrial players, and is a research and technology transfer network dedicated to the various energy storage systems: rechargeable batteries, supercapacitors and alternative technologies intended for a variety of uses. Furthermore, a series of tools to support research actions associated with energy storage has been introduced, covering TRL 1 to 8, through funding taken primarily from the Investments for the Future Programme, and the related actions are therefore implemented by the ANR and ADEME.

3.5.2.2. Participation by France in the ERA-NET Cofund

The ERA-NETs are European Framework Programme instruments in the energy sector that assist in developing partnerships between the members of the SET-Plan to fund common research and innovation priorities that are included in action plans.

A dozen or so ERA-NET Cofunds on the theme of energy resulting from discussions undertaken as part of the SET-Plan have been initiated since the launch of Horizon 2020. In particular, France is involved in SMARTGRID+, SOLAR ERANET, GEOTHERMICA, OCEAN, EnSGPlusRegSys and SOLAR COFUND 2.

These programmes are implemented nationally by ADEME and the ANR, and the funding is provided by the Investments for the Future Programme or budgets allocated to research by the two operators.

At this stage, France's feedback on the use of European cooperation vectors such as ERA-NET Cofunds is positive. This has enabled public-private cooperation and the deployment of pilot lines for the production of energy system components that strongly promote interactions between academic research and applied and pre-industrial research.

Furthermore, the multilateral nature of these actions represents a valuable opportunity for dialogue among the various national funding agencies. It contributes to reinforcing cooperation between Member States in facing the challenges of energy transition in a context involving the closer alignment of the various energy transition policies within the EU.

3.5.2.3. Strengthened a bilateral Franco-German cooperation to promote the development of innovative solutions

The French Ministry of Higher Education, Research and Innovation, through the ANR, and the German Federal Ministry of Education and Research (BMBF) launched a bilateral call for projects in 2018 with funding of €20 million on energy storage and distribution (expected to close in January 2019).

This call for projects is intended to support the development of innovative, efficient and sustainable solutions for energy storage and distribution.

It falls within a context of increased cooperation between France and Germany in the energy sphere. The purpose of this partnership is to stimulate innovation in France and Germany to contribute to the introduction of a sustainable energy system in Europe by 2050.

The call will support collaborative projects bringing together French and German partners, where the upstream research activities (technological readiness level (TRL) between 1 and 5) are aimed at developing economically, ecologically and socially efficient solutions for energy storage and distribution in France, Germany and Europe. This mechanism is intended for both research bodies and companies.

The projects expected must relate to one of the two principal themes: 1. Conversion and storage of energy from renewable sources; 2. Smart energy networks (for transport and distribution). The themes covered may contribute to achieving the targets stated in the SET-Plan batteries and storage action plan.

3.5.2.4. Opening of the Investments for the Future Programme to joint actions to undertake the actions defined in the SET-Plan

To meet the targets defined in the action plans approved in the SET-Plan, France is suggesting the development and continuation of joint research projects with other countries covered by the SET-Plan through its Investments for the Future Programme (PIA).

The aim of the PIA is to prepare France for the challenges of tomorrow (competitiveness, environment, energy, health, etc.) and to increase its growth potential by investing in higher education and training, research, industry and SMEs, sustainable development and digitisation. The Investments for the Future Programme is intended to support projects that promote innovation and job creation in sectors with significant potential for the French economy. This enhances France's strategic competitive advantages. The implementation of the Investments for the Future Programme is managed by the Secretary-General for Investment (SGPI). It is supported by several operators, including ADEME, one of the major players in innovation for energy and ecological transition in France.

To support and manage these projects in the energy sphere, ADEME is offering support for project drivers, in particular in the form of State aid subject to the European regulations on competition. These are awarded through calls for projects and include the following:

- State aid in the form of repayable advances;
- subsidies, reserved primarily for research bodies.

In the energy sector, the French authorities have decided to open calls to collaboration projects by French stakeholders with countries that are members of the SET-Plan and beyond, to international cooperation. A non-French company may benefit from these investment mechanisms to obtain funding for its innovative projects on the condition that the demonstrators or projects are located in France and directly benefit the French economy and labour market. Furthermore, the PIA also enables specific operators such as ADEME or BPI France to make equity investments where applicable, for example for innovative industrial solutions.

This opportunity was presented by France to the SET-Plan steering committee, and has been the subject of regular information updates for European bodies by the French Ministries responsible for research and energy.

3.5.3 - The principal sources of funding for energy research and innovation

3.5.3.1. The Investments for the Future Programme – Projects implemented by ADEME

Alongside the funding of public research bodies, the Government supports R&D actions in the energy sphere implemented by ADEME, BPI France and the Caisse des Depôts et Consignations (CDC), and by the ANR (energy transition institutions, generic calls for projects).

Between 2010 and 2017, ADEME implemented two actions for the first two sections of the PIA: 'energy and ecological transition demonstrators' and 'vehicles and transport of the future', thus covering numerous themes divided among four broad aspects:

- production of renewable energies, energy storage and smart electricity networks;
- energy efficiency in buildings, industry and agriculture and bio-based chemistry;
- circular economy and waste;
- transport (including all its components) and mobility.

Various funding tools were provided, such as calls for projects for demonstrators, SME initiatives and equity interventions, enabling the funding, through 85 calls for projects, of 745 projects for a total grant amount of €2.5 billion (total project budget: €7.22 billion).

Continuing on from PIA 1&2, ADEME has implemented several actions as part of the third section of the PIA (commenced in late 2017), for a total amount of €1 billion:

- ‘regional demonstrators and those for ambitious innovation’, with €400 million in equity and €300 million in State aid (the CDC is also an operator, with separate loans for the regional component). For ADEME this action constitutes the next stage in the actions for PIA 1&2 to support ‘ecological and energy transition demonstrators’;
- ‘innovation competition’ dedicated to SMEs, with €150 million in State aid (BPI is also an operator with €150 million, which must also cover the regional component);
- support for ‘innovation ecosystems’ in the area of sustainable mobility, with €150 million in State aid.

3.5.3.2. Incentive actions intended to stimulate research and innovation associated with renewable energies – Energy Transition Institutes

Energy Transition Institutes (ITE) are public-private platforms that aim to create campuses of excellence to bring together academic research, major groups and SMEs on issues specific to energy transition, to foster innovation by bringing together public R&D efforts and industrial strategies. The ITE thus target the industrial development of a complete sector, from technological innovation to demonstrator and industrial prototype.

As part of the Investments for the Future Programme (PIA), the ANR monitors these dozen or so structures, which were awarded labels in 2011 and 2012 in the following domains:

- green chemistry and agro-based materials;
- renewable marine energies;
- solar energies;
- geothermal energy;
- smart electricity grids;
- energy efficiency;
- sustainable building;
- decarbonised vehicles and mobility.

This programme is currently allocated a total budget of around €450 million, funding up to 50% of ITE activities.

3.5.3.3. European research funding – The Framework Programme (MESRI)

Approximately €2.8 billion has been allocated to date as part of the Horizon 2020 Energy programme, representing 7,400 European participations. French partners have been awarded €258 million (9.2%) of these funds. France is thus the fifth largest beneficiary of the energy programme behind Germany (€454 million - 16.2%), Spain (€346 million - 12.3%), the United Kingdom (€292 million - 10.4%) and Italy (€267 million - 9.5%). However, these French players have a very significant success rate (18%), just behind Germany (18.7%) but ahead of the United Kingdom (14.9%), Spain (13.8%) and Italy (11.9%).

3.5.3.4. The NER 300 Fund – a tool designed for the pre-commercial demonstration of decarbonised technological solutions

The European demonstration fund New Entrant Reserve 300 (NER 300) is a funding programme for demonstration projects in the European Union that are innovative and commercial in scale, and focused on the themes of CO_2 capture and storage and renewable energies. The fund was created in 2009 as part of the climate-energy package and adopted during the French Presidency of the European Union.

It has been allocated 300 million emission quotas from the new entrant reserve, the sale of which have generated €2.1 billion.

The NER 300 fund therefore appears to be a valuable tool for funding projects with high TRLs, providing an opportunity for new technologies in the energy sector to achieve the level of readiness necessary for market entry.

In this context, two French projects have been recognised and are currently being implemented:

- the Vertimed/PGL floating wind farm project made up of three wind turbines installed in the Mediterranean Sea, the purpose of which is to demonstrate the commercial feasibility of the proposed technological solution;
- the GEOSTRAS geothermal energy project, which is designed to demonstrate the feasibility of generating renewable electricity and heat using a deep geothermal source and developing an innovative underground heat exchanger.

The Innovation Fund, the successor to the NER 300 fund for the 2021–2030 period, must take over to continue the funding of innovative pre-commercial renewable energy projects. There is also an extension to its scope planned to include industrial processes that demonstrate a reduction in GHG emissions compared to benchmark solutions.

SECTION B: ANALYTICAL BASIS

4. CURRENT SITUATION AND PROJECTIONS WITH EXISTING POLICIES AND MEASURES

4.1. Projected change in the main exogenous factors influencing the development of the energy system and GHG emissions

4.1.1. Macroeconomic forecasts (GDP and population growth)

The following assumptions have been used for the projections reported in this section and the following one:

GDP growth and change in industrial added value: up to 2035, the assumptions used are those for the parameters recommended in 2017 by the European Commission for projected greenhouse gas emissions (taken from the EU Reference Scenario 2016). The scope is then extended to 2050 using the same growth rate as for the 2030–2035 period.

Annual GDP growth rate (%)	**2015-2020**	**2020–2025**	**2025-2030**	**2030-2035**	**2035-2050**
	1.6	1.3	1.4	1.7	1.7

Annual growth rate of gross industrial added value (%)	**2015-2020**	**2020–2025**	**2025-2030**	**2030-2035**	**2035-2050**
	1.4	1.0	1.1	1.3	1.3

Population growth: the population projections (Metropolitan France and overseas territories) are those taken from the 2013–2070 central population projection scenario from the National Institute of Statistics and Economic Analysis (Insee).

Number of inhabitants (thousands)	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
	66,391	67,820	69,093	70,281	71,417	72,449	73,312	74,025

Source: Insee, 2016

The following assumptions have been used in relation to the change in household number and size:

	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Number of households (thousands)	28,342	29,488	30,568	31,683	32,760	33,641	34,317	34,862
Average number of persons per household	2.3	2.2	2.2	2.1	2.1	2.1	2.1	2.1

Source: DGEC calculations

4.1.1.1. Sector-based changes that could affect the energy system and GHG emissions

No such changes have been identified in particular.

4.1.1.2. Global energy trends, international fossil fuel prices and EU ETS carbon prices

The assumptions used are those for the parameters recommended in 2017 by the European Commission for projected greenhouse gas emissions (taken from the EU Reference Scenario 2016).

	Fuel and gas import price (in constant €2013/BOE)							
	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Oil (Brent crude oil)	48.19	75.01	85.15	93.8	97.85	103.6	105.98	108.43
Coal (CIF ARA 6000)	11.47	14.31	17.09	20.51	21.72	22.64	23.46	24.11
Gas (NCV, CIF average EU import)	38.8	48.25	52.21	56.77	60.63	62.68	63.96	64.95

	EU ETS carbon price							
	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Euro constant €2013/tCO2	7.5	15	22.5	33.5	42	50	69	88

Technology cost developments

Cost of electric vehicles

The change in the cost of batteries for cars and light commercial vehicles is based on an assumed reduction in the cost of batteries per kWh until 2030, and then price stability until 2050.

	Change in the cost of batteries							
	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Euro constant €/kWh of battery	320	200	150	100	100	100	100	100

4.2. Decarbonisation

4.2.1. GHG emissions and removals

4.2.1.1. Trend in current GHG emissions and removals in the EU ETS, effort sharing and LULUCF sectors and different energy sectors

Trend by sector

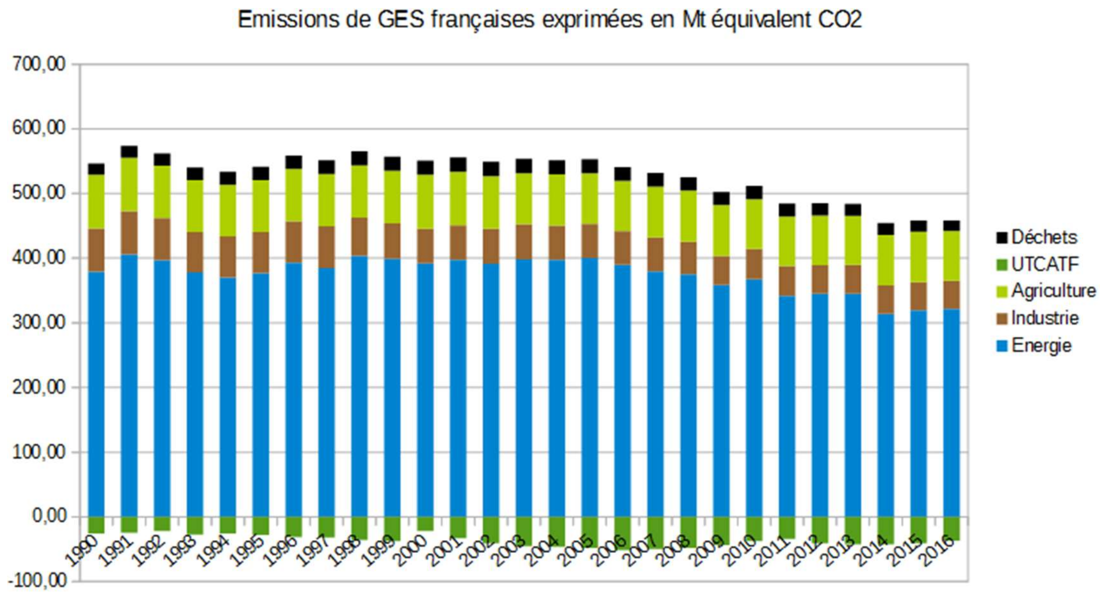
The following table and graph show the historical trend in GHG emissions and removals for France (scope of the Kyoto Protocol[20]) between 1990 and 2016, by broad sector and then specifically for the energy sector (CRF categories), on the basis of the 2018 inventory.

GHG emissions and removals between 1990 and 2016 in MtCO2e, Kyoto scope

	1990	1995	2000	2005	2010	2015	2016	2016/1990 trend
1. Energy	379.06	376.84	391.91	400.26	367.31	319.34	321.87	-15.1%
2. Industrial processes and product use	67.02	63.67	53.67	52.90	46.71	43.71	43.36	-35.3%
3. Agriculture	82.98	80.38	83.36	78.03	77.18	77.81	76.69	-7.6%
4. LULUCF	-25.85	-27.66	-21.84	-47.98	-37.55	-40.83	-36.58	41.5%
5. Waste	17.31	20.50	21.90	21.65	20.36	17.20	16.24	-6.1%
Total (excluding LULUCF)	**546.37**	**541.40**	**550.83**	**552.84**	**511.55**	**458.06**	**458.17**	**-16.1%**
Total (including LULUCF)	**520.52**	**513.73**	**528.98**	**504.86**	**474.00**	**417.23**	**421.59**	**-19.0%**

Source: CITEPA/MTES, 2018 submission, UNFCCC/CRF format – Kyoto scope

[20] The scope of French emissions under the Kyoto Protocol comprises Metropolitan France (including Corsica) and the ultraperipheral French regions of the European Union: French Guiana, Guadeloupe, Martinique, Réunion, Mayotte and Saint-Martin.



Source: CITEPA/MTES, 2018 submission, UNFCCC/CRF format – Kyoto scope

Emissions de GES françaises exprimées en Mt equivalent CO2	French GHG emissions expressed in MtCO2e
Déchets	Waste
UTCATF	LULUCF
Agriculture	Agriculture
Industrie	Industry
Energie	Energy

In 2016, GHG emissions for France (excluding LULUCF) were 458.2 MtCO2e. They had fallen by 16.1% compared to 1990, against population growth of 15.0%. French emissions per inhabitant over that same scope fell from 9.4 tCO2eq to 6.9 tCO2eq between 1990 and 2016, thus a reduction of more than 25%. GDP increased by 48.6% over the same period and the intensity of emissions per unit of GDP fell by 43.6% between 1990 and 2016, reflecting an absence of correlation between emissions and economic growth.

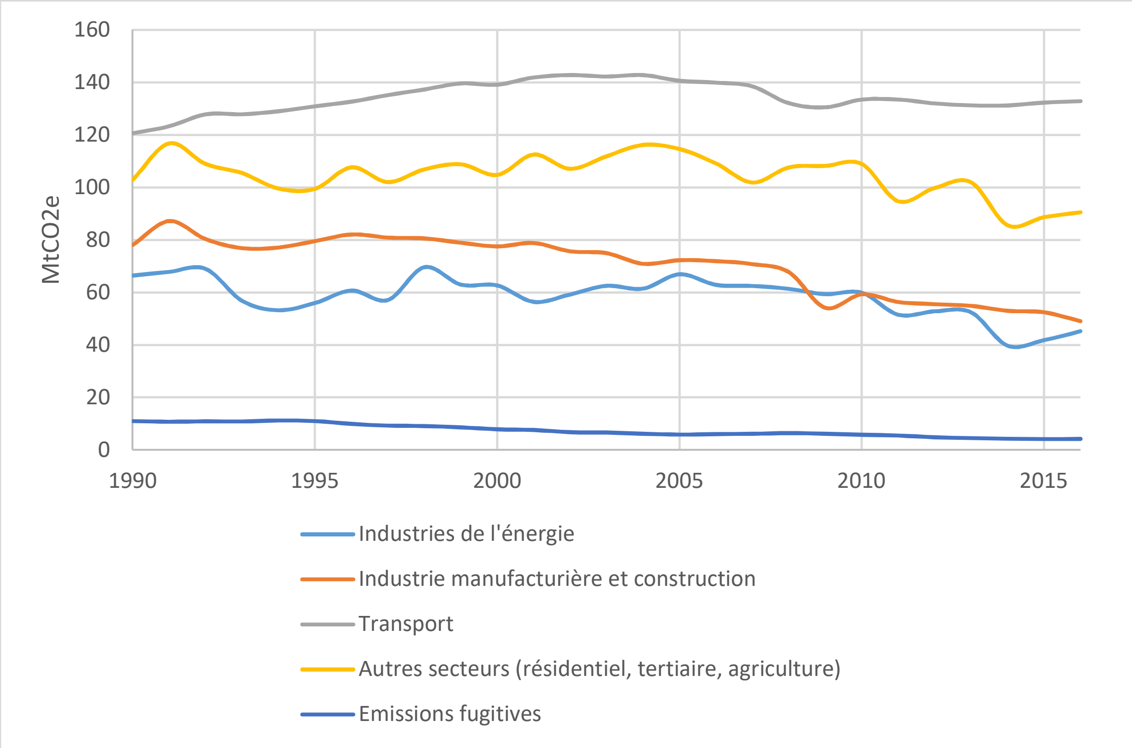
Energy use is the principal source of GHG emissions in France, representing 70.3% of emissions in 2016. For emissions caused by energy combustion, the sector responsible for the most emissions is transport (41.3%), followed by ‘other sectors’ (according to the CRF classification) including residential, tertiary and agricultural energy emissions (28.1%).

Breakdown of the various energy sub-sectors (CRF categories) in MtCO2e:

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2016/1990 trend**
Energy industry	66.39	55.96	62.64	66.91	59.87	41.80	45.20	-31.9%
Manufacturing industries and construction	78.07	79.54	77.52	72.26	59.26	52.42	49.08	-37.1%
Transport	120.66	130.89	139.13	140.62	133.44	132.32	132.85	10.1%

Other sectors (residential, tertiary, agriculture)	102.94	99.46	104.77	114.61	108.95	88.64	90.55	-12.0%
Fugitive emissions	10.99	10.99	7.85	5.85	5.79	4.16	4.20	-61.8%

Figure 19: Trend in energy emissions from 1990 to 2016



MtCO2e	MtCO2e
Industries de l'énergie	Energy industries
Industrie manufacturière et construction	Manufacturing and construction industries
Transport	Transport
Autres secteurs (résidentiel, tertiaire, agriculture)	Other sectors (residential, tertiary, agriculture)
Emissions fugitives	Fugitive emissions

Trend in emissions for the ETS and ESR sectors

The following table and graph show the trend in GHG emissions for the ETS and ESR sectors between 2005 and 2016. It should be noted that the ETS emissions between 2005 and 2012 include verified emissions and an estimate to reflect the current scope of the ETS in order to enable a comparison of trends in these emissions over time.

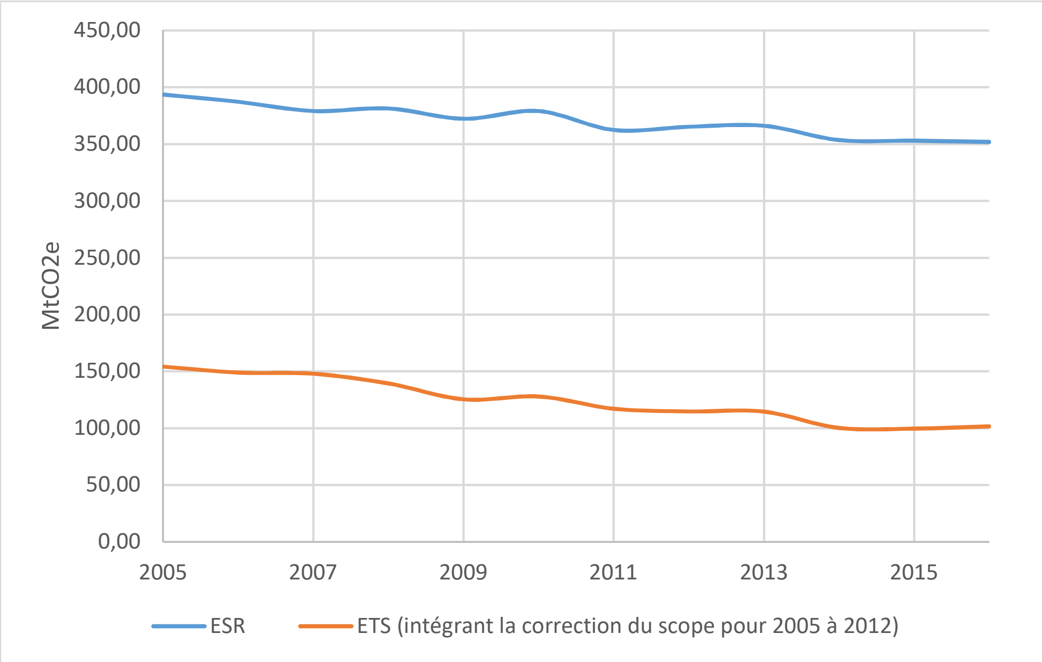
GHG emissions for the ETS and ESR sectors in MtCO2e

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
ESR	393.64	387.22	379.15	381.36	372.29	379.09	362.40	365.27	366.12	353.53	353.01	351.92

ETS*	154.15	148.95	147.91	139.38	125.35	127.88	117.12	114.76	114.55	100.23	99.6	101.62

* integrates the correction of the scope for the years 2005 to 2012

Figure 20: Emissions for the ESR and ETS sectors



MtCO2e	MtCO2e
ESR	ESR
ETS (integrant la correction du scope pour 2005 à 2012)	ETS (integrates the correction of the scope for the years 2005 to 2012)

Emissions for the ESR sector fell by 10.6% between 2005 and 2016. Emissions for the ETS (over a constant scope for the third period) fell by 34.1% over the same period.

4.2.1.2. Projections of sectoral developments with existing national and EU policies and measures at least until 2040 (including for the year 2030)

France performed an exercise that involved forecasting scenarios between June 2017 and March 2018. A scenario was built ‘with existing measures’, or WEM, considering all policies and measures decided on and implemented before 1 July 2017.

Overall results

The following table and graph show the historical and projected trends for GHG emissions (Kyoto scope) in the WEM scenario. Excluding LULUCF, the reduction in emissions is:

- **16% between 1990 and 2020;**
- **24% between 1990 and 2030;**
- **31% between 1990 and 2050.**

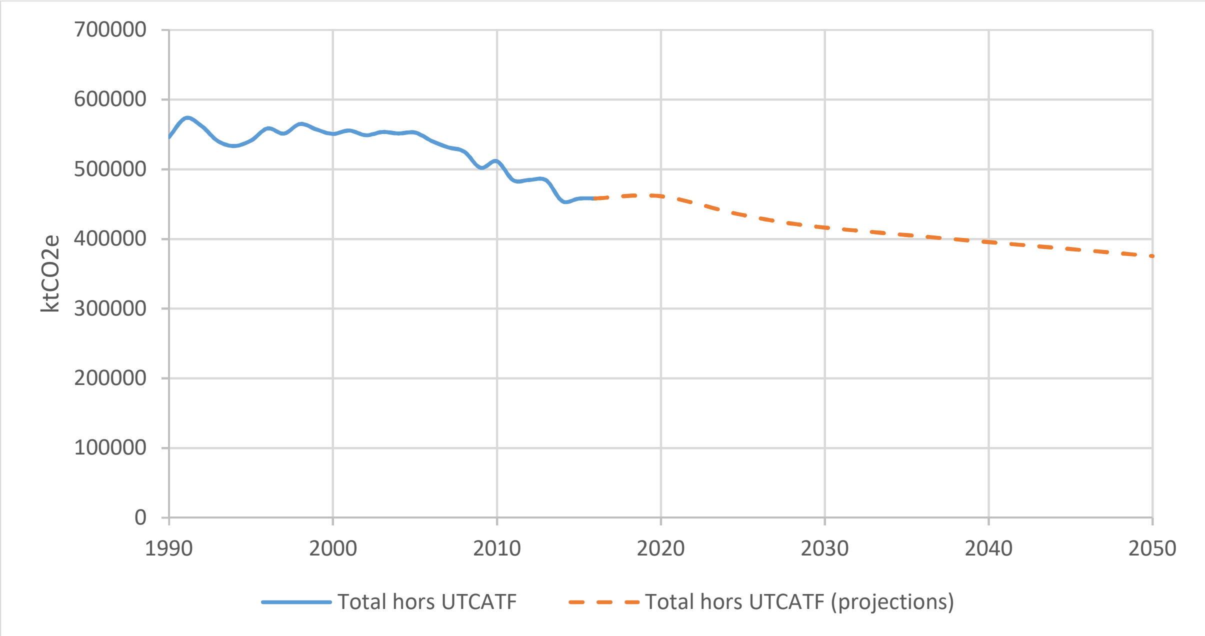
Including LULUCF, the reduction in emissions is:

- **19% between 1990 and 2020;**
- **26% between 1990 and 2030;**
- **30% between 1990 and 2050.**

Historical and projected trends in GHG emissions in the WEM scenario in ktCO2e:

	1990	2010	2015	2020	2025	2030	2040	2050
	Historical			Projected				
Total excluding LULUCF	546,369	511,554	458,060	461,344	434,442	416,451	395,961	375,470
Total including LULUCF	520,522	474,003	417,231	422,836	402,843	387,413	374,631	361,849
Variation in the total excluding LULUCF compared to 1990		-6%	-16%	-16%	-20%	-24%	-28%	-31%
Variation in the total including LULUCF compared to 1990		-9%	-20%	-19%	-23%	-26%	-28%	-30%

Figure 21: Historical and projected trends in GHG emissions (excluding LULUCF) – WEM scenario



Source: Inventory of Kyoto scope, CITEPA/MTES, submission for 2018 and MTES WEM scenario emission projections, 2018

ktCO2e	ktCO2e
Total hors UTCATF	Total excluding LULUCF
Total hors UTCATF (projections)	Total excluding LULUCF (projections)

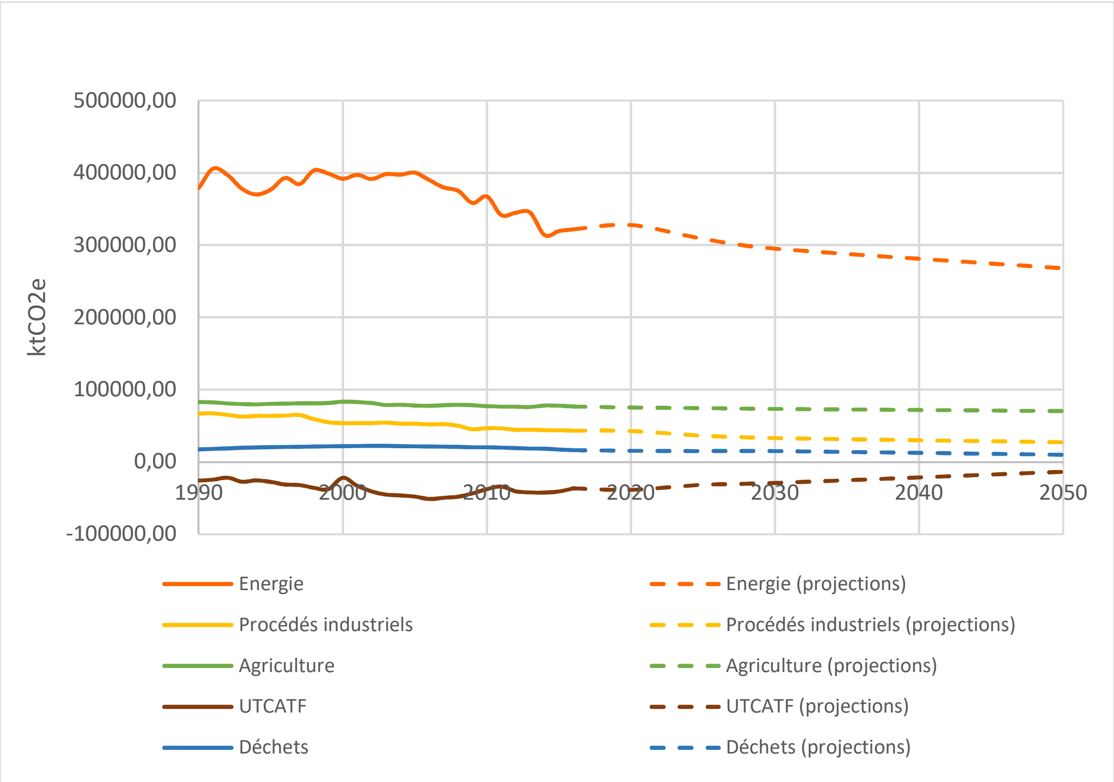
Results by sector

The tables and graphs below show the breakdown by sector of the emission projections for France, firstly by broad sector and then specifically for the energy sector. The results are shown using the CRF categories defined in the IPCC guidelines for national GHG inventories.

Historical and projected trends in GHG emissions in the WEM scenario by broad sector (in ktCO2e):

	1990	2010	2015	2020	2025	2030	2040	2050
	Historical			Projected				
Energy (ktCO2e)	379,060	367,307	319,342	327,831	308,674	295,078	281,497	267,915
Industrial processes (ktCO2e)	67,024	46,706	43,712	42,740	36,305	33,005	30,117	27,228
Agriculture (ktCO2e)	82,980	77,181	77,808	75,295	74,430	73,348	71,871	70,394
LULUCF (ktCO2e)	-25,847	-37,551	-40,829	-38,509	-31,598	-29,039	-21,330	-13,621
Waste (ktCO2e)	17,306	20,359	17,198	15,478	15,033	15,020	12,476	9,932
Total (excluding LULUCF) (ktCO2e)	546,369	511,554	458,060	461,344	434,442	416,451	395,961	375,470
Total (including LULUCF) (ktCO2e)	520,522	474,003	417,231	422,836	402,843	387,413	374,631	361,849

Figure 22: Projections by sector – WEM scenario



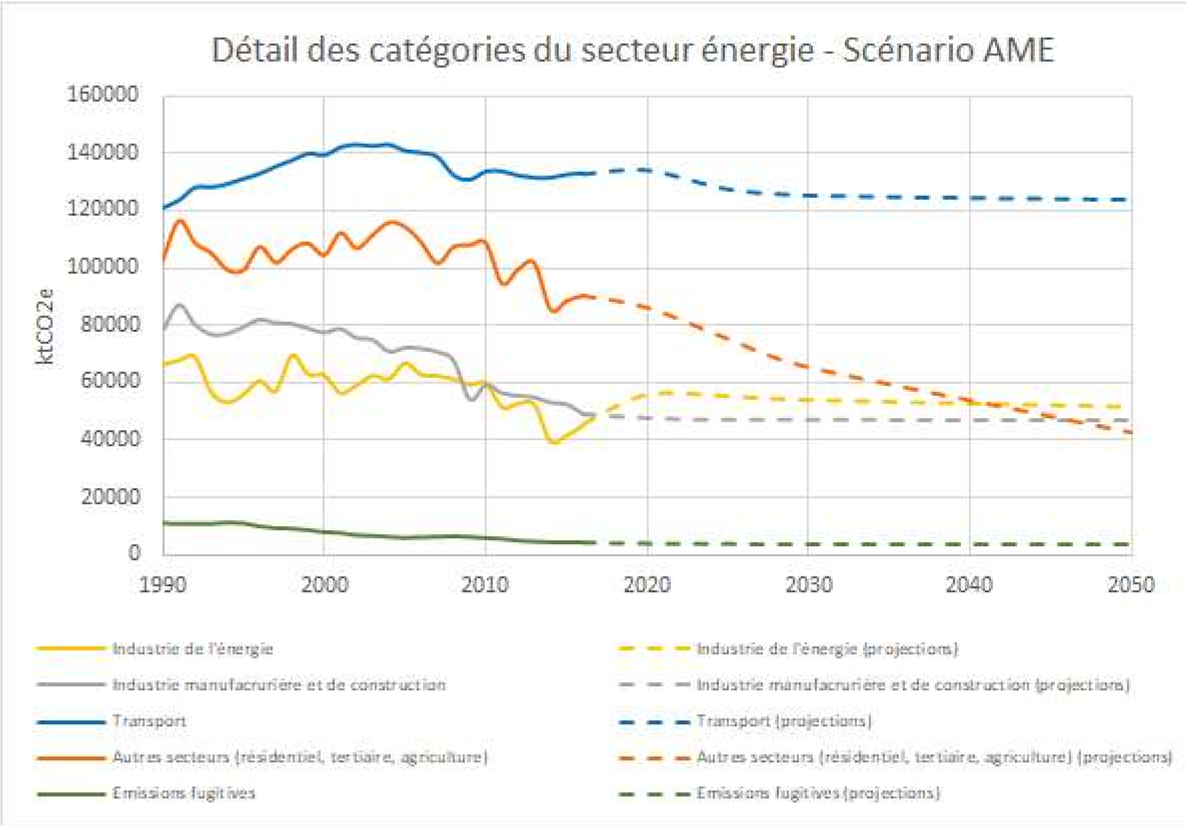
ktCO2e	ktCO2e

Energie	Energy
Energie (projections)	Energy (projections)
Procédés industriels	Industrial processes
Procédés industriels (projections)	Industrial processes (projections)
Agriculture	Agriculture
Agriculture (projections)	Agriculture (projections)
UTCATF	LULUCF
UTCATF (projections)	LULUCF (projections)
Déchets	Waste
Déchets (projections)	Waste (projections)

Breakdown of categories for the energy sector (in ktCO2e):

	1990	**2010**	**2015**	**2020**	**2025**	**2030**	**2040**	**2050**
	Historical			Projected				
Energy industry	66,392	59,872	41,799	55,739	55,122	53,804	52,590	51,376
Manufacturing industries and construction	78,074	59,255	52,419	47,663	46,983	46,957	46,824	46,690
Transport	120,665	133,442	132,322	134,233	127,605	125,490	124,711	123,931
Other sectors (residential, tertiary, agriculture)	102,938	108,952	88,638	86,400	75,405	65,395	53,996	42,597
Fugitive emissions	10,991	5,786	4,165	3,797	3,560	3,433	3,377	3,321

Figure 23: Breakdown of categories for the energy sector – WEM scenario



Détail des catégories du secteur énergie - Scénario AME	Breakdown of categories for the energy sector - WEM scenario
ktCO2e	ktCO2e
Industrie de l'énergie	Energy industry
Industrie de l'énergie (projections)	Energy industry (projections)
Industrie manufacturière et de construction	Manufacturing and construction industries
Industrie manufacturière et de construction (projections)	Manufacturing and construction industries (projections)
Transport	Transport
Transport (projections)	Transport (projections)
Autres secteurs (résidentiel, tertiaire, agriculture)	Other sectors (residential, tertiary, agriculture)
Autres secteurs (résidentiel, tertiaire, agriculture) (projections)	Other sectors (residential, tertiary, agriculture) (projections)
Émissions fugitives	Fugitive emissions
Émissions fugitives (projections)	Fugitive emissions (projections)

The above figures show that the existing measures make it possible to reduce or stabilise the emissions for the various sectors.

In particular, the existing measures enable:

- **A reduction in emissions for the transport sector (energy emissions), of 5% in 2030 and 6% in 2050 compared to 2015. In 2050, they will essentially be at their 1990 level.**

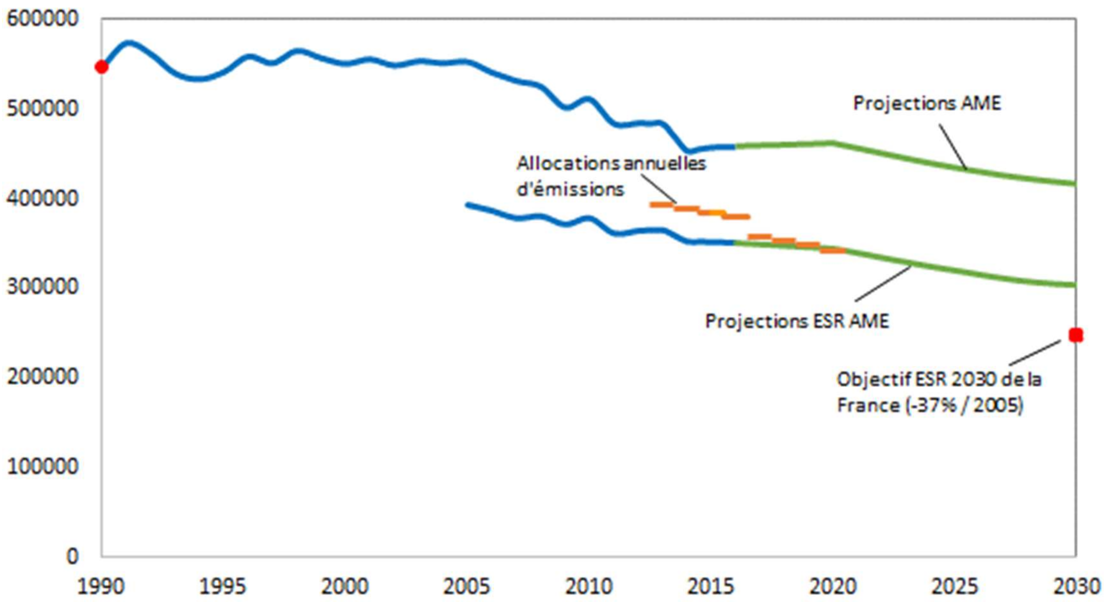
- **A significant reduction in emissions for the residential/tertiary sector. Emissions for the category of 'other energy sectors' including residential, tertiary and agriculture (which represents a minor share of the category) fall by 26% in 2030 and 52% in 2050 compared to 2015.**
- **A reduction in emissions for the manufacturing industry sector of 10% in 2030 and 11% in 2050 compared to 2015.**
- **A reduction in emissions for the industrial processes, agriculture (excluding energy) and waste processing sectors of 24%, 6% and 13% respectively between 2015 and 2030 and 38%, 10% and 42% respectively between 2015 and 2050.**
- **A reduction in GHG removals of 29% in 2030 and 67% in 2050 compared to their level in 2015. The quantity of GHG removals has been revised downwards following an adjustment to the WEM scenario compared to the initial version of the PNIEC project.**

Results for WEM projections for the ESR sector

The WEM projections have been broken down into ETS and ESR emissions in order to assess whether France's European targets have been met in the WEM scenario.

The figure below shows the projections for total emissions, the projections for ESR emissions and the Annual Emission Allocations taken from the Effort Sharing Decision (ESD) and the target set by the Effort Sharing Regulation (ESR) in 2030 for France (a reduction of 37% compared to 2005, thus approximately 248 MtCO2e in 2030).

Figure 24: Projections for the WEM scenario for ESR



Projections AME	WEM projections
Allocations annuelles d'émissions	Annual emission allocations
Projections ESR AME	WEM ESR projections
Objectif ESR de la France (-37%/2005)	ESR target for France (-37%/2005)

In 2020, the ESR emissions forecast in the WEM scenario are 345,449 ktCO2e, and thus very slightly above (+0.3%) the annual emission allowance stated in the ESD for France in 2020 (344,300 ktCO2e). According to the projections, and given the surplus of annual emission allowances accumulated since 2013, the existing measures therefore make it possible for France to comply with the requirements imposed by the ESD in 2020.

In 2030, the ESR emissions forecast in the WEM scenario reach a level of 303,378 ktCO2e, which is approximately 21% above the 2030 ESR target set for France. The existing measures therefore do not make it possible for France to meet the requirements of the ESR for 2030.

4.2.2. Renewable energies

All of the measures developed in Part 3 should modify the French energy mix. This section reviews the situation in the various sectors and finishes with the projections for expected energy mixes following application of the measures described in Part 3, to meet the targets stated in Part 2.

4.2.2.1. Renewable and recovered heating and cooling

Heating represents 42.3% of final energy consumption in 2017, namely 741 TWh. The residential and tertiary sector represents 65% of final consumption of heating, industry represents 30%, and the portion associated with agriculture is minimal.

Heat is essentially generated 40% by gas, 21% by renewable energies (biomass, heat pumps, geothermal energy, biogas, solar thermal), electricity and oil (18% and 16% respectively) and to a marginal extent by coal (5%).

The share for renewable energies has been increasing by an average of 0.8 point each year since 2010. This significant increase is the result of an increase in heat generation from renewable sources and a fall in final heat consumption. In 2028, renewable heat generation will be between 219 and 247 TWh.

The total heat requirement is expected to be 639 TWh in 2023 and 579 TWh in 2028. The Law on Energy Transition for Green Growth has set a target of 38% renewable energies in final heat consumption by 2030. To meet this target, the speed of growth of the renewable heat rate will need to be increased by an average of 1.2% each year, thus 1.5 times faster than the speed observed between 2010 and 2016. The LTECV also sets a target of a five-fold increase in the quantity of renewable and recovered heat and cold delivered by district heating and cooling systems by 2030 compared to 2012.

France also has European commitments, with a total target of 23% renewables by 2020, which means a target rate for renewable heat of 33% by 2020. This target does not seem attainable within the mandated deadline. The Renewable Energies Directive has recently been revised and published, and requires each Member State to increase its rate of renewable and recovered heat by at last 1.3 points each year between 2020 and 2030. This new target is compatible with the framework set by the LTECV and the targets imposed by the MEP.

The following table illustrates the progress for renewable heat against the targets set by the previous MEP for 2018 and 2023.

2012	2017	Target in MEP_{2016} for 2018	Low target in MEP_{2016} for 2023	High target in MEP_{2016} for 2023
127.7 TWh	155 TWh	173 TWh	200 TWh	221 TWh

The targets for renewable heat set by the MEP adopted in 2016 and values achieved in 2012 (reference year) and 2017

The following table shows the final consumption target for renewable heat that can be achieved through the implementation of the measures. The following table shows the target increase in heat generated using renewable sources set in the MEP 2 and the trajectory achieved.

	Target in MEP 2023	Low target in MEP 2028 Scenario A	High target in MEP 2028 Scenario B
Renewable heat	196 TWh	219 TWh	247 TWh

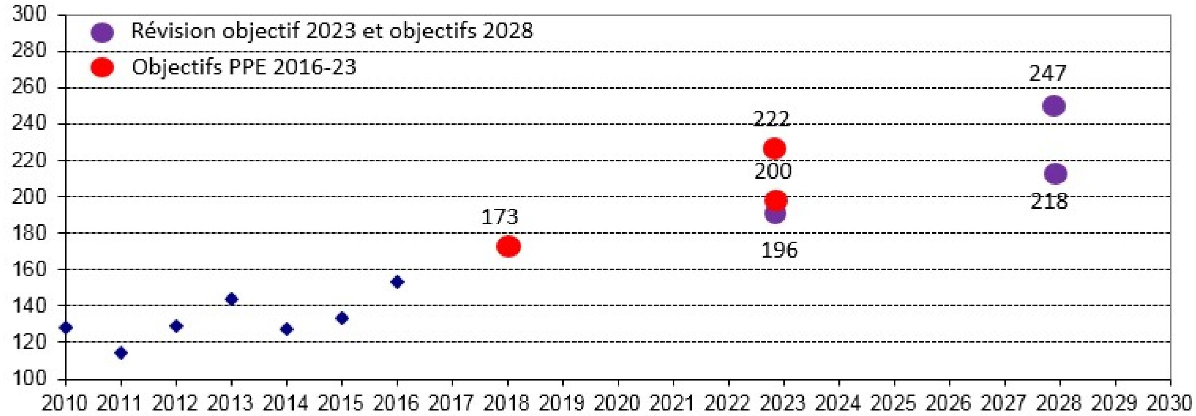


Figure 34: Past and future trend in the final consumption of renewable heat (TWh)

Révision objectif 2023 et objectifs 2028	Review of 2023 target and 2028 targets
Objectifs PPE 2016-23	MEP targets for 2016–2023

Solid biomass

State of play in the sector

Solid biomass is the leading renewable energy in France: in 2017, it represented 78% of renewable heat production. This sector groups together both the wood used by households (independent heating devices such as inserts, stoves and boilers), biomass plants for industrial, collective and tertiary heating, renewable heat produced by biomass cogeneration, and the renewable share of heat produced by urban waste energy recovery units. Around 7.3 to 7.8 million households were consuming wood in 2017 (domestic final wood consumption in 2017 was 80 TWh). Additionally, between 2009 and 2017, the Heat Fund financed nearly 1,093 biomass boilers, including 163 in industry and the rest for the collective sector.

2012	2017	Target in MEP2016 for 2018	Low target in MEP2016 for 2023	High target in MEP2016 for 2023
107 TWh	120 TWh	139 TWh	151 TWh	163 TWh

Targets for renewable heat generated from biomass set by the MEP adopted in 2016 and the values achieved in 2012 (reference year) and 2017

The biomass sector is lagging behind the MEP's 2018 target, with a more marked delay forecast compared to the 2023 target. This delay is seen particularly in the collective and industrial sectors, where biomass has not progressed as expected due to the fall in gas prices. In the call for BCIAT projects (Wood Collective Industry Agriculture Tertiary) managed by ADEME, it was noted that manufacturers are turning to solutions to recover the by-products of their activities (wood waste, etc.). Local reorganisation and the electoral context also made it more difficult to implement biomass projects.

In the domestic wood/biomass sector, there has also been a decrease since 2014 in sales of domestic wood devices (closed fireplaces, inserts and log stoves) and growth in the pellet stove sector (+13% in 2018). After 2017, when sales were up, the market again contracted in 2018 (decrease of 1.5%).

Maximum supply potential

The aspects relating to the biomass resource are discussed above.

Under a European agreement, the heat generated by incinerated domestic waste with energy recovery is considered to be 50% renewable. This resource is accounted for with biomass. There is no objective to increase this resource, but rather only to maximise the energy recovery of a resource for which the trend will be downward.

Socioeconomic, industrial and environmental issues

Yields

Wood can be used directly in devices to produce heat. It is biomass that does not require a conversion stage to be used as fuel.

Independent wood devices referenced under the Green Flame label have good yields (> 75% for inserts, closed fireplaces and log stoves, and > 87% for pellet stoves). In the tertiary, collective and industrial sectors, the efficiency of boilers is up to 85% on average and 95% when they supply district heating and cooling.

In addition to the upstream challenges of mobilising biomass, it is important to promote the most energy-efficient uses of biomass. The use of biomass for heat production should be promoted. It is also important to continue energy recovery of domestic waste treatment units (discussed in a specific chapter).

Sector support issues

The increase in the price for fossil fuels should have a positive influence on investments in renewable heating solutions, which have been decreasing since 2013 due to lower gas prices. Additional actions, such as the increase in the Heat Fund amount and the simplification of the Heat Fund rules, are needed to reinvigorate investment. This will enable support for projects in industry, agriculture and the tertiary sector, through the call for BCIAT projects, and for collective boilers, possibly linked to a district heating system. Support through the CITE for individual wood-burning equipment is also a major challenge for this pathway.

Costs

The solid biomass sector has competitive full production costs. Therefore, for private individuals, the cost of heat production from a log-burning stove is between €48 and €69/MWh and from pellets between €86 and €103/MWh. For collective uses, biomass boilers have a production cost of between €64 and €110/MWh. For industrial biomass, production costs are between €48 and €73/MWh[21]. However, the investment cost is higher than that of the benchmark fossil-fuel solutions, which explains why this sector requires support. No significant reduction is expected in terms of production costs for the biomass sector within the MEP time scales. One of the challenges facing the sector is to develop a more efficient French combustion devices industry by 2022, in anticipation of changes in European ecodesign regulations,[22] and to reduce the production costs of the most powerful devices (6 and 7 stars).

The characteristics of the sector in terms of employment

The wood energy sector generates more than 22,000 jobs in France, including 70% for the domestic wood industry[23]. In 2017, the sector had a ratio of 160 jobs per TWh produced. About 50% of these jobs are direct: those involved in the biofuels production and usage chain (such as forestry work) or the manufacture and maintenance of boilers. The sector relies on national know-how with operators present throughout the value chain. The French industrial context consists of companies operating in the areas of stoves, inserts, boilers and flues for the domestic sector,[24] companies positioned in the manufacture of wood boilers, and companies involved in the operation of boilers for the collective, tertiary and industrial sectors. The total market is €2.8 billion for the domestic wood sector, and €1.7 billion for the collective, tertiary and industrial sectors. Grants to private individuals are contingent upon the use of RGE-certified installers. The qualification of wood energy installers through the Qualibois and Qualibat labels will continue.

Environmental challenges

The increased mobilisation of biomass is one of the priorities for green growth and the fight against climate change. This mobilisation must take place in line with sustainable practices and must form part of the dialogue on the best operational coordination of uses. Cultivation practices and mobilised resources incorporate the challenges of carbon storage in soil, the maintenance of biodiversity, and adaptation to climate change. The National Biomass Mobilisation Strategy (SNMB) devotes a chapter to the conditions of this mobilisation.

A strategic environmental assessment report has been prepared on this SNMB, identifying three major challenges for the production of biomass resources: climate change mitigation, which the mobilisation of biomass addresses through the sequestration effect in wood products with long life cycles and through materials and energy substitution; preservation of soil quality; and preservation and reinforcement of biodiversity and ecosystem services. In terms of soils, to avoid loss of organic matter and minerals, the SNMB includes measures to promote organic soil improvement, research on the link between organic matter in soils and cultivation practices, and the identification of sensitive forest soil areas from which the quantities of residues exported must be limited. In relation to biodiversity, the SNMB could have an effect not just on the volume of old living wood, by encouraging the harvesting of more wood in forests, but also on the volume of dead wood. However, the implementation of the SNMB will also stimulate renewal efforts, which will diversify forest habitats in open/rejuvenated environments. The effect of the SNMB on biodiversity could therefore be positive or negative depending on operating and restocking

21. Source: ADEME study 'Costs of renewable energies', 2016.
22. Two European regulations have been passed on the ecodesign of solid-fuel boilers with a capacity under 500 kW and independent wood-fired heating appliances.
23. Source: 'Markets and jobs in the field of renewable energies', ADEME, July 2017
24. France is the European leader in the production of renewable heat equipment using biomass. French production was valued at €134.7 million in 2015.

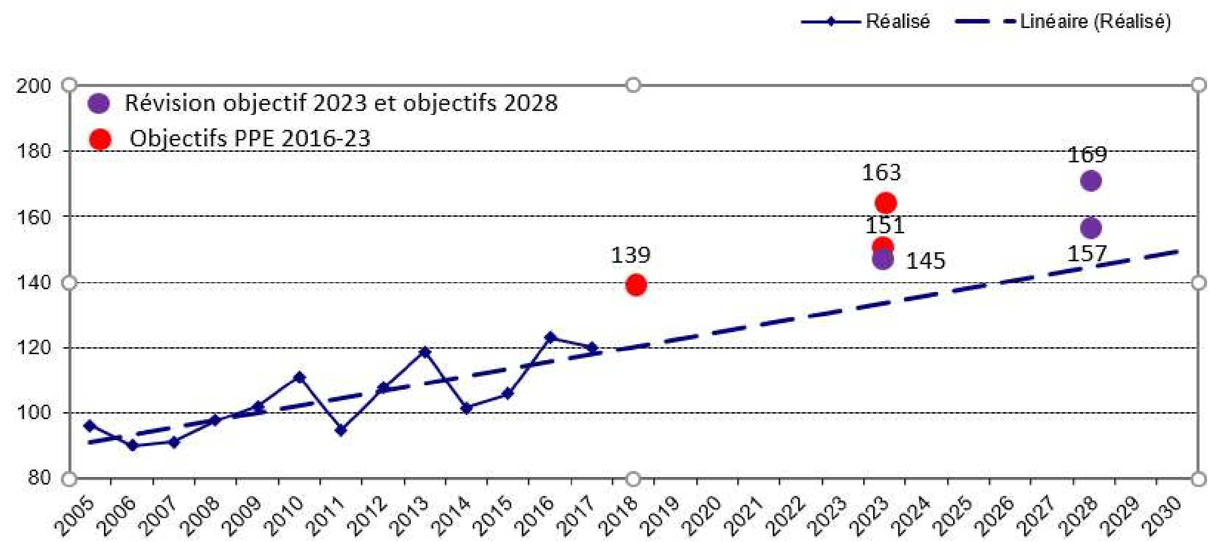
practices and local conditions. A specific environmental measure has been adopted vis-à-vis forest biodiversity (preservation of standing and fallen biodiversity-friendly old wood) and measures to increase knowledge, awareness and training for stakeholders. While ensuring a mobilisation of agricultural biomass resources that is balanced against the issues associated with biodiversity preservation (biodiversity-sensitive zoning and moderation of inputs), apart from environmental measures, the SNMB has an uncertain impact on agricultural biodiversity. The SNMB is considered to have neutral to positive effects on the other environmental challenges deemed to be less of a priority in relation to upstream biomass production sectors (adaptation to climate change, limiting of the consumption of natural agricultural and forest species, sustainable management of water resources, preservation of the quality of the landscape and air quality, limiting of nuisances).

Improved air quality is another key issue, which involves the replacement of older devices with more efficient equipment (minimum 6-star class under the Green Flame label[25]), in particular by maintaining the CITE and ADEME Air-Wood Fund. In 2016, between 7.3 and 7.8 million households used wood, 1.1 million of which in open fireplaces. Performance in terms of atmospheric emissions is progressing satisfactorily. All these performance values will be regulatory at EC level in 2020 (boilers) and 2022 (independent equipment). Additional measures are needed to promote the use of dry wood: a dry, split and debarked fuel emits nearly ten times fewer particles than an unlabelled commercial fuel[26], with the difference being even greater with a self-consumption fuel. A national awareness campaign would also enable the development of a supervised sector and would be able to meet air quality challenges. A four-year trial was launched in 2013 under the Atmosphere Protection Plan (PPA) for the Arve Valley (74) in order to renew individual wood-burning installations. Based on this example, the Air-Wood Fund sponsored by ADEME aims to reduce particle emissions from individual wood burning in the PPAs and must be continued, with targeted actions where relevant from an environmental and economic points of view.

Finally, in order to assess the impact of biomass projects properly, polluting emission factors need to be updated to take account of bag filter processing technologies that are under development. Emission values for NOx and dust from district heating plants with a capacity in excess of 20 MW will be updated by CITEPA in the first half of 2018. A review of emission factors for medium- and small-capacity industrial boilers will begin in the middle of the year and must be continued over time.

25. The 5-star class was abandoned on 1 January 2018.
26. Source: CERIC study.

Figure 25: Final consumption of heat produced from biomass (TWh)



Révision objectif 2023 et objectifs 2028	Review of 2023 target and 2028 targets
Objectifs PPE 2016-23	MEP targets for 2016–2023
Réalisé	Achieved
Linéaire (Réalisé)	Linear (Achieved)

Heat pumps

State of play in the sector

The number of installed heat pumps in 2017 is around 7.1 million, of which 78% are air/air, 13% are air/water, 6% are thermodynamic water-heaters, and 3% are geothermal equipment[27]. The renewable thermal production of the heat pump sector amounted to 27.6 TWh in 2017. The renewable share used by heat pumps was 75% in private dwellings, 16% in tertiary and 9% in collective[28].

	2012	2017	Target in MEP$_{2016}$ for 2018	Low target in MEP$_{2016}$ for 2023	High target in MEP$_{2016}$ for 2023
Aerothermal heat pumps	14.5 TWh	23.5 TWh	21 TWh	27 TWh	30 TWh
Geothermal heat pumps	2.9 TWh	3.14 TWh	4.6 TWh	5.8 TWh	7 TWh

Targets for renewable heat generated from heat pumps set by the MEP adopted in 2016 and the values achieved in 2012 (reference year) and 2017

27. A distinction is made between aerothermal heat pumps that take heat from the air and transfer it either by radiators (air/water) or by forced air (air/air) and geothermal heat pumps (water/water), which take heat from the ground or from surface water and return it through heated floors or radiators.
28. Overview of renewable and recovered heat – Autumn 2017

The ambitious objectives of the previous MEP exercise for 2018 had already been surpassed in 2016. The overall dynamics of the heat pump sector are indeed stronger than expected. However, the situation differs between aerothermal heat pumps and geothermal heat pumps: there is a huge development in the air/air heat pump market, with a slowdown in the development of air/water heat pumps and a major decline in geothermal heat pumps (-15% sales per year since 2008).

Maximum supply potential

Heat pumps have potential for development, particularly in private dwellings (new and renovated) and in the tertiary sector. The French Heat Pump Association (AFPAC) estimates the maximum potential to be 75 TWh in the residential sector and 40 TWh in the tertiary sector by 2050.

Socioeconomic, industrial and environmental issues

Yield

Heat pumps consume electricity or fuel (gas or fuel oil) to operate. Their performance is described by a coefficient (COP) that expresses the energy returned/energy consumed ratio. The COP for heat pumps is between 3 and 4.5 for heating and between 2.5 and 3 for hot water. Only systems with a COP above 2.5 are taken into account for the achievement of European renewables targets. Geothermal heat pumps have the highest COPs. There is room for improvement in increasing the COPs of heat pumps.

Sector support issues

There has been a direct impact of Government support policies on the development of the sector since 2008. Heat pumps are eligible for the energy transition tax credit, which has been 30% since 2015 (based on eligibility conditions). A lower VAT rate is also applicable to the installation of heat pumps eligible for the CITE. It is important that this support be maintained for the sector.

In the collective, tertiary and industrial sectors, the Heat Fund supports projects for heat pump-assisted geothermal heat production. Since 2018, the Heat Fund has also been financing the most efficient renewable cold production systems, including those using district heating-based geothermal heat pumps. Support for renewable cold via the Heat Fund and the recognition of renewable cold in the Renewable Energy Directive are important challenges for the support of geothermal heat pumps, especially in the tertiary sector.

Heating regulation challenges

Heating regulation requirements for new buildings are having a major impact on the development of the sector (the growth of heat pumps and thermodynamic water heaters in new buildings was boosted by the cumulative effect of RT2012 and CITE). To continue this dynamic, it is essential to set ambitious targets for future heating regulations based on the ‘Energy 3’ level of the current E+C- label at the very least, and by imposing an ambitious renewable heat minimum threshold for all new buildings (private, collective and tertiary)[29].

Costs

The full costs of production for air/water heat pumps and geothermal heat pumps in private dwellings are competitive compared to the gas benchmark (€116 to €145/MWh). In collective installations, the full cost of production of geothermal heat pumps is €56 to €112/MWh.

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29. Self-consumption is deducted from electrical requirements in the case of PV, while renewable energy, because it is consumed on-site, is deducted from requirements.

Geothermal heat pumps are a more expensive investment than aerothermal heat pumps, because of the extra cost of the horizontal or vertical heat exchanger (which almost doubles the investment price), but this cost is offset by very low operating costs. There have been significant price drops in recent years (-17% for air/air heat pumps and -6% for air/water heat pumps).

The characteristics of the sector in terms of employment

The heat pump market was worth €2.8 billion in 2017. It is estimated that around 24,000 jobs are associated with heat pump markets across 20 industrial sites in France. Some 85% of jobs are related to manufacturing, installation and distribution, and the other 15% to maintenance and repair. In 2016, the sector had a ratio of 949 jobs per TWh produced.

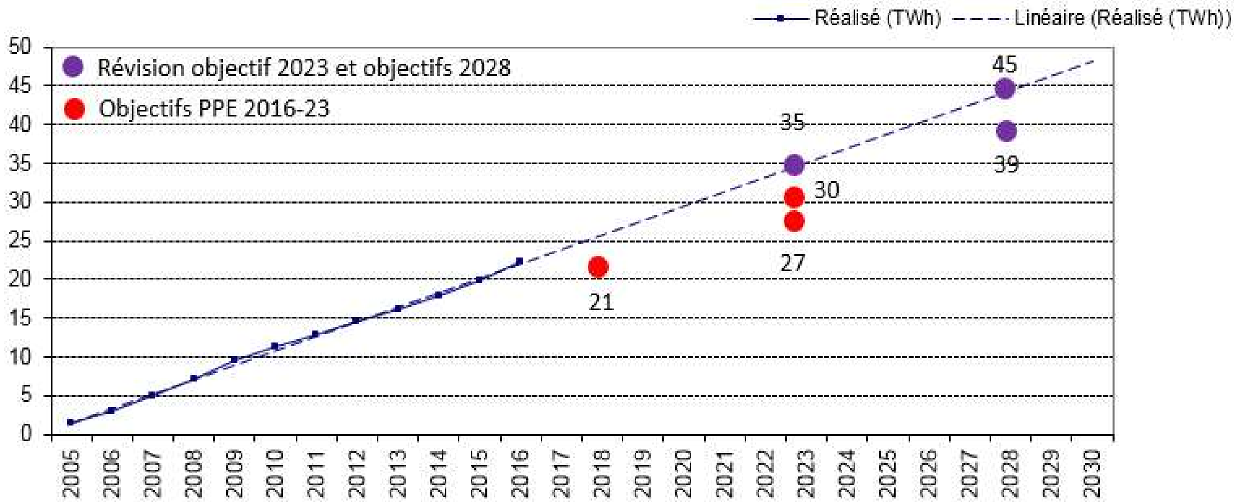
The air/water heat pump market is partly supplied by imports from Asia and partly by European production. The geothermal heat pump market is mainly sourced by European production with significant French production, in a market in danger (4,000 jobs are associated with geothermal energy in France, the majority linked to geothermal heat pumps).

Environmental challenges

The most significant impact of heat pumps is linked to the use of refrigerants (risk of leaking) with high global warming potential. Research and development are essentially focused on improving the performance of equipment, replacing refrigerants and reducing noise. An implementing regulation for the European Directive on ecodesign for energy-related products, adopted in 2015, addressed the minimum performance requirements of heat pumps placed on the market, as well as enhanced acoustic requirements in 2017. Finally, the end of life of heat pumps is managed as part of the waste management of electrical and electronic equipment, with priority being given to recycling.

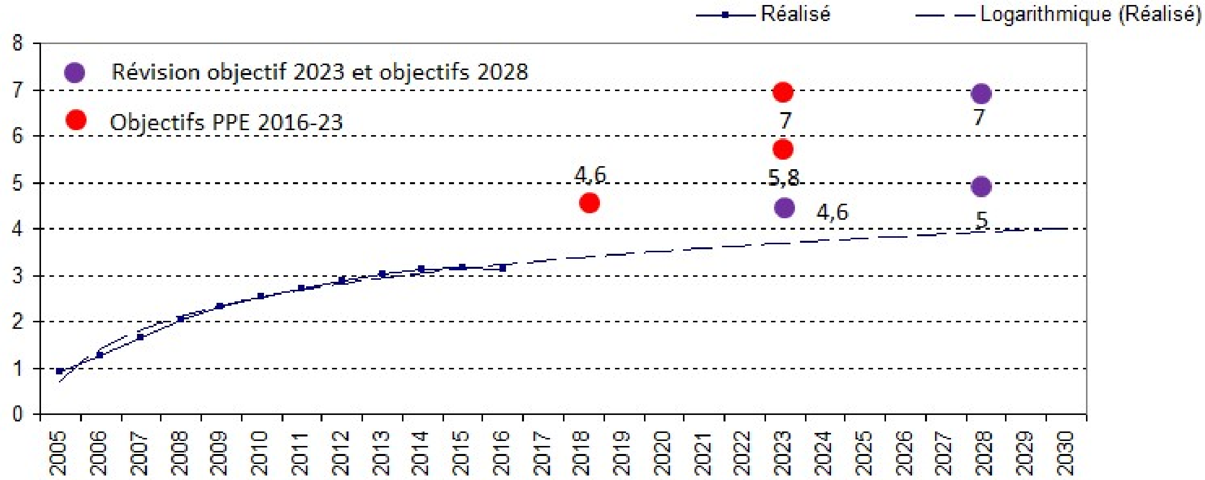
District cooling using geothermal heat pumps for cold production is an alternative to individual air conditioners. Through centralised maintenance, this solution makes it possible to obtain low leakage rates.

Figure 26: Final heat consumption produced by aerothermal heat pumps (TWh)



Révision objectif 2023 et objectifs 2028	Review of 2023 target and 2028 targets
Objectifs PPE 2016-23	MEP targets for 2016–2023
Réalisé (TWh)	Achieved (TWh)
Linéaire (Réalisé (TWh))	Linear (Achieved (TWh))

Figure 27: Final heat consumption produced by geothermal heat pumps (TWh)



Révision objectif 2023 et objectifs 2028	Review of 2023 target and 2028 targets
Objectifs PPE 2016-23	MEP targets for 2016–2023
Réalisé	Achieved (TWh)
Logarithmique (Réalisé)	Linear (Achieved (TWh))

Deep geothermal energy

Geothermal energy is the use of thermal energy contained in the subsoil. This chapter deals only with deep geothermal energy, which includes 'low geothermal energy' (30 °C to 90 °C) using resources up to about 2,000 m, and 'medium geothermal energy' (over 90 °C), which involves centralised production commonly used for district heating via heat networks. 'Very low geothermal energy' (less than 30 °C) is the heat produced by heat pumps (see above). 'High geothermal energy' (over 150 °C) is covered in the electricity section (see below).

State of play in the sector

There are 79 deep geothermal energy installations in France, of which 49 are located in the Paris basin, 21 in the Aquitaine basin, and the others in Alsace, the Rhone Valley and Limagne. These installations provided a total of 1,970 GWh of renewable thermal generation in 2017. A total of 90% of this production was for district heating, 8% for agriculture and 2% for thermal establishments.

2012	2017	Low target in MEP_{2016} for 2023	High target in MEP_{2016} for 2023
1.2 TWh	1.97 TWh	4.6 TWh	6.4 TWh

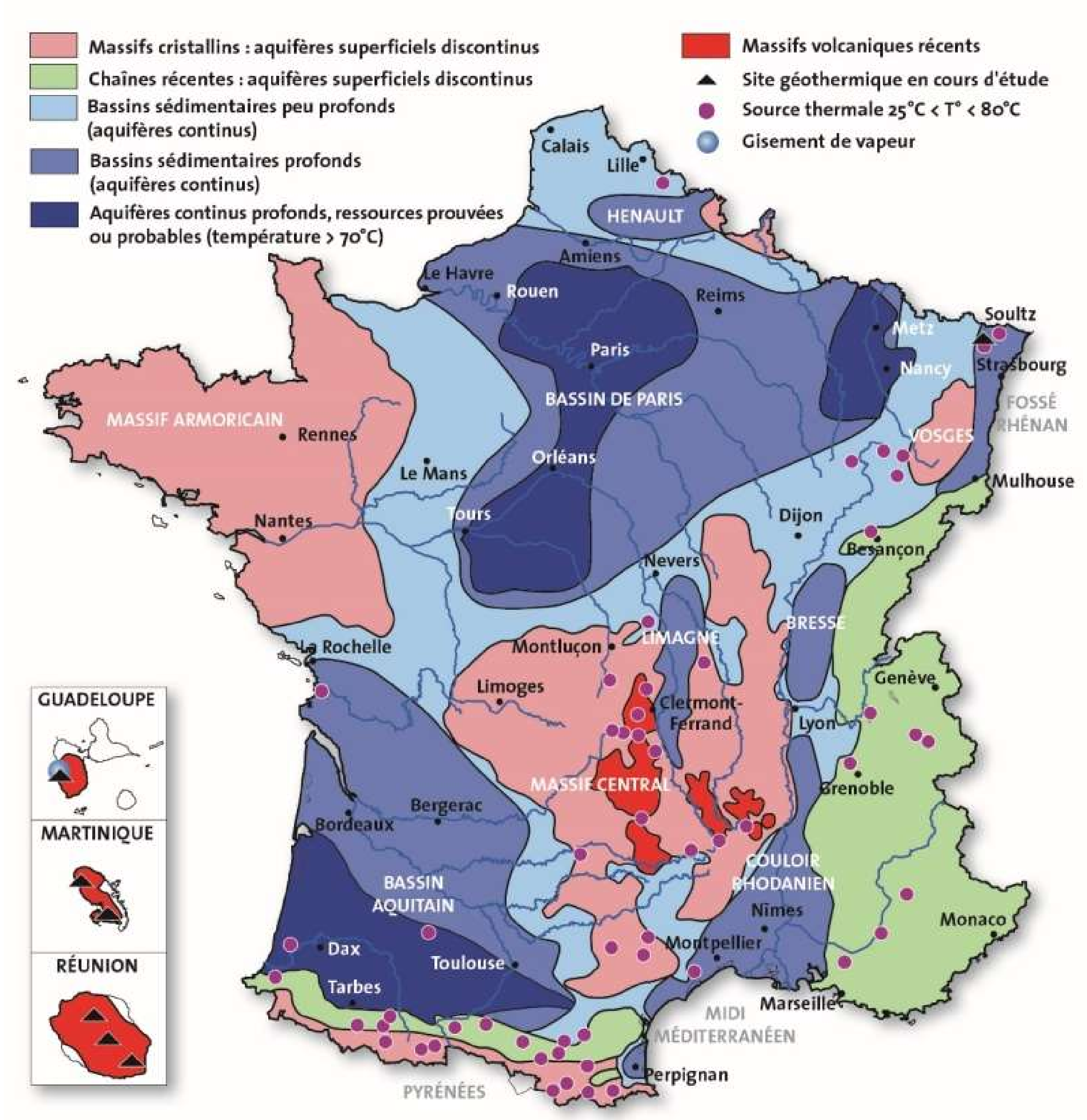
Targets for renewable heat generated from deep geothermal energy set by the MEP adopted in 2016 and the values achieved in 2012 (reference year) and 2017

The current rate of development of low- and medium-energy geothermal heat production does not match that predicted by the previous MEP exercise. There is indeed a stagnation that could continue, as few projects are in the study phase. The average rate of development was 70 MWth/year between 2010 and 2016, whereas it would be necessary to reach a rate of six to ten times higher to achieve the low-to-high objectives of the previous MEP for 2023. It is therefore important to boost support but also to review the 2023 target downwards, and aim for about six operations a year of 10 MW thermal units between 2018 and 2023 and 11 operations per year of 10 MWth between 2024 and 2028.

Maximum supply potential

The use of deep geothermal energy is limited to sufficiently deep and permeable geological formations containing aquifers where the water has been heated deep down in contact with the rocks. One of the challenges facing the sector relates to the development of deep geothermal energy coupled with heat networks in Île-de-France (creation, extension of existing networks and conversion of networks using fossil fuels to geothermal), but also other aquifers less well known than the Dogger aquifer. Other deep aquifers have high potential but their precise resources are unknown; for example, the Trias and Lusitanien aquifers in Île-de-France, aquifers in the Aquitaine Basin, Alsace, Hauts de France and the Provence-Alpes-Côtes d'Azur region. The maximum potential of deep geothermal energy for heat production is estimated to be 5.8 TWh.

Figure 28: Map of aquifers in Metropolitan France (Source: ©BRGM IM@Gé)



Massifs cristallins : aquifères superficiels discontinus	Crystalline mountains: discontinuous surface aquifers

Chaînes récentes : aquifères superficiels discontinus	Recent chains: discontinuous surface aquifers
Bassins sédimentaires peu profonds (aquifères continus)	Shallow sedimentary basins (continuous aquifers)
Bassins sédimentaires profonds (aquifères continus)	Deep sedimentary basins (continuous aquifers)
Aquifères continus profonds, ressources prouvées ou probables (température > 70°C)	Deep continuous aquifers, proven or probable resources (temperature > 70 °C)
Massif volcaniques récents	Recent volcanic mountains
Site géothermique en cours d'étude	Geothermal site under study
Source géothermale en cours d'étude	Geothermal source under study
Source thermale 25°C< T° < 80°C	Thermal source 25 °C < T° < 80 °C
Gisement de vapeur	Steam deposit
Massif armorican	Armorican massif
Bassin de Paris	Paris basin
Bassin aquitain	Aquitaine basin
Couloir rhodanien	Rhone Valley
Fossé rhénan	Upper Rhine Plain
Genève	Geneva
Pyrénées	Pyrenees
Midi Méditerranéen	Midi-Mediterranean
Guadeloupe	Guadeloupe
Martinique	Martinique
Réunion	Reunion

Socioeconomic, industrial and environmental issues

Yield

The energy yield of deep geothermal operations is very good, especially when coupled with district heating. It is estimated that the yield is around 95%. Deep geothermal energy is also a long-term energy: the life of a well is at least 30 years.

Coordination

One of the challenges of geothermal energy is to set up local coordination: the regions where a dedicated geothermal coordinator is in place show a more marked dynamic in terms of development of the sector (e.g. Centre Val de Loire, Hauts de France and Grand Est). In addition, at least one trained coordinator per large region would help to raise awareness among individuals and public or private institutions about the advantages of geothermal energy for the production of heat and/or cold. This action should be promoted by both ADEME and the Regions concerned.

Coverage of geological risks

Geological risk, linked to the discovery of a resource with the appropriate temperature and flow characteristics, hinders the development of projects. Furthermore, investment in the exploration phase is costly, which means that the risk of an insufficient resource must be insured. Accordingly, since the 1980s, the SAF environment Fund[30] has covered both the short-term risk (insufficient geothermal resources) and the long-term risk (reduced exploitability of the geothermal resource) for projects aimed

30. SAF environnement is a subsidiary of the Caisse des Dépôts et des Consignations.

at producing heat. The continuation of this mechanism, which has proven effective, must be guaranteed and made scalable (see the next issue on little-known aquifers). Furthermore, the establishment of the GEODEEP Guarantee Fund, with the support of ADEME and the participation of the Caisse des Dépôts et Consignations, will make it possible to cover the risk of geological risks in the drilling phase for projects in Metropolitan France producing heat, where the estimated temperature is higher than 120 °C, making it possible to produce electricity and/or heat where the resource is located in less well-known mainland geological contexts. This mechanism is currently being reported to the European Commission and it is important to finalise it to support all deep geothermal projects that will be filed.

The Heat Fund already supports deep geothermal operations (production of doublets or triplets and associated heat networks). A project could be implemented to stimulate operations on insufficiently known aquifers, for example by financing additional exploration activities (3D seismic surveys, etc.) to provide a guarantee for the drilling to be undertaken. A study on this potential development could be conducted in order to determine the exact methods and the necessary allocations, for example in the context of the doubling of the Heat Fund.

Innovation

The sector benefits from French know-how and must maintain its lead in terms of innovation. The development of geothermally sourced cold-/hot-coupled networks is a major challenge. The Renewable Energy Directive (EU) 2018/2001 gives a new place to renewable cold production. Furthermore, an amendment to the Mining Code explicitly mentioning cold production using geothermal energy could help to develop this technology.

Since 2018, the Heat Fund has been supporting renewable cold technologies with a high degree of efficiency.

Costs

Low- and medium-temperature thermal energy technology is well developed. While investment costs are high and require major capital input (return period exceeding 10 years, excluding grants), running costs are, by contrast, low, which makes this one of the least costly renewable energies over the long term which in turn provides a guarantee of price stability. According to ADEME, the full cost of production of deep geothermal energy is €74 to €99/MWh. Work is under way in the sector to ensure better identification of the costs per technology and better characterisation of the life cycle analysis. The potential for innovation exists in most segments of the project value chain (sub-horizontal, multi-shaft drilling, optimisation of the exploitation of reservoirs, materials, etc.). Production costs should therefore remain stable or decrease slightly.

The characteristics of the sector in terms of employment

The low-energy geothermal energy market was worth €53 million in 2014. Drilling companies (including near-to-surface geothermal energy drilling companies) account for about 2,400 full-time employees and geothermal energy for district heat generation also mobilises full-time grid operators. Professionals are trained and certified, and the French sector has the relevant know-how. In 2016, the sector had a ratio of 1,500 jobs per TWh produced.

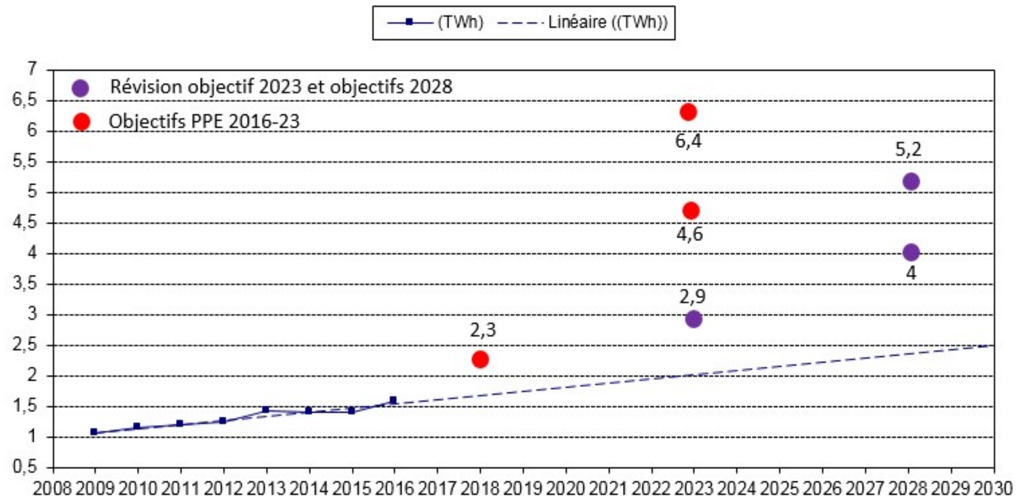
Environmental challenges

It is mainly in the exploration phase that certain risks and nuisances can arise, especially during drilling operations (risk of creating connections between several aquifers, lorry traffic, etc.). The existing regulatory context (Mining Code, Water Law) governs the implementation of operations to minimise nuisance.

During the exploration phase, geothermal operations have little or no impact. The main issue thus concerns the possibility of depleting the resource, which could be mitigated by alternating production of hot and cold or by refilling the subsoil (cooling of buildings, summer injection of solar energy or excess residual energy).

A life cycle analysis has been conducted in the past on some exemplary operations (Soultz-sous-Forêt, Bouillante). It would be interesting to carry out a life cycle analysis on an operation typical of the Paris basin.

Figure 29: Final consumption of heat produced from deep geothermal energy (TWh)



Révision objectif 2023 et objectifs 2028	Review of 2023 target and 2028 targets
Objectifs PPE 2016-23	MEP targets for 2016–2023
(TWh)	(TWh)
Linéaire ((TWh))	Linear (TWh)

Solar thermal

State of play in the sector

In 2016, total solar thermal power resources in Metropolitan France occupied an installed area of 2.29 million m² with total production of 1.17 TWh/year. The installed floor area in the residential sector represents 54% of the total area, with 43% in the tertiary sector and 3.5% in industry and agriculture.

Solar thermal technology is used exclusively for the production of domestic hot water (from a single solar water heater or a shared domestic hot water system) or for the joint production of hot water and heating (combined solar system).

2012	2017	Low target in MEP2016 for 2023	High target in MEP2016 for 2023
1 TWh	1.18 TWh	3.1 TWh	4.6 TWh

Targets for renewable heat generated from solar thermal energy set by the MEP adopted in 2016 and the values achieved in 2012 (reference year) and 2017

The previous MEP provided for the revitalisation of solar thermal energy through large-scale applications in collective and industry heating and in district heating, and prospects in the private residential and collective sectors in the event of an enhancement in the heating regulations governing the generation of renewable heat. The final consumption of heat from solar thermal was based on an average rate of 100,000 m² installed per year in private dwellings and about 200,000 m² installed per year in the collective/tertiary sector. In 2015, fewer than 100,000 m² were installed across all sectors, so the rate was three times lower. For 2023, the MEP targets need a five- to nine-fold increase in the m² of thermal surface area to be installed per year on average over the 2016–2023 period compared to 2015. There were some encouraging signs in 2017, such as a halt to the decline of solar in collective applications and growth in the combined solar segment (fewer than 500 installations per year). In 2017, the production of solar thermal energy increased +3.7% compared to 2016.

Maximum supply potential

France has particularly good solar resources, ranking fifth in Europe. The maximum potential of solar thermal energy is estimated as 6 TWh (by 2050).

Socioeconomic, industrial and environmental issues

Yield

The energy yield varies depending on the climatic zone in which the solar equipment is installed:

- the productivity of individual facilities is around 300 kWh/m²/year in the north of France and 500 kWh/m²/year in the south;
- the productivity of collective or district facilities is around 450 kWh/m²/year in the north of France and 600 kWh/m²/year in the south;
- the productivity of industrial facilities in the south of France is around 700 kWh/m²/year. These are used as an additional resource and can provide 30% of the heating demand of a manufacturer.

The seasonal energy efficiency of combined solar systems is at least equal to 90%. Energy efficiency for water heating varies between 65% and 85%, depending on the extraction profile. In terms of meeting demand:

- solar water heaters provide 50%–60% of domestic hot water (DHW) needs;
- combined solar systems provide 30% of cumulative DHW + heating requirements, distributed 60%–70% for DHW versus 15%–25% for heating;
- collective and tertiary solar water heaters provide 50% of hot water requirements.

Heating regulation challenges

Following a period of marked growth until 2008, it is the domestic solar market in particular that has seen the sharpest decline. Despite the requirement for at least 5 kWh/m² of renewable energy in new private dwellings, solar thermal energy is struggling to develop because it competes with other renewable equipment with lower installation costs and which also meet the RT2012 thermal regulation criteria. Enhancing these criteria would make it possible to use more efficient solar equipment.

As the markets for new collective or tertiary buildings are not under an obligation to include renewable energies, they are not developing in this market. The Renewable Energy Directive (EU) 2018/2001 provides for a minimum level of renewable energies in all new and heavily renovated buildings, including in the collective and tertiary sector (in addition to private dwellings). The installation of solar thermal energy in new builds and in renovations would represent an efficient response to this new requirement. The modernisation of the RT2012 calculation engine is currently being considered in order to upgrade energy regulation, coordination and storage systems, and would be favourable to the development of the sector. Finally, an obligation to study the solar thermal solution in new operations was successfully launched in Brittany by the Brest conurbation and could be duplicated in other regions.

In renovation, solar thermal installations are eligible for the CITE (energy transition tax credit). A CITE credit differentiated according to technology would make it possible to promote the performance of solar solutions.

The dissemination of combined solar systems is also supported as part of the boost provided by the ‘energy savings 2018–2020’ initiative. This scheme provides for the introduction of rebates for certain operations undertaken between 1 April 2018 and 31 December 2020, for energy-poor households replacing oil-fired boilers with equipment using renewable energies (biomass boiler, air/water, water/water or hybrid heat pumps, combined solar system, connection to a district heating network).

Potential of solar energy on the grid and in industry

An opportunity for the development of solar thermal energy in industry and on district heating and cooling is there for the taking. The Heat Fund would enable support for solar energy in these sectors. Innovative solar concentration technology is already being supported through the Heat Fund’s call for projects on new emerging technologies and must continue. In industry, new business models are developing, such as sale by kWh or leasing, which make it possible to offer competitive deals compared to gas (including the cost of storage). Finally, studying the replacement of energy in favour of a renewable solution in energy audits would also make it possible to raise awareness about solar alternatives and their benefits.

Solar thermal energy has major potential. It is in ‘competition’ with the photovoltaic sector insofar as it mobilises the same surfaces and investment capacities. The sector’s maximum potential lies in the collective sector (including on the grid), the tertiary sector and in industry, where large surface areas can be deployed, thus lowering costs. The sector believes that it has the immediate capacity to manufacture and install three to four times more solar thermal equipment than it does today. The sector today is mostly export-based.

Current and foreseeable costs

The full cost of producing solar heat in private dwellings is higher than the cost of thermodynamic water heaters. For combined solar systems, this is between €225 and €337/MWh[31]. The cost of heat in the collective sector is 40% lower than in private dwellings, at €78 to €114/MWh. On-grid solar energy also offers attractive costs at between €76 and €128/MWh. Professionals foresee a 10% to 15% reduction in the overall 20-year cost by 2025 for solar water heaters and for combined solar systems. Lower costs are also expected for solar energy in industry.

The characteristics of the sector in terms of employment

The solar thermal market (Metropolitan France and overseas territories) amounted to €319 million in 2017 and generated 2,320 jobs[32]. In 2017, the sector had a ratio of 1,160 jobs per TWh produced. The decline in solar energy led to a fall in solar thermal jobs (-34% jobs between 2013 and 2017). The jobs are mostly located in the manufacturing, installation and maintenance of equipment. The manufacture of equipment in France today is mostly geared towards exports (85% of activity in 2015). Most installers of solar thermal collectors are grouped under the Qualisol label, which has made it possible to increase the reliability of the installations. Finally, the collective sector is brought together within SOCOL[33],

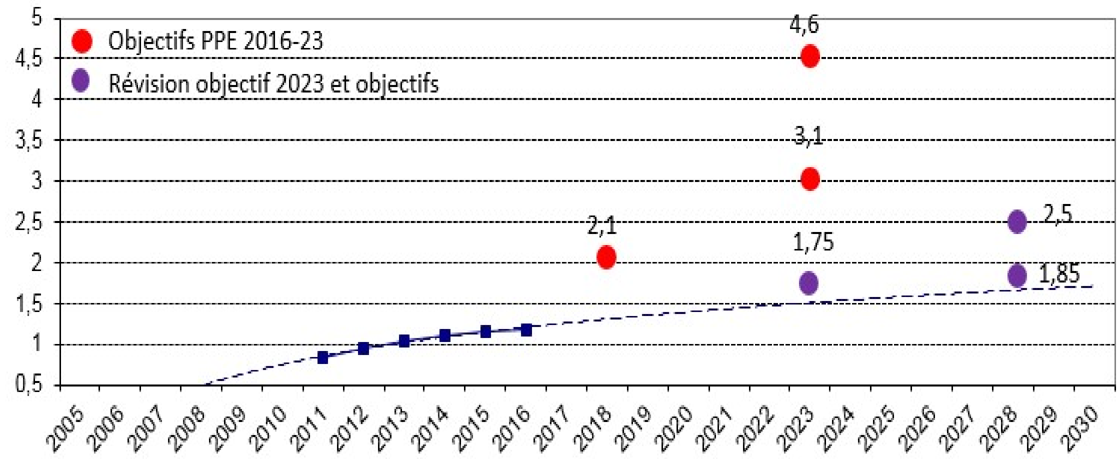
31. Source: ADEME study ‘Costs of renewable energies’, 2016.
32. Source: ‘Markets and jobs in the field of renewable energies’, ADEME, 2019.
33. Scheme launched in 2009 by Eneplan, with the support of ADEME and GRDF.

which has developed qualifications for design offices and installers, to bring stakeholders together and disseminate best practices. SOCOL covers nearly 1,000 experts, professionals and project owners.

Environmental challenges

Solar thermal energy is low in CO_2 emissions, at around 35 gCO_2/kWh (solar water heaters). The most significant impact is therefore related to the electric or gas/oil auxiliary (coverage rate of 50%). Finally, the end of life of solar water heaters is managed as part of the waste management of electrical and electronic equipment, favouring recycling.

Figure 30: Final consumption of heat produced by solar thermal energy (TWh)



Objectifs PPE 2016-23	MEP targets for 2016–2023
Révision objectif 2023 et objectifs	Review of 2023 target and targets
SDES métropole (TWh)	Metropolitan SDES (TWh)
Log. (SDES métropole (TWh))	Log. (Metropolitan SDES (TWh))

Recovered heat

Waste (residual) heat is the heat generated as the by-product of a process, which is not necessarily recovered[34]. When this waste heat is recovered and used, the process is called heat recovery. There are many sources of recovered heat: waste heat at industrial sites, tertiary buildings (data centres, waste water plants, etc.), energy recovery units for domestic waste known as WTE (Waste-to-Energy) units (in terms of their non-renewable part[35]) or heat from waste processing sites (SRF, heat treatment of slurry, etc.). The Law on Energy Transition for Green Growth sets a target of a five-fold increase in the

34. The heat produced by cogeneration, for the purpose of the simultaneous generation of heat and electricity, is not considered to be recovered heat (Official Gazette No 32, 8 March 2007, on the conditions governing the application of the reduced VAT rate on calorific energy delivered).

35. By convention, it is considered that 50% of the energy generated by domestic waste energy recovery units is renewable and 50% is recovered heat.

amount of renewable and recovered heat and cold delivered by the grids by 2030 (baseline 2012). Recovered heat, whether recovered locally on-site for self-consumption or in response to local needs via a district heating system, contributes to these objectives.

The quantity of recovered industrial heat currently used by district heating is estimated as 445 GWh[36]. The amount of heat recovered from waste energy recovery units and delivered is 4 TWh[37].

Maximum supply potential

The technical potential of industrial waste heat at more than 30 °C is estimated to be 109 TWh,[38] while the national waste heat resource from domestic waste treatment units (excluding optimisation of existing units), waste water treatment plants and data centres is 8.4 TWh. Considering the portion that can be recovered outside that resource, the amount of waste heat at more than 60 °C available near existing district heating networks is quantified as 12.3 TWh, including 56 sites near an existing district heating system, which total 9 TWh. Considering the decline in energy consumption in industry by 2035, we can estimate a maximum recoverable potential in the grids of 7.7 TWh. The maximum potential of domestic waste energy recovery units following optimisation or modification of existing units is estimated as 10 TWh of additional heat compared to 2009, of which 6 TWh could supply district heating and cooling (for an equivalent amount of waste burned). This represents total potential of 9 to 10.5 TWh in heat delivered by district heating and cooling from energy recovery units. Finally, solid recovered fuels could also contribute up to 1.7 TWh to the development of heat recovery in district heating and cooling systems.

There is also potential for heat recovery from waste water. The resources in Île de France have been estimated as 2 TWh, of which 1.1 TWh is recoverable. An estimate of the potential of each region could be developed as part of the SRADDET. ADEME could also assess this potential when updating its study on waste heat.

Socioeconomic, industrial and environmental issues

The challenges of industrial heat recovery mainly concern contracting capacity between industrial plants, or between an industrial plant and a district heating system (public or private). Issues relating to the duration of commitment, and more generally of economic returns, can also hinder projects. A study of the financing of ongoing industrial recovery investments will identify the obstacles to the development of projects, as well as the levers for action to be implemented (financial, regulatory, fiscal, etc.)[39]. The Heat Fund has been supporting waste heat recovery projects since 2015. This progress must be continued by targeting a specific action on the 50 or so sites identified near an existing network. Since 2015, classified facilities for environmental protection over 20 MW with non-recovered waste heat must[40] conduct a cost-benefit analysis on the appropriateness of recovering this heat in a district heating system. Similarly, any new or substantially overhauled energy production installation connected to a district heating system must prioritise a study on the possibility of recovering waste heat from sites near

36. Source: annual survey of heat networks, 2017, SNCU.

37. For more details on the evaluation of the heat generated from waste energy recovery, see Section 5.5.

38. Source: 'Industrial waste heat, 2017', ADEME.

39. Study conducted by ADEME in 2018.

40. This relates to new installations or those being substantially overhauled. A substantial overhaul means a renovation where the cost exceeds 50% of the cost of a comparable new unit.

the system. This study, where it is legally required, is now one of the listed documents that must be provided with any Heat Fund grant application. The specific issues of waste energy recovery (including WTE units, SRF, etc.) are discussed below.

The recovery of waste heat by an industrial plant is part of the process of supplying cheap energy in a given territory, which enhances the attractiveness of the area and helps sustain industrial activity. Dialogue, the sharing of services and the creation of energy infrastructures in areas where heat-intensive industries are grouped could promote energy exchanges between stakeholders (communities, companies, etc.), with clear communication about the expected benefits in terms of economics and environment, even if the priorities, strategies and objectives of these stakeholders differ.

Current and foreseeable costs

The average cost of waste heat recovery projects funded by the Heat Fund is €97/MWh (excluding grants). It should be noted that the cost of the heat sold by WTE units to district heating networks is very competitive, around €10 to €25/MWh.

Environmental challenges

The environmental challenges associated with waste heat recovery are positive because this process enables a reduction in energy consumption by capturing unused thermal energy.

Energy recovery from waste

Waste use for energy production purposes contributes to the circular economy when it uses waste that could not have been avoided or recovered in the form of materials. The LTECV sets two principles for energy recovery from waste: the management of treatment near the source and the search for efficient waste energy recovery processes. In 2016, energy recovery from waste accounted for the following:

- 3.3 TWh produced by biogas from non-hazardous waste landfills (ISDND);
- 9.4 TWh produced by domestic waste incineration plants (DWIP);
- 5.5 TWh produced by biogas from anaerobic digestion.

Plants for the co-incineration of waste[41] also produce several TWh of energy recovered from waste.

Recoverable waste resources

The circular economy policy initiated by the LTECV should radically change the situation in respect of energy recovery from waste. Waste flows will be redirected on a large scale. By 2025:

- **9.8 Mt fewer wastes will be landfilled in ISDND, in particular biowaste, i.e. waste that produces biogas. This trend will lead to a 25% reduction in biogas production in ISDND, and thus a fall of 2.5 TWh.**
- DWIP will receive 2.9 Mt less domestic waste (LHV[42] 2,300 kWh/t) and an extra 1.5 Mt of recycling rejects (LHV 2,800 kWh/t). This should lead to an approximately 2.5 TWh reduction in energy production.

41 Facility for which the main purpose is to produce energy or material products and which uses waste as regular fuel or secondary fuel or in which a thermal process is used for waste disposal.
42 *Lower Heating Value.*

- 8 Mt of biowaste should be collected separately and recovered. Half (4 Mt) will be used through methanation, which should generate an extra 2.8 TWh energy reduction.
- 2.4 Mt of high calorific recycling rejects (LHV 3,500 kWh/t) will be turned into solid recovered fuel and should be able to generate 8.4 TWh of energy.

Some of the above waste for energy recovery could be subject to thermal treatment such as: pyrogasification. These processes are still under development in France and it is currently not possible to determine the amount of waste that will be recovered through these methods.

In terms of diversion of biowaste from landfills, the European Commission communication of 26 January 2017 declares that biogas recovery from ISDND may no longer constitute a target in and of itself. For that reason, the existing injection support mechanism for electricity generation will be continued to completion but will not be extended beyond that point. It will provide extra capacity of 60 MW of new facilities, by 2023 at the latest. Support mechanisms should take into account the decrease in available resources and support the sectors concerned.

Socioeconomic, industrial and environmental issues

Domestic waste incineration plants

A total of 126 domestic waste incineration plants are installed in France. In 2015, the 113 installations equipped with energy recovery systems produced 2.3 TWh of electricity and 7.1 TWh of heat. The composition of French incineration plants is as follows:

- 52 units accounting for 56% of incinerated waste are considered to be energy recovery units (> R1);
- 64 units accounting for 42% of incinerated waste are considered to be recovery units (R1 < 0.6 or 0.65);
- 10 small units accounting for 2% of incinerated waste are considered to be waste disposal facilities (no recovery). According to an inventory undertaken in 2019, 6 of these 10 facilities have already closed and the remaining facilities will continue to operate with an objective of improving their energy performance.

The stock of facilities is made up of a large number of very small, quite old units that underwent major upgrading to ensure standards maintenance between 2000 and 2005.

These facilities are adapting continuously, and the recovery of residual energy from incineration is expected to develop and become widespread. Only a small number of facilities will be built in the coming years. It is also crucial to encourage the optimisation of existing units. This could entail possible support for optimisation operations from the Heat Fund and the Waste Fund. ADEME monitors optimisation work on these units and raises awareness among local authorities about the benefits of optimal energy recovery by their facilities (economic, taxation, environmental, local development and employment impacts, etc.).

In 2017, 14 DWIP exceeded the 65% energy recovery threshold thanks to grants from ADEME, and 742,964 MWh/year of additional energy was recovered. Eight other DWIP facilities are expected to exceed the R1 threshold in 2020 thanks to 2018 grants from ADEME's Waste Fund and Heat Fund, representing an additional energy recovery of 421,070 MWh/year.

A BREF[43] is currently being developed, and this will make energy performance schemes mandatory[44]. This optimisation could result in additional heat generation of between 7 and 10 TWh, including 60% (4 to 6 TWh) intended for district heating and cooling networks. It would be appropriate to maintain the grants paid through the Waste Fund (and through the Heat Fund for heat recovery networks).

In 2028, heat production from DWIP is expected to be between 15 and 18 TWh and electricity generation should account for 2.3 TWh.

Facilities producing energy by burning solid recovered fuel (SRF)

In 2017, 800 kt of solid recovered fuel (SRF) was produced in France: 100 kt was exported, 300 kt was consumed by the cement sector, 200 kt was used by facilities supported as part of the ADEME call for SRF projects and 200 kt did not find an outlet. By 2025, annual SRF resources are expected to amount to 2.5 Mt, including 1 Mt for coincineration in cement factories. A total of 1.4 Mt (around 4.9 TWh) could therefore be used in SRF energy recovery units. This flow is, however, expected to decrease over time because of the efficiency of prevention and material-recovery improvement policies.

Waste energy production outputs range between 25% and 40% for power generation, depending on the technologies used, between 45% and 55% for heat production through cogeneration and around 90% for pure heat generation. Priority will therefore be given to heat generation.

The SRF resource without any identified outlet therefore has potential of 200 kt in 2018, increasing by approximately 150 kt each year until 2025. Some 260 kt of SRF (+150 in Réunion) will be consumed in a facility receiving a regional ADEME grant for an annual volume of 120 MW LHV. The support cost for this call for projects amounts to €3.5/MWh on average, generated over a 20-year period in the form of investment grants.

The Waste Fund finances heat generation in Metropolitan France using SRF (100% SRF) through the call for SRF projects. For its part, the Heat Fund finances district heating systems, enabling the recovery of energy produced from SRF as recovered energy, in accordance with the LTECV target of a five-fold increase of the amount of renewable heat and cold and recovery in those networks by 2030. The reduced VAT rate of 5.5% is also applicable to networks that use more than 50% renewable and recovered energy, including waste.

Biofuel and biogas production

The inputs that can be used in a methaniser primarily include livestock effluents, agricultural biomass (energy crops, agricultural residues, etc.), by-products from agrifood industries, household and professional biowaste (food waste, vegetable waste), sewage slurry (urban and industrial) or other recoverable organic waste from sanitation. Some of these inputs, such as fats, can also be used for the production of biofuels. Others are by-products from agrifood industries, for which it is important not to create imbalances with existing recoveries.

The anaerobic digestion sector is described in the section on biogas.

Overall food waste resources (biowaste excluding green waste) are estimated as 8 Mt, half of which could be used for anaerobic digestion after source separation, thus an amount of 4 Mt/year by 2025. In addition to food waste, the collection of all professional biowaste accounts for approximately 2 Mt of food waste, with the bulk of current mobilised resources being used for anaerobic digestion, and

43. BREF; Best Available Techniques Reference.
44. The decree on the regional waste prevention and management plan in accordance with the NOTRe Law provides for an improvement in energy efficiency of waste energy recovery units by limiting the portion of waste incinerated in units that do not meet the 'R1' standard to 50% of the quantities incinerated in 2010 by 2025.

therefore an additional 1 Mt of waste. This stock of 5 Mt of methanated waste could generate 3.5 TWh of primary energy.

Wood waste

End-of-life wood resources are also taken into account (see identification in Section 4.4), in addition to the quota that could be used as SRF.

Environmental challenges

All waste treatment plants are subject to the ICPE regulation[45] and are governed by a strict framework to assess their impacts and pollutants.

The objective is not to maximise energy production from waste but to maximise energy recovery of waste that could not be avoided and that is not recoverable as materials. Waste energy recovery should neither reduce waste prevention measures nor capture waste flows that could have been recovered as materials. Waste energy recovery is undertaken in accordance with the European Commission communication of 26 January 2017 on '*The role of waste-to-energy in the circular economy*'.

In total, 16.8 TWh of heat should be generated by thermal waste recovery facilities and 3.5 TWh used by the cement industry, and 2.3 TWh of electricity should be generated.

Of the 16.8 TWh of heat, half the heat generated by DWIP is considered to be renewable and counted in the biomass target. The other half is considered to be recovered energy. This contributes between -4.5 and 5.2 TWh to the renewable and recovered energy integration target. Of the 4.9 TWh of heat generated through SRF, it is estimated that around 2 TWh could be recovered by district heating networks and be counted as recovered energy.

General prospects for renewable heat and cold

The following table shows the energy sources that will meet the heat requirement within the period covered by the MEP.

		2023	2028, Scenario A	2028, Scenario B
Fossil fuels (fuel oil, coal, natural gas)		390	314	290
Electricity		99	95	88
Biogas (including injected biogas)		7	12	18
Wood		145	157	169
Renewable heat excluding biomass	**Heat pumps (aerothermal and geothermal)**	39	44	52

45. Establishments classified for environmental protection.

	Geothermal	3	4	5
	Solar thermal	2	2	3
Recovered energies		4.4	7.6	9.9
Total heat production		690	635	635

Heat mix that the MEP will make it possible to achieve for 2023 and 2028

In 2023, the MEP should make it possible to meet heat needs with 196 TWh of heat from renewable sources, i.e. 28% of final heat consumption.

In 2028, the MEP should make it possible to meet heat needs with 219 and 247 TWh of heat from renewable sources, i.e. 34.3% and 38.9% of final heat consumption. According to the target set by the LTECV, 38% of final heat consumption in 2030 must be provided by renewable energies.

This progression will be achieved through an average rate of increase in renewables and heat recovery of between 1.2 points and 1.8 points annually between 2020 and 2030, where the Renewable Energy Directive requires minimum growth of 1.3 points annually starting from 2020.

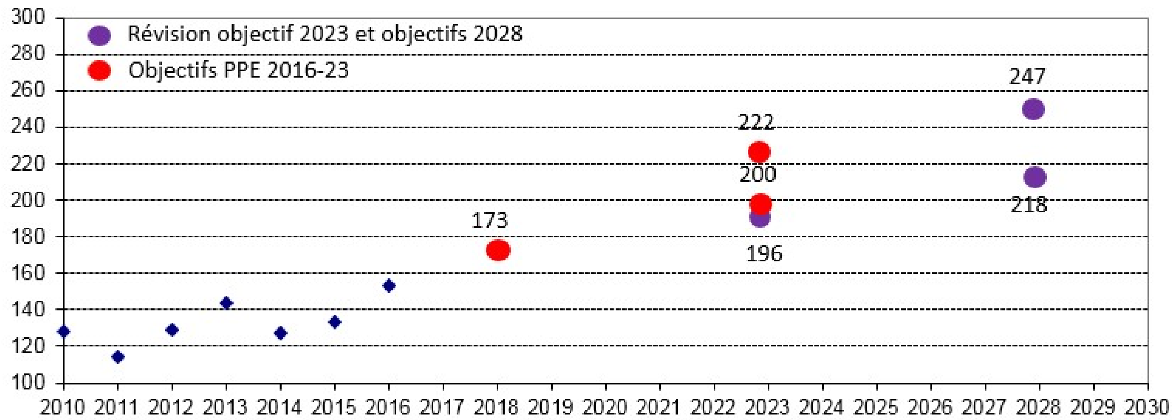
It should be noted that if x% of biogas is injected into the grid, x% of gas consumed to produce heat through the network is considered to be renewable.

It should also be noted that electricity from renewable sources is not accounted for here because the European methodology considers that, because specific goals have been set for renewable electricity, it should not be accounted for twice. Only targets that are not tracked by energy vector monitoring are monitored here. The table below shows the breakdown of biogas sources.

	2023	**2028 Scenario A**	**2028 Scenario B**
Heat produced by injected biomethane	3.9	8.3	12.1
Heat produced by cogeneration	2.6	3	5.3
Direct heat or district heating system	0.8	0.8	0.8

Origin of biogas in 2023 and 2028 (TWh)

Figure 31: Final consumption of renewable heat

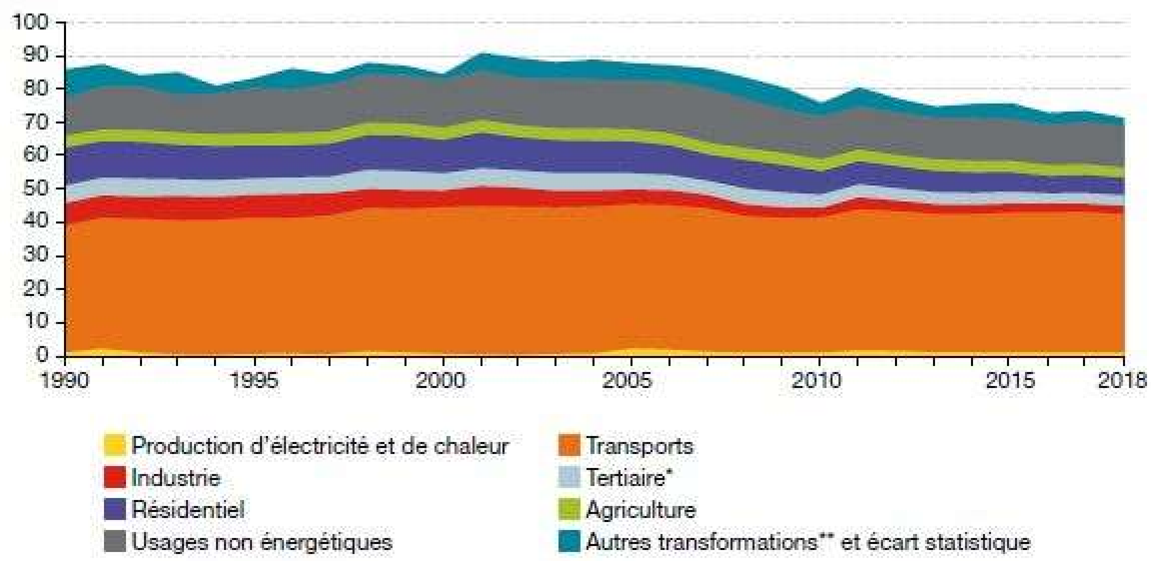


Révision objectif 2023 et objectifs 2028	Review of 2023 target and 2028 targets
Objectifs PPE 2016-23	MEP targets for 2016–2023

4.2.2.2. Biofuels

Primary consumption of oil products was 71.6 million tonnes of oil equivalent (Mtoe) in 2018. This figure continues the long-term downward trend initially seen in the mid-2000s (see figure below).

Figure 32: Primary consumption of oil products (excluding biofuels, marine and international aviation bunkers) in Mtoe[46]



Production d'électricité et de chaleur	Electricity and heat production

46. Data adjusted for climate variations.

Transports	Transport
Industrie	Industry
Tertiaire	Tertiary
Résidentiel	Residential
Agriculture	Agriculture
Usages non énergétiques	Non-energy uses
Autres transformations** et écart statistique	Other processing** and statistical gap

Consumption of liquid fossil fuels is expected to decrease as a result of actions to control consumption, and in particular those relating to mobility: modification of mobility options, decrease in unit consumption by vehicles, replacement of internal combustion vehicles by electric vehicles, or substitution of fossil fuels by bio-based fuels. Final consumption of liquid fuels is expected to be around 406 TWh in 2023 and 348 TWh in 2028.

In 2015, Directive 2015/1513/EU, on indirect land-use change (ILUC)47 confirmed a target set previously by the renewable energy directives48 of 10% renewable energies in transport in 2020, with a ceiling value of 7% for biofuels in competition with food crops, and an indicative target of 0.5% in 2020 for advanced biofuels. It establishes a list of raw materials that enable the develop of advanced biofuels. The LTECV adopted a more ambitious target of 15% renewable energies in final fuel consumption by 2030. To meet this target, it will be necessary to increase the rate of incorporation of biofuels and to ensure greater development of alternative fuels with lower carbon emissions than traditional fossil fuels. A new Renewable Energy Directive, referred to as RED II, was published on 21 December 2018. It sets a renewable energy target of 14% in transport by 2030, confirming the 7% ceiling for first-generation biofuels. It also reiterates and reinforces the sustainability criteria defined in the first Renewable Energy Directive, and aims to limit the effect of indirect land-use change by identifying the raw materials most at risk, capping their incorporation into biofuels and then gradually eliminating them by 2030. State of play in the sector

In France, conventional biofuels (produced from food-related materials) represent 7% of fuel energy. Biofuels are included in liquid fuels to the extent authorised by European regulations.

One of the objectives of the MEP is to develop ‘advanced’ second-generation fuels produced from wastes and residues and defined in Annex IX-A to Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (known as the RED II Directive). The first MEP set targets for the incorporation of advanced biofuels (from waste, residues or lignocellulosic material) with the assumption that molasses, C starch and acid residues of edible oils would be considered as advanced biofuels. However, these three substances have not been included in the list of raw materials that enable the production of advanced biofuels under the RED II classification.

	Situation in 2016	**Target in MEP 2018**	**Target in MEP 2023**

47. Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources (Text with EEA relevance) **(ILUC)**.

[48] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance).

% incorporation in petrol used	nd	1.6%	3.4 %
% incorporation in diesel used	nd	1%	2.3 %

Table 36: Targets set by the MEP adopted in 2016 for the consumption of second-generation biofuels

The 2023 and 2028 targets stated in the revised version of the MEP have been determined for a new scope, reflecting the requirements established in the RED II Directive. In other words, they do not include biofuels produced from raw materials listed in Annex IX-A to the Directive. The figures in this MEP are therefore lower than those shown in the 2016 version, since their scope has been revised.

Box 5: Aeronautical biofuels

Air transport will need to roll out innovative and sustainable aeronautical biofuels in line with the continuous progress of technologies, operational improvements and market measures such as CORSIA, to meet the climate change challenge and reduce its carbon footprint. These biofuels are a strategic lever for reducing net emissions in a growing sector that has a limited choice of energy alternatives. Bio-based fuels, which can originate in the circular economy, would make it possible to reduce up to 90% of carbon emissions over the entire life cycle.

Considerable progress has been made in recent years, in particular in terms of the performance and certification of aeronautical biofuels. The operational use of aeronautical biofuels is now controlled. The roadmap produced by ANCRE (the National Alliance for the Coordination of Energy Research) has assessed the potential of the French production pathways for aeronautical biofuels. In global terms, five aeronautical biofuels sectors have been certified by the ASTM (American Society for Testing and Materials) and have been identified as possible renewable and sustainable alternatives to aeronautical fossil fuels. Certain biofuels can be incorporated up to 50% into the volume of fossil fuel, thus representing significant emission reductions. Other innovative sectors are being studied, with different degrees of feasibility and variable timelines for certification, confirming the richness of the available technological potential. Certified technologies for the production of aeronautical biofuels make it possible to manufacture molecules that are very similar to those present in kerosene and totally compatible. The use of these biofuels does not require any adaptation of the aircraft or airport infrastructures.

To promote the emergence of a French aeronautical biofuels sector, the Government, Air France, Airbus, Safran, Suez and Total agreed in late 2017 on a ‘Commitment to green growth’ to study the feasibility of implementing a French production and distribution pathway for sustainable aeronautical biofuels. The conclusions of that study are expected in late 2019.

Description of current resources

The production of second-generation biofuels involves the use of materials that do not compete with the production of food products.

Inputs that may be used include agricultural residues, household, municipal or industrial waste, plant waste and residues, straw, manure and sewage slurry, livestock effluents, algae, waste and residues from silviculture, pulp residues, wood, and renewable fuels of non-organic origin.

Some materials are used in already mature industrial processes. Others, such as lignocellulose plants, are used for the development of new industrial processes:

- the thermochemical method makes it possible to obtain synthetic biodiesel: also known as BtL (Biomass to Liquid);
- the biochemical method provides ethanol.

These new sectors have more favourable energy balances than those of the first generation and make it possible to limit the problems of land use and competition with food outlets.

Some of these inputs, such as household waste or sewage slurry, offer resources that can be used either for the production of biofuels or for the production of biomethane. Others are by-products from industries for which it is important not to create imbalances with existing recoveries. The potential of materials is sufficient to achieve the objectives of advanced biofuel production.

The main challenges for the development of the sector are organising input mobilisation, supply logistics towards processing plants, and the cost of creating industrial processing units.

Socioeconomic, industrial and environmental issues

The biofuel production sector is currently structured around first-generation fuels. By using 80% of ethanol production in fuel, it contributes to the economic profitability of the sugar sector in France (8,900 jobs[49]). In the diesel sector, it also provides the recovery of 1.4 million tonnes of French rapeseed oil[50]. The second-generation biofuel production chain is still emerging, and the costs and employment content are as yet unknown.

Environmental challenges

To be counted as renewable energy in fuels, biofuels must meet sustainability criteria (related to the preservation of the quality of cultivated land, GHG emissions, etc.). This tightly controlled system is the world’s most comprehensive sustainability programme for avoiding the negative side effects of biofuel production. This is why the quantities of first-generation fuels produced will be stabilised, but will not be increased.

The following table shows the energy sources that will make it possible to meet liquid fuel needs within the period covered by the MEP when the measures laid down in this MEP will be adopted.

		2023	2028
Petrol	**Fossil**	84	79
	1G Renewable	6	6
	2G Renewable	2	3
Diesel	**Fossil**	294	233
	1G Renewable	22	18
	2G Renewable	3	8
TOTAL		412	347

55. Source: SNPAA
50. Source: sustainability declarations

Liquid fuel mix that the MEP will make it possible to achieve in 2023 and 2028 (TWh).

Second-generation renewable fuels include advanced biofuels, as well as biofuels from used oil and animal fat, listed in Annex IX-B to Directive (EU) 2018/2001.

In 2023, the MEP should make it possible to meet liquid fuel needs with 33 TWh of fuels from renewable sources, i.e. 9% of final fuel consumption.

In 2028, the MEP should make it possible to meet liquid fuel needs with 35 TWh of fuels from renewable sources, i.e. 11 % of final fuel consumption.

According to the target set by the LTECV, 15% of final energy consumption used in transport in 2030 must be provided by renewable energies.

4.2.2.3. Renewable gas

In 2018, natural gas consumption was 470 TWh HHV. Measures to control energy demand are expected to reduce gas consumption to 439 TWh HHV in 2023 and 377 TWh HHV in 2028. The law has set a target of increasing the share of renewable energies to 10% of gas consumption in 2030. There are essentially three technologies that could be used to meet this target, namely anaerobic digestion, gasification and the conversion of renewable electricity into synthesis gas.

Renewable gas production targets

At the end of 2018, there were nearly 650 planned biomethane production facilities with a cumulative production potential of 14 TWh per year. Given this large number of projects, some stakeholders are asking for a renewable gas production target that goes beyond the target of 10% in 2030, as set by Article L. 100-4 of the Energy Code.

The cost of producing biomethane is significantly higher than natural gas. In 2018, the average purchase price of injected biomethane was €102/MWh HHV, compared to an average natural gas price of €23/MWh HHV. The development of this sector therefore requires substantial public support. The prospects expected for cost reductions mean it is not possible to imagine the development of the sector without public support over the MEP period.

The production costs for gasification of organic matter for injection into natural gas networks are estimated as being higher than biomethane production costs.

To control public expenditure allocated to support renewable gas, the MEP sets targets to 2028 that are consistent with a share of 7% to 10% of total gas consumption in 2030, while linking support to efforts to be made by the various sectors to decrease production costs.

Anaerobic digestion

State of play in the sector

Anaerobic digestion is the decomposition of organic matter by micro-organisms into biogas, consisting mainly of methane and carbon dioxide. This biogas can then be recovered in various ways. It can be purified to obtain a gas with thermodynamic properties equivalent to natural gas, which means that it can be injected into gas network grids or conditioned as a fuel for gas vehicles (bioNGV). Biogas can also be used directly as a fuel. Finally, it can be used to produce electricity in cogeneration installations, but this use is not preferred because of its lower energy yield.

	2017	Target in MEP2016 for 2023
Biogas injected into grids (TWh)	0.4 TWh	8 TWh
Biogas used to generate electricity[51]	1.9 TWh of electricity, (5.5 TWh of biogas)	2.6 TWh of electricity, (7.3 TWh of biogas)
Total biogas consumed (direct use or injected in heat grids, excluding bioNGV)	5.9 TWh	15.3 TWh

Targets set by the MEP adopted in 2016 for the consumption of biomethane

As at 31 December 2018, 635 facilities were generating electricity from biogas, for a total capacity of 456 MW. Electricity generation from biogas was 2.1 TWh in 2017, using 6 TWh of biogas.

A total of 76 facilities inject biomethane into the natural gas grids, after production and purification of biogas, for a total production capacity of 1.2 TWh per year. The production of biomethane directly recovered as fuel remains marginal. It is important to develop the use of biogas in transport, out of the network when necessary.

Maximum potential of anaerobic digestion

Anaerobic digestion involves the use of organic matter that can easily be broken down by micro-organisms. To reconcile the development of anaerobic digestion and compliance with land use criteria, France has chosen to develop anaerobic digestion based on the use of wastes or residues. Article D. 543-292 of the Environment Code therefore provides that a methaniser cannot use more than 15% of food or energy crops, grown as a main crop.

The inputs that can be used in a methaniser include livestock effluents, agricultural residues, by-products from agrifood industries, domestic biowaste, vegetable waste, and sewage slurry such as fats, constituting a resource that can be used for the production of both biofuels and biomethane. Others are by-products from agrifood industries, for which it is important not to create imbalances with existing recoveries. The use of agricultural waste must incorporate a balance between the production of biogas and the return of carbon to the soil.

The availability of methanisable materials by 2035 is estimated as 100 Mt by ADEME, i.e. 50 Mt of livestock effluents, 46 Mt of vegetable matter and 3 Mt of domestic waste, for a total of 70 TWh of primary energy.

Socioeconomic, industrial and environmental issues

The energy yield of an anaerobic digestion plant depends primarily on the recovery technique used to generate the biogas. For recovery by injection into natural gas networks, the energy yield of an anaerobic digestion plant is estimated as 94%, taking account of the heating needs of the methaniser. For recovery by electricity generation, the electrical yield is about 35%.

51. Energy equivalence of the target in capacities.

This energy yield gap explains why alternative recoveries to electricity production are prioritised, and particularly injection into gas grids, where this is possible.

Natural gas grids have been designed to transport natural gas from a few import points to a large number of consumers throughout France. The development of biomethane injection could require the grid to be reinforced in order to facilitate the injection of sources distributed throughout the country towards the arteries of the network.

The anaerobic digestion sector needs to advance in terms of acceptability. This will include good practices in terms of dialogue that must be assimilated by project leaders. Acceptability must be monitored constantly, so that it does not become a hindrance to the development of the sector.

In 2016, the biogas sector employed 2,110 direct FTEs[52]. The employment ratio of the biogas sector is therefore 389 FTE/TWh. Equipment is mainly imported.

Current and foreseeable costs

The cost of generating biomethane injected into a natural gas grid following purification is about €95/MWh HHV.

With the development of anaerobic digestion, a reduction in plant costs is expected due to a series effect on the equipment and the development of supply for maintenance-servicing operations. Technical progress could also be observed for the purification of biogas. The project costs could reach an average of €75/MWh HHV for injected biomethane projects selected by call of tenders by 2023 and €60/MWh HHV by 2028.

Environmental challenges

Anaerobic digestion is based on the use of wastes and residues, so it does not have any particular impact in terms of land use. Potential conflicts of use relating to the inputs of anaerobic digestion plants will continue to be monitored.

Hydrogen and power-to-gas

Hydrogen

French solutions must be ready for deployment in Metropolitan France by 2030–2040, and they must be set up so that they participate in the development of a competitive sector. This involves improving electrolysis and mass storage technologies, as a complement to developing other uses, particularly for mobility. By 2035, plans will be in place to prepare for the development and integration of the technology for converting electricity from renewable sources into gas by producing suitably sized demonstrators. Today there are four demonstrators in France, including one under construction, and the objective is to increase their number so as to gradually change scale, while developing a French industrial sector.

Some isolated areas already need flexibility and renewable energy storage capacity to decarbonise their energy production without destabilising their electrical systems. Non-interconnected zones could therefore represent useful spaces for trials or indeed pilot deployments, benefiting from a more advantageous regulatory framework.

The drastically lower costs of electrolysis systems now make it possible to envisage different markets, as discussed below. The cost of producing hydrogen through electrolysis depends on the technology

52. Source: 'Markets and jobs contributing to energy and ecological transition', ADEME, July 2019.

used, the length of use and above all the price of electricity. For instance, alkaline electrolysers can produce hydrogen for €4 to €5/kg (or €100 to €130/MWh HHV) for about 4,000 to 5,000 hours/year and with an electricity cost of €50/MWh. By 2030, based on a projection of significant industrial development of these technologies, hydrogen produced by electrolysis could cost anywhere between €2.5 and €3.5/kg (€65 to €90/MWh HHV).

Industrial hydrogen

The current global hydrogen market is essentially an industrial market: hydrogen is a product used in the oil and chemical industries. On a global scale, the industrial hydrogen market is estimated today as 60 Mt. In France, it stands at about 1 Mt.

In 2018, the cost price of hydrogen produced in large quantities from fossil products (gas steam reforming) was €1.5 to €2.5/kg (i.e. around €38 to €65/MWh) for industrial customers consuming large volumes (refineries). For some less intensive uses that are sufficiently stable (glass, agrifoods, metallurgy, electronics) and for which hydrogen is transported and delivered by lorry – known as 'diffuse industrial uses' – its cost price is €10 to €20/kg (€250 to €510/MWh), but only rarely less than €8/kg (about €200/MWh). There is therefore accessible market potential today for hydrogen produced directly on site by electrolysis.

A balance will need to be found between diffuse uses, for which the current price is higher but which involve more complex industrial processes (non-uniform configurations, which can raise costs) and more mass uses, where the price of current technologies is higher, but which enable the rapid deployment of electrolysers in series, and thus increasing power.

Hydrogen for mobility

Hydrogen in mobility is complementary to batteries and bioNGV. It offers key advantages for intensive uses requiring long battery life and short recharging times, especially in urban areas where measures are taken to reduce pollution and noise. Many projects are already emerging across the country around fleets of light commercial vehicles (e.g. 'Hype' hydrogen taxi fleets in Paris) and heavy vehicles (buses, trucks, trains, etc.).

Due to a still limited volume effect, the total cost of ownership of a hydrogen vehicle remains higher than their fossil fuel equivalents (20% to 50%). However, with start-up support, it would be possible to cover the extra cost of fuel-cell vehicles and to refuel vehicles at an equivalent cost to that of the energy for a diesel vehicle. By 2030, in particular as a result of the progress expected in terms of the cost of electrolysis, the decarbonised hydrogen distributed at service stations should be priced at a level (< €7/kg, i.e. < €7 per 100 km) compatible with the needs of hydrogen mobility.

These advantages are found mainly in certain heavy transport modes (road, rail and river), for which the weight, bulk and embedded energy of batteries are still prohibitive. These heavy transport modes are a major lever for quickly ensuring high volumes of hydrogen, and generating an autonomous ecosystem by economies of scale through the faster deployment of large stations. This is a key point in the economic model of recharging stations.

To develop mobility from hydrogen, the goal is:

- to encourage the development of a range of heavy vehicles, not only on the road but also in other modes (boats, trains, aircraft);
- to pursue a regional fleets approach. In this respect, the role of local authorities in aggregating uses within regional projects is key. Other uses may also be considered in these regional projects (e.g. bridging between industry and mobility).

Hydrogen for storage

As an energy vector, the hydrogen produced by electrolysis is a long-term structural solution for the integration of renewable energies into the electrical system: compared with other storage solutions such as batteries, hydrogen is currently the most promising interseasonal large-scale storage medium for intermittent electrical renewables. It can also be used as a storage vector, either by direct injection into the gas grid or by methanation (production of synthetic methane).

Compared with other storage solutions such as batteries, hydrogen is currently the most promising interseasonal passive storage medium (see the section on storage). Electrolysers are also capable of providing other services to the electrical grid, like other storage technologies or other means of flexibility (demand management, development of interconnectors).

A study conducted by RTE in 2019 on the challenges for the electrical grid related to developing hydrogen production through electrolysis highlights the benefits of hydrogen over the long term. The production of hydrogen by electrolysing water from decarbonised electricity leads to a significant reduction in national and European CO_2 emissions. However, there is a certain level of variability depending on the scope and scenarios. Still, according to RTE, the value that electrolysers can add to the grid by 2035 will still remain relatively limited, and grid linking will not be necessary within that time frame.

Power-to-gas

The 'power-to-gas' principle is based on the conversion of a quantity of electricity into hydrogen using electrolysis. The hydrogen produced can be decarbonised provided that the electricity used to produce it is itself decarbonised. Under these conditions, hydrogen is compatible with the targets that France has set for renewable energy development, and the reduction of greenhouse gas emissions and pollutants.

Hydrogen produced via electrolysis can also be transformed into synthetic methane following a recombination of hydrogen with CO_2 – this is known as methanation.

The conversion of renewable electricity into gas is generally mentioned in situations where the generation of renewable electricity would be surplus to consumption, in order to enable the recovery of the surplus electricity generated. These situations are not expected in France on a large scale before 2035, according to the energy scenario considered.

The resulting gas can be used directly or injected into existing gas grids. While it seems possible to inject small quantities of hydrogen directly into the gas grids (see current demonstrators), beyond a certain percentage – which still needs to be determined with precision – issues of technical compatibility and/or grid safety could arise (compatibility of materials, burner settings using gas, measurement of quantities delivered, etc.).

The use of power-to-gas is mentioned in connection with the variable production of renewable electricity such as solar or wind (which makes it possible to obtain hydrogen from renewable sources) and in particular in situations where the generation of renewable electricity would be surplus to consumption, thus enabling the recovery of the surplus electricity generated. Power-to-gas is a seasonal storage solution that supports power grids. Based on existing technologies, it is even the only way to store electricity over very long periods. The advantage of power-to-gas architectures lies both in the synergy created between the electricity and gas grids and in the multiple uses of hydrogen and synthetic methane.

However, as mentioned above, the need to implement power-to-gas on a large scale is unlikely to arise in France before 2035.

All energy system stakeholders therefore still need an industrial scale experimentation framework. At the same time, R&D efforts are also needed in less mature electrolysis technologies.

Recovery gas produced through gasification

State of play in the sector

The gasification of solid recovered fuels (SRF), as well as the co-incineration of gas from gasification for the production of heat and electricity, are among the energy recovery processes identified as some of the most effective by the European Commission. As for the gasification of organic matter, the synthesis gas from the gasification of SRF can be used, depending on its level of purity, to produce heat or for conversion into methane for injection into the natural gas grids.

Additional studies need to be undertaken to specify the energy yield of SRF gasification, to specify the maximum supply potential, and to identify the risk of cannibalising the waste resources used by other sectors. These studies will also focus on the environmental impacts of this sector, particularly in terms of greenhouse gas emissions.

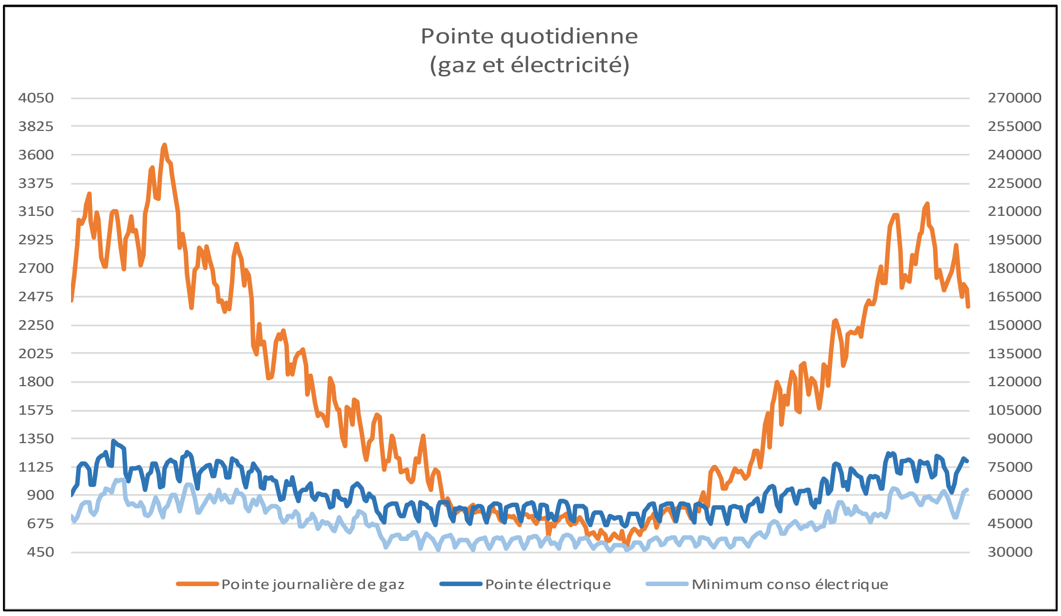
Total prospective gas

Gas consumption is characterised by significant seasonality: the differential for gas consumption between the winter peak and the summer off-peak is a factor of around 10. In France, the gas spike is connected on the one hand with direct use for heat (about 100 GW) and, on the other hand and to a lesser extent, with gas consumption for electricity generation (less than 10 GW).

In 2016 (the benchmark year for the chart), the seasonal variation for gas consumption between the spike and the minimum consumption point was higher than the same differential for electricity:

- between 450 and 3,700 GWh/day for gas consumption;
- between 32 and 92 GW for the electricity spike.

Figure 33: Daily spike (gas in GWh/day on the left and electricity in MW on the right)

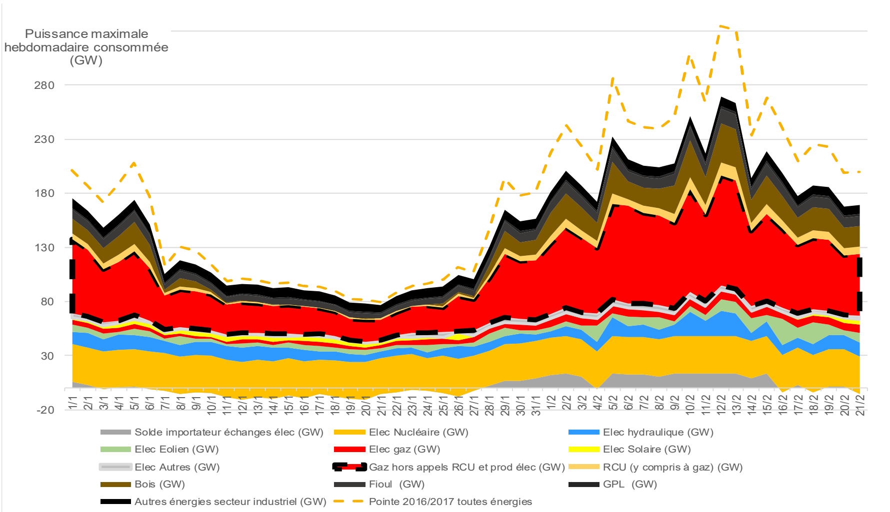


Pointe quotidienne (gaz et électrique)	Daily peak (gas and electricity)
Pointe journalière de gaz	Daily gas peak
Pointe électrique	Electricity peak
Minimum conso électrique	Minimum electricity consumption

The targets for reducing fossil fuels make a case for reviewing natural gas use by focusing it on the sectors where its use is essential and by reducing the demand spike for gas.

While there are some advantages in using gas, principally in terms of storage and volume modulation in the grids, it is 100% imported and therefore requires big investment in the networks. Since gas consumption is thermosensitive, a significant drop in the use of gas for heat is required to achieve the goal of lowering the gas consumption spike. In the future, it appears necessary to speed up the pace of building renovations in order to reduce the thermosensitive share of consumption on the one hand, and to prioritise biomass district heating systems on the other.

Figure 34: Demand curve for all energies in 2028



Solde importateur échangés élec (GW)	Import balance elec. trades (GW)
Élec Nucléaire (GW)	Nuclear elec. (GW)
Élec hydraulique (GW)	Hydroelec. (GW)
Élec Éolien (GW)	Wind elec. (GW)
Élec gaz (GW)	Gas elec. (GW)
Élec Solaire (GW)	Solar elec. (GW)
Élec Autres (GW)	Other elec. (GW)
Gaz hors appel RCU et prod élec (GW)	Gas excluding DH and elec. prod (GW)
RCU (y compris à gaz) (GW)	DH (including gas) (GW)
Bois (GW)	Wood (GW)
Fioul (GW)	Fuel oil (GW)
GPL (GW)	LPG (GW)
Autres énergies secteur industriel (GW)	Other energies, industrial sector (GW)
Pointe 2016/2017 toutes énergies	Peak 2016/2017 all energies
Puissance maximale hebdomadaire consommée (GW)	Maximum weekly power consumed (GW)

The following table shows the energy sources that will make it possible to meet gas needs within the period covered by the MEP when the measures laid down in this MEP will be adopted.

	2023	**2028 Scenario A**	**2028 Scenario B**
Natural gas	314 (LHV) 351 (HHV)	271 (LHV) 304 (HHV)	264 (LHV) 296 (HHV)

Biogas (injected biomethane)	5 (LHV) 6 (HHV)	13 (LHV) 14 (HHV)	20 (LHV) 22 (HHV)
Biogas (others)	7 (HHV) 8 (HHV)	9 (LHV) 10 (HHV)	9 (LHV) 10 (HHV)

Gas mix that the MEP will make it possible to achieve in 2023 and 2028 (TWh)

In 2023, the MEP should make it possible to meet gas needs with 14 TWh HHV of gas from renewable sources, i.e. 3% of final gas consumption.

In 2028, the MEP should make it possible to meet gas needs with between 24 and 32 TWh of gas from renewable sources, i.e. between 6% and 8% of gas consumption.

According to the target set by the LTECV, 10% of final gas consumption in 2030 must be provided by renewable energies.

4.2.2.4. Renewable electricity

Electricity accounted for 27% of final energy consumption in 2018, or 439 TWh (adjusted for climatic variations). The tertiary residential sector accounted for 66% of final electricity consumption and industry for 28%, while transport and agriculture remained minimal at around 2%.

In 2018, 71.7% of the electricity was produced from nuclear, 7.2% using thermal fossil fuels and 21.1% from renewable energies.

The electricity requirement is estimated at 440 TWh in 2023 and 426 TWh in 2028 (excluding exports and grid losses). The underlying assumption is stability of consumption, with decreases in consumption linked to energy efficiency improvements being offset by usage switchovers.

French law has set a target of 40% renewable energy in electricity generation in 2030. To achieve this goal, it is necessary to initiate major changes in the electrical system, with an acceleration of all renewable energy pathways. The efforts to be made, however, depend on the availability, maturity and competitiveness of the individual pathways.

Situation in 2017	Target in MEP_{2016} for 2018	Low target in MEP_{2016} for 2023	High target in MEP_{2016} for 2023
49	53	71	78

Targets set by the MEP adopted in 2016 for installed capacity of renewable electricity generation (GW)

Three types of cross-sector actions have been initiated to promote the development of renewable electricity: the reform of support mechanisms, administrative simplifications and the development of crowdfunding.

Simplifying tender procedures and the designation of winners

A decree[53] passed in 2016 simplified the procedure for calls for tenders and the designation of winners for power generation facilities, contributing to a reduction in the deadlines for selecting winning projects, which previously could take 18 or even 27 months. The administrative simplifications imposed include the following in particular:

- simplification of authorisations to operate under the Energy Code, by very significantly increasing the power thresholds for renewable energy installations subject to this procedure in order to exempt most of them when they are developed within the framework of the support mechanisms provided by the Government;
- simplification of the legal framework applicable to offshore renewable energies by limiting appeal deadlines, by entrusting the handling of appeals to a specialised Administrative Court of Appeal in first and final instance, by extending the duration of Maritime Public Domain (MPD) concessions from 30 to 40 years, and by reducing the time-to-file for Water Law authorisations; Decree No 2016-9 of 8 January 2016 on offshore renewable energy generation and transmission installations was published on 10 January 2016;
- simplification of the administrative procedures required to gain access to the purchase obligation, with abolition of the CODOA procedure (certificate creating an entitlement to the purchase obligation);
- simplification of planning procedures[54] by making it possible to extend the period of validity of planning permits several times for all renewable energy production installations, up to a maximum of 10 years from the issuance of the decision;
- general application of the single permit allowing the abolition of the need for a building permit for onshore wind farms and simplification of the legal framework for this sector, with the Administrative Court of Appeal overseeing initial claims.

Hydroelectricity	**Wind**	**Solar-based electricity**	**Bioenergy**
2017–2018: 15 months	2018–2019: 5 months	2018–2019: 5 months ground PV and building PV	2018–2019: 8 months

Periods observed between the publication of the specifications and the selection of winners after reform

Developing crowdfunding and promoting local ownership of projects

Participatory investment (crowdfunding) makes it possible to strengthen local ownership of renewable installations and to facilitate projects by improving local support. Tenders launched since 2016 have systematically favoured projects that implement crowdfunding solutions (involving citizens or local authorities) by integrating criteria and bonuses linked to participatory investment. The Government has also relaxed the conditions for crowdfunding of renewable energy projects on financing platforms.

[53] Decree No 2016-170 of 18 February 2016 on tender procedures for power generation facilities.
[54] Decree No 2016-6 of 5 January 2016 on the period of validity of planning permits and a variety of mechanisms related to the application of land rights and associated taxation.

Sector	Number of winners	Of which involved in CF	% involved in CF
Biomass for electricity	38	2	5%
Self-consumption	399	56	14 %
Small hydroelectricity	33	6	18%
Ground-based solar power plant	561	386	69 %
Solar on building	2,252	651	29 %
Innovative solar	50	36	72%
Wind	68	9	13%

Use of crowdfunding by sector as at 1 November 2019 – Source: DGEC

Improving the completion rate of projects

Specific attention is paid to the project completion rate in order to optimise the effectiveness of the tenders launched. For the first photovoltaic tenders launched in 2011 and 2013, the completion rates were between 44% and 83% (see table below). For new tenders, the introduction of financial performance guarantees and the obligation to obtain planning permission prior to the bid will contribute in particular to a decrease in rates of never-completed tender projects. This indicator will continue to be carefully monitored and published on the Ministry's website.

	Number of winners	Power applied (MW)	% commissioned in numbers	% commissioned in power
2011 tender **Installations from 100 to 250 kWp**	696	145	62.8%	64.8%
2011 tender **Installations over 250 kWp**	88	456	83%	82.5%
2013 tender **Installations from 100 to 250 kWp**	587	122	69.3%	69.1%
2013 tender **Installations over 250 kWp**	121	380	72.7%	61.1%
2014 tender **Installations over 250 kWp**	250	1100	72 %	70.4 %
2015 tender	1,093	244	44.6 %	44.4 %

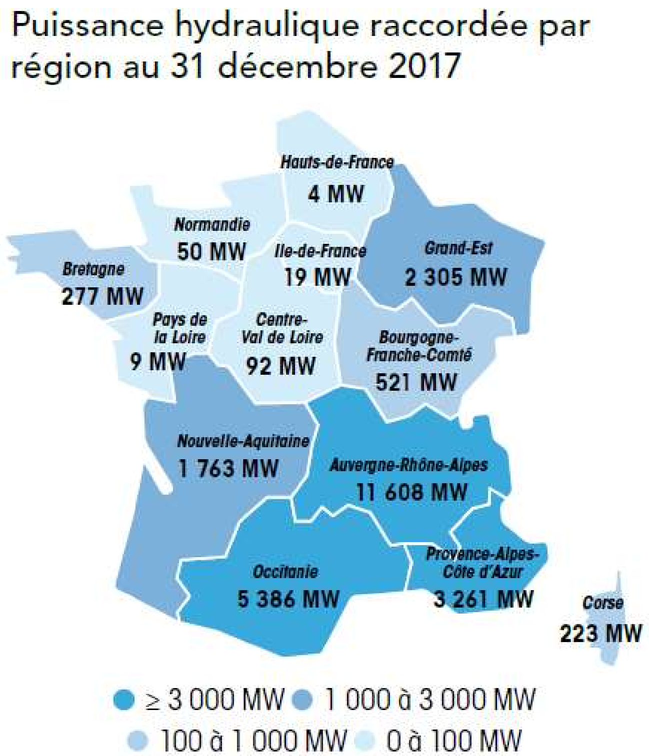
Commissioning rate for solar installations in 2011–2015 tenders as at 1 July 2018 – Source: DGEC

Hydroelectricity

State of play in the sector

Hydroelectric potential in France is already extensively exploited following the construction of many installations during the 20th century. In 2017, hydroelectric power generation was 53.6 TWh, or 10% of French electricity generation.

Figure 35: Regional distribution of capacity of hydroelectric generation (Source: RTE)



Puissance hydraulique raccordée par region au 31 décembre 2017	Hydro power connected by region as at 31 December 2017
Bretagne	Brittany
Normandie	Normandy
Hauts-de-France	Hauts-de-France
Pays de la Loire	Pays de la Loire
Centre-Val de Loire	Centre-Val de Loire
Ile-de-France	Ile-de-France
Bourgogne-Franche-Comté	Bourgogne-Franche-Comté
Nouvelle-Aquitaine	Nouvelle-Aquitaine
Auvergne-Rhône-Alpes	Auvergne-Rhône-Alpes
Occitanie	Occitanie
Provence-Alpes-Côte d’Azur	Provence-Alpes-Côte d’Azur
Corse	Corsica
≥ 3 000 MW	≥ 3,000 MW
1 000 à 3 000 MW	1,000 to 3,000 MW
100 à 1 000 MW	100 to 1,000 MW
0 à 100 MW	0 to 100 MW

Situation in 2017	**Target in MEP$_{2016}$ for 2018**	**Low target in MEP$_{2016}$ for 2023**	**High target in MEP$_{2016}$ for 2023**
25,294*	25,180	25,680	25,930

Targets set by the MEP adopted in 2016 for installed capacity of hydroelectricity generation (MW)[55] excluding Corsica*

Maximum supply potential

The table below assesses the additional resource potential above that is already exploited in France. These figures are taken from a report assessing resources[56] supplemented by an assessment of the additional electricity generation potential that could be generated by the over-equipment and modernisation of existing licensed plants by 2028, as well as the potential for equipping all mills for electricity generation.

The evaluated potential is technical potential, which does not take into account factors such as the environmental constraints (excluding classification in list 1) or the economic constraints of the projects. The real potential is therefore significantly less.

Potential			**Total**	**Of which not in list 1**
New power stations	**Concessions (greenfield sites)**	> 10 MW	Approx. 2,090 MW	Approx. 370 MW
		< 10 MW		Approx. 120 MW
	Permits	Greenfield sites	Approx. 750 MW	Approx. 170 MW
		Existing sites (unequipped dams), excluding mills	Between 260 and 470 MW	
		Existing sites (unequipped dams), mills	Approx. 350 MW	
Over-equipping and modernisation of existing licensed plants by 2028			Approx. 400 MW	

Potential hydroelectric capacity (MW)

Socioeconomic, industrial and environmental issues

For hydroelectricity, power plant load factors are highly dependent on:

- the type of development: the presence of a reservoir or watercourse;

55. The numbers shown in the 2016 MEP are only for extra capacity. In this table, it is the total capacities that are shown, for the sake of comparability with the other pathways.

56 'An understanding of French hydroelectric potential', Summary, available from: https://www.ecologique-solidaire.gouv.fr/sites/default/files/potentiel%20hydro_synth%C3%A8se%20publique_vf.pdf

- the technical characteristics: the electric power of the power station, which is optimised depending on the water resource and installation cost;
- the hydrology, which can vary significantly from one year to the next.

On average nationally, the load factor is around 25% (about 2,200 full power equivalent hours), but it generally varies between 20% and 40% (about 1,800 to 3,600 full power equivalent hours). Lake power plants, which have significant installed power to produce at peak hours, generally have lower load rates than run-of-river plants, for which the power is calibrated according to the average flow rate of the watercourse. Some plants designed to generate power from the minimum flows to be left in the watercourses run at full power almost all year round.

The hydroelectric industry is essential for the transition of the electrical system:

- it is a renewable pathway that can be predicted and managed;
- its flexibility (lake and sluice installations) makes it possible to manage the supply-demand balance reactively during periods of tension within the electrical system, instead of using expensive thermal systems that emit greenhouse gases;
- hydraulic storage also makes it possible to position generation activities to match consumption over long periods (weekly or even seasonally).

Hydroelectricity regularly accounts for more than 20% of grid power during peak periods. Moreover, thanks to its flexibility, this sector accounts for about 50% of the adjustment mechanism, which is a device that allows RTE to ensure a balance between generation and consumption of electricity at all times.

Current and foreseeable costs

Hydroelectricity is a competitive renewable energy because of the long life of the facilities, which are subject to regular investment. Construction costs are high (civil engineering, equipment, grid connection), but operating and maintenance costs are relatively low. Costs related to environmental improvements are becoming increasingly significant.

Substantial disparities in costs are observed depending on the characteristics of the power plant and in particular depending on the installed power, the height of fall used and the hydrology of the site. The average unit costs observed[57] are:

- between €30 and €50/MWh for large run-of-river installations;
- between €70 and €90/MWh for high-power installations with substantial fall heights;
- between €70 and €160/MWh for lower-power installations.

The hydroelectric sector is a mature sector and significant changes in these costs are not anticipated.

The characteristics of the sector in terms of market and employment

In 2016, the hydroelectricity market was worth €3.6 billion[58]. The French hydroelectric industry boasts world-renowned know-how and dynamic export activity. Studies and engineering make up the bulk of

57. LCOE - levelised cost of energy.
58. All market and employment figures are taken from ‘Markets and jobs in the field of renewable energies’, ADEME, July 2017.

exports. In 2016, exports in the hydroelectricity sector accounted for €91 million, corresponding to 300 jobs.

The hydroelectric sector accounted for around 12,300 jobs in France in 2016 according to ADEME, concentrated mainly on operation. The engineering wings of EDF and General Electric are the two main French players involved in major installations. An ecosystem of SMEs also exists around small hydropower, which has significant potential to develop for export.

In 2016, the employment factor for this sector was 230 FTE/TWh.

Environmental challenges

To preserve the quality of aquatic environments and guarantee other uses of water, the environmental regulations applicable to hydroelectric installations have been strengthened significantly: maintenance of a minimum flow in the watercourse, and developments to restore ecological continuity, systems to limit fish mortality, etc.

Like existing structures, hydroelectricity projects raise very different environmental issues depending on the size of the project and the location. For a small-scale project aimed at equipping an existing dam, the impact of the project may be limited to the problem of downstream migration of fish in connection with the installation of a turbine and the modification of the hydrological landscape in case of a bypassed section. For a hydroelectric project on a greenfield site, additional impacts should be considered, such as those related to flooding (hydromorphology, water quality), or those related to ecological continuity for the run or transit of sediments. For large-scale projects with reservoir dams, the management of the impacts of sluice operation during project design is crucial. Finally, regardless of the size of the project, the cumulative effects must be evaluated where there are already installations on the watercourse concerned, particularly in terms of ecological continuity or when flooding is in prospect.

Given their higher cost and their lower benefit for the electrical system in terms of their environmental impact, the development of new low-power projects should be avoided on sites with a particular environmental sensitivity. On the other hand, additional installations or new facilities to improve the flexibility of the hydroelectricity stock must be prioritised.

Onshore wind farms

Description of the existing installations

As at 31 December 2018, 1,808 facilities were connected in France (including the overseas territories and Corsica)[59], and the French stock of existing installations therefore represents 15,075 MW and approximately 7,500 wind turbines. In 2018, 150 wind farms with a capacity of 1.47 GW were connected to the grid. Wind energy accounted for 5.9% of French electricity generation in 2018, which puts France in fourth position among EU nations.

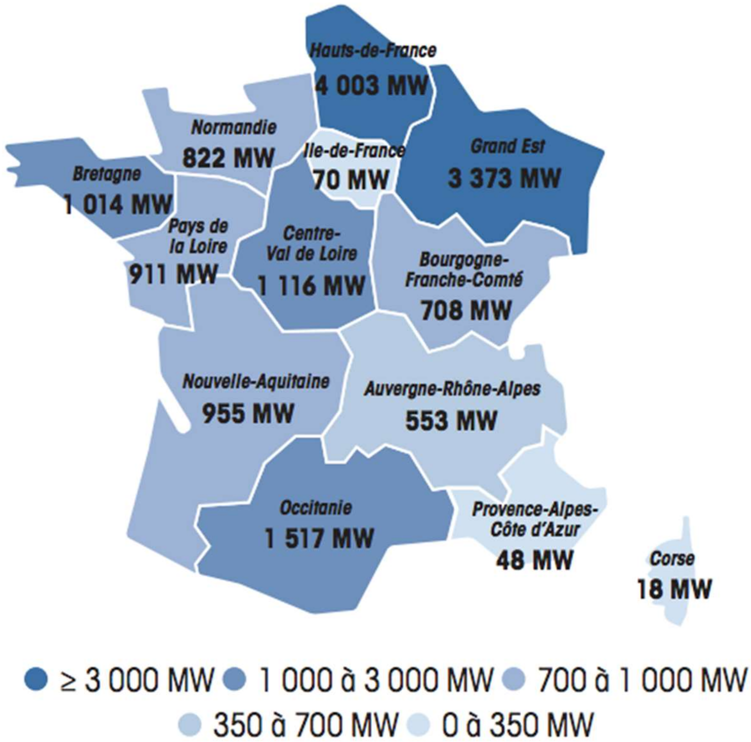
Situation in 2017	Target in MEP_{2016} for 2018	Low target in MEP_{2016} for 2023	High target in MEP_{2016} for 2023
13,470	15,000	21,800	26,000

Targets set by the MEP adopted in 2016 for installed capacity of wind generation (MW)

[59] The scope of the MEP is limited to Metropolitan France and does not include these non-interconnected areas.

The Hauts-de-France and Grand Est regions have the highest installed capacities, representing nearly 57% of the total power connected in France.

Figure 36: Regional distribution of connected wind generation capacity as at 31 December 2018 (MW) (Source: RTE)



Bretagne	Brittany
Normandie	Normandy
Hauts-de-France	Hauts-de-France
Pays de la Loire	Pays de la Loire
Centre-Val de Loire	Centre-Val de Loire
Ile-de-France	Ile-de-France
Bourgogne-Franche-Comté	Bourgogne-Franche-Comté
Nouvelle-Aquitaine	Nouvelle-Aquitaine
Auvergne-Rhône-Alpes	Auvergne-Rhône-Alpes
Occitanie	Occitanie
Provence-Alpes-Côte d'Azur	Provence-Alpes-Côte d'Azur
Corse	Corsica
≥ 3 000 MW	≥ 3,000 MW
1 000 à 3 000 MW	1,000 to 3,000 MW
700 à 1 000 MW	700 to 1,000 MW
350 à 700 MW	350 to 700 MW
0 à 350 MW	0 to 350 MW

Maximum supply potential

As part of its study on 'A 100% renewable electricity mix', ADEME published an analysis of the theoretical wind resource in Metropolitan France in 2015. This analysis superimposes, over the entire country, wind speed data and maps of 'exclusion constraints' that make the installation of wind turbines technically impossible in these zones for technical reasons (topography, terrain, etc.) or for reasons associated with land use requirements: proximity to homes, military aviation training areas, radars, areas that are sensitive from a biodiversity perspective.

The potential energy resource also depends on the technology of the wind turbine. This study considered two types of wind turbines: the standard wind turbine and the new-generation wind turbine, known as the ‘canvas’ wind turbine.

	Installed power	**Output/year**
Standard wind turbines	170 GW	360 TWh
New generation ‘canvas’ wind turbines	120 GW	330 TWh

National wind power potential

The first French wind farms commissioned from 2000 onwards will also reach the end of their useful lives during the period covered by the MEP, raising the question of replacement. The replacement of these farms will make it possible to preserve existing sites by equipping them with more modern machines. An increase in the productive capacity of existing installations could also result from the replacement of those installations, with the use of the best available techniques. Given these challenges, particular attention should be paid by the MEP to identifying those existing installations that could be replaced and to establishing conditions that enable their replacement. In particular, volumes to be replaced must be taken into account in volumes available as part of tenders, in order to ensure the sufficient development of new production capacities. In view of the work to be undertaken, the indicative schedule for tenders presented in the MEP only concerns new installations and does not take into account those that may be replaced.

Socioeconomic, industrial and environmental issues

Wind turbines do not operate all year round at full speed. A wind turbine operates within a wind speed range of between 10 and 90 km/h. Load factors (number of hours of operation per year) for onshore wind farms have been considered until now to be between 24% (2,100 h/year) and 26% (2,300 h/year). However, recent technological progress makes it possible to anticipate significant growth in these load factors, which, by 2023 and 2028, could reach figures in the order of 28% (2,500 h/year) and 30% (2,600 h/year) respectively.

This progress is possible through the use of higher machines capable of capturing stronger and more consistent winds. The use of larger rotors will also make it possible to capture weaker winds and will therefore enable wind farm development in areas that were previously considered difficult to exploit.

Since wind energy is variable, the unpredictable nature of the resource requires modifications to the way that the power grid is managed, which are developed in Section 5. Today however, wind turbines contribute to securing the French power supply through their participation in the capacity mechanism. System operators are studying the possibility of using the technical capabilities of wind farms for voltage adjustment.

Current and foreseeable costs

In global terms, onshore wind has a total cost of approximately €50/MWh. This value is around €67/MWh in Europe[60]. In France, for installations with more than six wind turbines, the prices offered in the most recent tender periods were around €63 to €66/MWh.

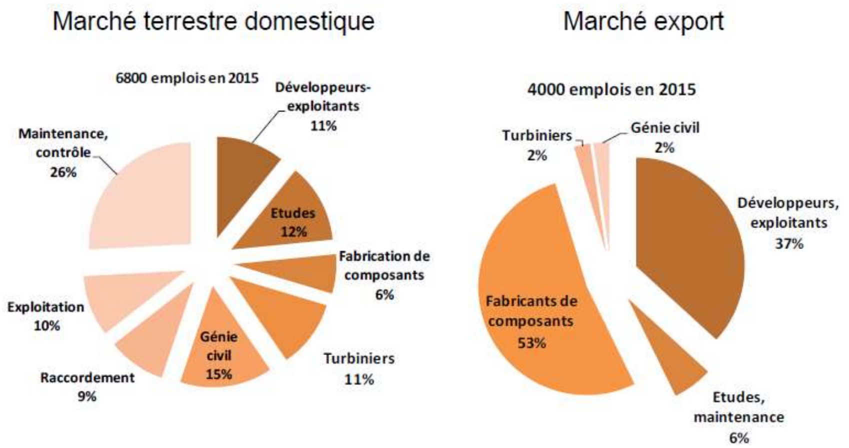
Wind power is a sector that has potential for innovation[61] and therefore cost reduction. The various estimates converge towards a decrease of about 2% per year in the cost of wind-generated MWh. In 2028, the cost of projects commissioned could be around €55/MWh.

The characteristics of the sector in terms of market and employment

The wind power sector has been developing in France and, according to ADEME, in 2016 represented more than 18,000 jobs, with 1,100 new jobs in 2018 (source: FEE). These jobs are distributed across the entire value chain: industry, development, maintenance, etc.

According to ADEME, the average employment composition of this sector is 750 FTE/TWh.

Figure 37: Distribution of direct FTE by value chain link – Source: BiPS éolien, ADEME, 2017



Marché terrestre domestique	Domestic land market
6800 emplois en 2015	6,800 jobs in 2015
Développeurs-exploitants	Developers-operators
Études	Studies
Fabrication de composants	Component production
Turbiniers	Turbine suppliers
Génie civil	Civil engineering
Raccordement	Connection
Exploitation	Operation
Maintenance, contrôle	Maintenance, monitoring
Marché export	Export market
4000 emplois en 2015	4,000 jobs in 2015
Génie civil	Civil engineering
Développeurs, exploitants	Developers, operators
Études, maintenance	Studies, maintenance

60 Renewable Power Generation Costs in 2017, IRENA, January 2018.
61 A characterisation of these innovations was undertaken in the study on 'Characterisation of technological innovations in the wind energy sector and maturities of the sectors', published by ADEME in May 2017.

Fabricants de composants	Component producers
Turbiniers	Turbine suppliers

Jobs in the wind energy sector are essentially local and cannot be relocated, especially in development and maintenance activities. On the industrial front, despite the absence of French 'big turbine manufacturers', many industrial players have been able to gain a foothold in the sector, especially in the manufacture of components. Some foreign turbine manufacturers install production units on French territory to get closer to its market.

In 2017, the market was worth €5.1 billion.

Environmental challenges

The environmental challenges of wind power are essentially linked to its potential impact on biodiversity. They also concern project landscape integration and impact on radar. Since 2011, these issues have been taken into account during project development as part of the procedure relating to establishments classified for environmental protection (ICPE).

A ministerial decree[62] also requires that wind turbines, delivery stations and cables be dismantled at the end of their operation. It also requires that foundations be excavated and replaced by land with characteristics comparable to the land in the vicinity of the installation, to a depth of at least one metre in the case of agricultural land.

It is also possible for the owner of the land to set more stringent restoration conditions in a private agreement than the conditions applying under the regulations, when leasing the land to the wind farm operator.

To ensure that these dismantling and restoration works are carried out, including in cases of default by the operator, the commissioning of a wind farm is subject to the provision of financial guarantees in an amount of €50,000 per wind turbine.

Most metals (steel, cast iron, copper, aluminium) and concrete are recycled. Wind turbine blades can be recovered to produce heat or reused to make cement.

In terms of carbon impact, wind turbines emit about 12.7 g of CO_2 equivalent – according to ADEME studies – to produce 1 kWh of electricity.

Photovoltaic power

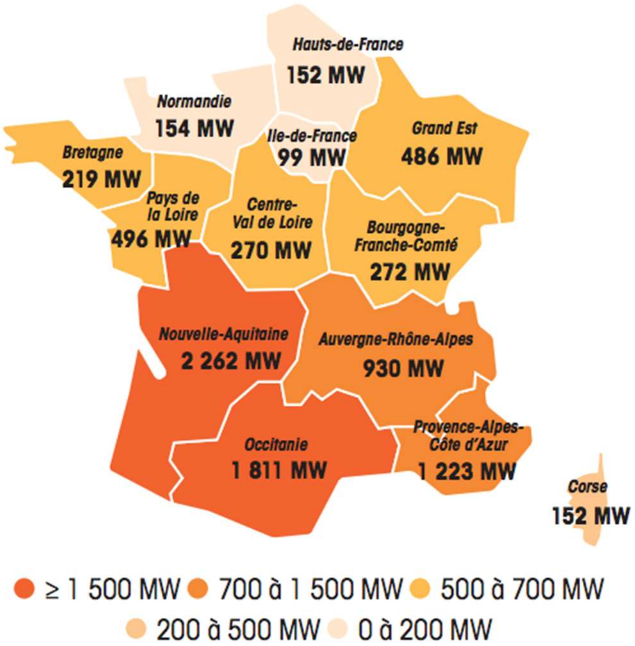
State of play in the sector

In the course of 2018, photovoltaic installations with a total capacity of 0.862 GW were connected to the grid. As at 30 September 2018, 424,805 facilities had an installed capacity of 8.9 GW. Photovoltaic solar energy represented 2.4% of French electricity consumption in 2018, an increase of 12% compared to 2017. The Nouvelle-Aquitaine, Occitanie, Provence-Alpes-Cote d'Azur and Auvergne Rhône-Alpes regions have the highest installed capacities, representing nearly 70% of the total connected power in France. However, there is an increasing number of projects in the north and east of the country.

Figure 38: Regional distribution of connected photovoltaic generation capacity as at 31 December 2018 (MW)

62 Decree of 26 August 2011 on the restoration and creation of financial guarantees for electricity generation installations using mechanical wind energy.

Source: RTE



Bretagne	Brittany
Normandie	Normandy
Hauts-de-France	Hauts-de-France
Pays de la Loire	Pays de la Loire
Centre-Val de Loire	Centre-Val de Loire
Ile-de-France	Ile-de-France
Bourgogne-Franche-Comté	Bourgogne-Franche-Comté
Nouvelle-Aquitaine	Nouvelle-Aquitaine
Auvergne-Rhône-Alpes	Auvergne-Rhône-Alpes
Occitanie	Occitanie
Provence-Alpes-Côte d'Azur	Provence-Alpes-Côte d'Azur
Corse	Corsica
≥ 1 5000 MW	≥ 15,000 MW
70 à 1 500 MW	70 to 1,500 MW
500 à 700 MW	500 to 700 MW
200 à 500 MW	200 to 500 MW
0 à 200 MW	0 to 200 MW

Situation in 2017	Target in MEP2016 for 2018	Low target in MEP2016 for 2023	High target in MEP2016 for 2023
7,660	10,200	18,200	20,200

Targets set by the MEP adopted in 2016 for installed capacity of photovoltaic generation (MW)

To achieve these solar deployment targets by 2023 with a controlled cost for the community, the 2016 MEP focuses the acceleration of the solar sector's development on the most competitive solutions, such as ground-based photovoltaic installations (launch of tenders for capacities of 0.9 to 1.2 GW/year), while developing large power installations on roofs (one third of installed volumes) and installations on small and medium-sized roofs (target of 350 MW installed per year).

Maximum supply potential

ADEME estimates rooftop photovoltaic installation potential as around 350 GW, i.e. 350,000 ha of roof surface, which makes it possible to choose the most suitable locations. This corresponds to more than 350 TWh.

The French Research Centre on Risks, Environment, Mobility and Planning (CEREMA) has evaluated the potential for ground installations and those on parking facilities on land with no conflict of use in the southern regions of France. It estimates the surface areas that could be used as about 1.5 Mha, which would correspond to about 776 GW.

Socioeconomic, industrial and environmental issues

The load factor of photovoltaic installations depends on their location (sunshine, orientation) and the quality of the installed modules. On average, in the south of France, the load factor is considered to be around 130 kWh/m²/year.

The average load rate in France is 1,200 kWh/kWp (or 13.7%). For new panels, technological progress is improving performance and therefore increasing the average load rate. The surface yields for PV on the ground are also improving, approaching 1 MW per hectare, which would make it possible to use less land for an equal capacity and thus to reduce the impact on soils.

Photovoltaic electricity generation fluctuates during the day, depending on the solar radiation power captured by the sensors. Although it fluctuates, solar generation is predictable. Forecasting tools are increasingly reliable and enable better anticipation of photovoltaic production in the short, medium and long term. The fluctuating nature of this resource adds constraints in terms of controllability of generation and management of the electricity grid. Today, these fluctuations are no greater than those caused by demand forecast errors. The issues concerning the network for variable renewable energy penetration are discussed in the section on supply security.

Current and foreseeable costs

The 2009–2019 period saw photovoltaic equipment costs fall by more than 80% due to technological developments and global competitiveness gains, from > €2/Wp to about €0.40/Wp. The prices offered for the most recent tender periods are around €60/MWh for ground installations and €90/MWh for rooftop installations. A further decline in the cost of installations is expected, at a slower pace that will depend on technological progress (improved yields), productivity gains, and global supply-demand balances. On the basis of an observation of the current rates of decrease in complete costs, the fall in costs is estimated as 4% per year for ground installations and 5% to 7% per year for rooftop installations. In 2028, the cost of rooftop PV installations could be around €60/MWh, and €40/MWh for ground PV installations.

The characteristics of the sector in terms of market and employment

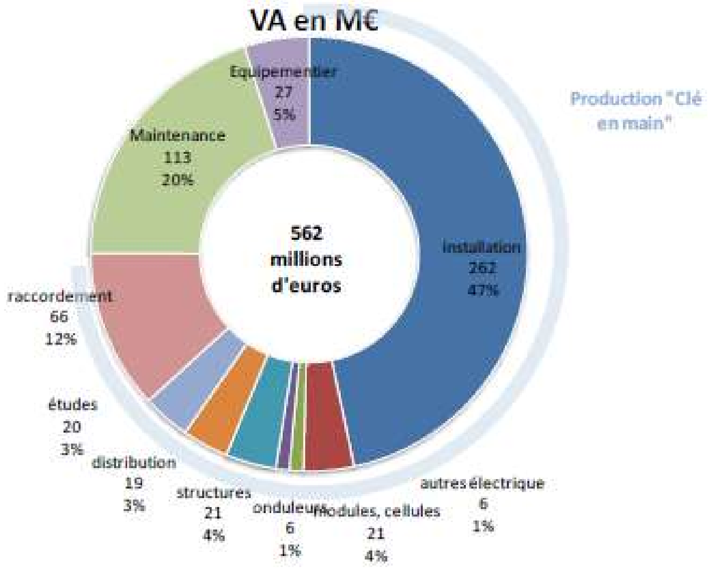
Activities associated with installation, grid connection and technical and commercial development make the implementation of solar installations an intensive activity in terms of jobs (up to 41 full-time equivalents (FTE) per MW installed annually for residential installations, according to ADEME). Ground facilities generate fewer jobs per installed MW (about 10 FTE/MW). The photovoltaic sector represented around 7,300 jobs in France in 2017[63].

[63]. 'Markets and jobs in the field of renewable energies', ADEME, 2019.

The French industry has suffered from very strong competition in the production of photovoltaic cells and modules (which represent only 4% of the added value of an installation), especially from Asian countries. Nevertheless, it is well positioned for certain equipment, including inverters and trackers.

In 2017, the sector represented 622 FTE/TWh and the market was worth €4.7 billion.

Figure 39: Added value of the PV industry. Source: BiPS PV, ADEME, 2016



VA en M€	AV in €M
Production « Clé en main »	Turnkey production
562 millions d'euros	€562 million
Installation	Installation
Autres électriques	Other electrical
Modules, cellules	Modules, cells
Onduleurs	Inverters
Structures	Structures
Distribution	Distribution
Études	Studies
Raccordement	Connection
Maintenance	Maintenance
Équipementier	Equipment manufacturers

Environmental challenges

Depending on type, the installation of solar facilities presents challenges of various kinds:

- Solar installations on rooftops and shade houses have very few social and environmental impacts and pose no difficulty in terms of conflict of use. The challenges concern architectural and landscaping issues. Innovation in the sector should provide technologies that are better integrated into their immediate environment.
- Solar facilities on the ground present a certain number of environmental challenges, mainly related to the biodiversity of the site and issues of land use conflict. These are taken into account during tender procedures, which make it possible to orientate the choice of sites towards

degraded land that cannot accommodate other developments. They are also analysed on a case-by-case basis as part of the impact study to which projects over 250 kW are subject in order to obtain planning permission.

The dismantling of installations, if it is well done, does not pose any particular difficulty. In addition, Directive 2012/19/EU on waste electrical and electronic equipment (WEEE) extended the scope of extended producer responsibility to include photovoltaic panels. France has transposed this Regulation into French law by means of Decree No 2014/928. As a result, suppliers must finance the management of their used equipment and associated recycling.

PV CYCLE France is the eco-organisation approved by the public authorities for the management of used photovoltaic panels. There are now 177 voluntary disposal points, meaning that 95% of photovoltaic panels may be recycled.

Generation of electricity from bioenergy

In 2018, the bioenergy sector produced 7.7 TWh of electricity, representing 1.6% of electricity consumption. The 2016 MEP did not set targets for all pathways used to generate electricity from bioenergy but, rather, only for the wood and biogas sectors.

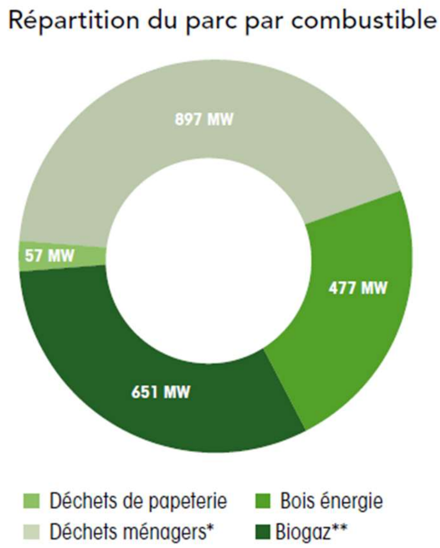
	Situation in 2016	Target in MEP_{2016} for 2018	Low target in MEP_{2016} for 2023	High target in MEP_{2016} for 2023
Installed electricity generation capacity from wood (MW)	596	540	790	1,040
Installed electricity generation capacity from biogas resulting from anaerobic digestion (MW)	110	137	237	300

Targets set by the MEP adopted in 2016 for installed capacity of electricity generation from bioenergy (MW)

Generation sectors

The generation of renewable electricity from biomass encompasses several sectors, which do not have the same degree of maturity, the same development prospects or the same challenges.

Figure 40: Distribution of electricity generation capacities from bioenergy in 2018 (MW)



Répartition du parc par combustible	Distribution of stock by fuel
Déchets de papeterie	Paper waste
Bois énergie	Wood energy
Déchets ménagers	Household waste
Biogaz	Biogas

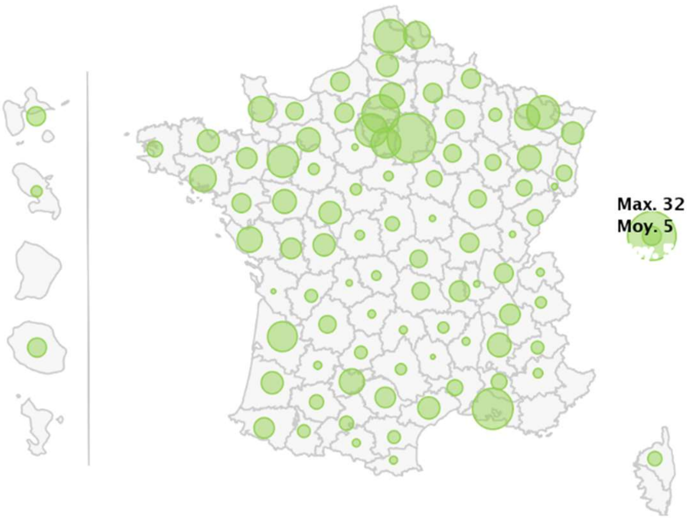
The 'biodegradable portion of domestic waste' sector groups together the energy produced by domestic waste incineration plants (DWIP). Half of the electricity generated by DWIP is accounted for as renewable. The elimination of the guaranteed electricity feed-in tariff in 2016 coincided with weak growth in 2016 (+10 MWe) and a decline in 2017, corresponding to the shutdown of a site (-13 MWe).

The 'wood energy' sector covers energy generated by combustion or incineration plants burning forest biomass and wood waste. The average annual growth rate observed from 2009 to 2015 was stable at about +50 MWe, which corresponds to equipping about four sites per year with the means to generate electricity.

The 'biogas' sector covers energy generated through biogas recovery. At the end of 2018, 633 installations were generating electricity from biogas:

- 453 methanisers with a capacity of 163 MW; only this sub-sector had a growth target in the MEP adopted in 2016;
- 152 non-hazardous waste storage facilities (ISDND) with a capacity of 267 MW;
- 28 waste water treatment plants with a capacity of 23 MW.

Figure 41: Regional distribution of connected biogas electrical power as at 31 December 2018 (in MW). Source: RTE



Max.	Max.
Moy.	Avg.

Maximum supply potential

On the basis of studies of available potential nationally, the National Biomass Mobilisation Strategy (SNMB) is setting targets for 2023 to mobilise the additional forest, agricultural and biowaste resources:

- 52 TWh for solid biomass;
- 18 TWh for biogas;
- 7.8 TWh renewable for non-hazardous waste recovered in DWIP.

Socioeconomic, industrial and environmental issues

According to the priorities outlined in the National Biomass Mobilisation Strategy (SNMB), bioenergy resources are rare resources. The value in energy terms is therefore to direct them towards the pathways presenting the highest yields, in particular recovery in the form of heat.

- The generation of electricity from biogas will be reserved for anaerobic digestion sites far from the gas grid for which there is no potential for direct recovery as bioNGV or fuel. The production of an anaerobic digestion plant is relatively stable over the year, excluding issues associated with availability of inputs, and cogeneration operations can be adapted throughout the day thanks to the flexibility afforded by biogas buffer storage. The average electrical power of anaerobic digestion plants (300 kW) is lower than for other electrical sectors.
- Given the cost of generating electricity from biomass, to optimise the total cost of achieving the targets for renewable energies and to promote the greatest possible energy efficiency, support to this pathway will be reserved for heat generation.

Electricity generation in the bioenergy sector is controllable, and as such can contribute to the supply security of the electricity network.

Current and foreseeable costs

The average purchase price of electricity generated by the 'biodegradable portion of domestic waste' sector is estimated as €56/MWh for 2016.

The average purchase price of electricity generated by the 'wood energy' sector is estimated as €149/MWh for 2016. This high purchase price can be explained by the need to cover the site's operational costs, including primarily the purchase of fuel, which represents between €15 and €25/MWh LHV, and staff. A moderate cost reduction is anticipated by the end of the current MEP period, and prices could reach around €140/MWh in 2028.

The purchase price of electricity generated by the 'biogas' sector is extremely variable depending on the origin of the biogas used. For new installations in Metropolitan France:

- the purchase price of electricity generated from landfill biogas ranged from €85/MWh to €145/MWh;
- the purchase price of electricity generated by anaerobic digestion or from biogas from waste water treatment plants ranged from €120/MWh to €210/MWh. Technical progress could also be observed for the purification of biogas. Based on the example of findings in other countries that have developed anaerobic digestion on a large scale, in particular Germany, the drop in costs should make it possible to reach €160/MWh by 2028 for electricity generation.

The characteristics of the sector in terms of employment

The domestic waste incinerator sector accounted for around 620 jobs in France in 2016 (up slightly from 2014), according to ADEME, mainly in the electricity generation segment.

The collective, tertiary and industrial wood pathway accounted for around 6,190 jobs in France in 2017 according to ADEME, with 940 jobs in the manufacturing segment, 470 in the installation-design segment, 4,000 jobs in maintenance and 1,180 in the sale of energy (heat and electricity). Jobs in the pathway relate primarily to the market production of fuels, woodchips and wood logs for the collective sector. In 2017, the market for the sector was worth €1.3 billion.

The biogas pathway for the production of heat and electricity and for injection accounted for about 2,430 jobs in France, including 270 jobs in the manufacturing segment, 1,210 jobs in the installation-design segment, and 630 jobs in sales and maintenance. Jobs in the sector are relatively stable compared to the previous year, because the increase in jobs related to the operation and sale of energy offset the decline in jobs related to investment.

In 2017, the biogas market stood at €410 million.

Environmental challenges

DWIPs have a potential impact in terms of air pollution that is controlled by the ICPE regulations. The recovery of the waste heat from DWIPs means that other forms of energy production can be replaced, thus reducing the impact on the environment.

Biomass cogeneration plants also have a potential impact in terms of air pollution, which is regulated by the ICPE regulations. The additional issue overlaps the issues of biodiversity conservation and conflict of use for the mobilisation of biomass.

Equipping landfills and waste water treatment plants with electricity generating systems makes it possible to recover waste energy and to reduce emissions of methane or CO_2 to the atmosphere when the methane is flared.

If biogas is produced from biowaste (from local authorities, agrifoods, catering, etc.) that is not being recovered to date, anaerobic digestion contributes to the European targets for reducing organic matter landfilling and contributes to limiting GHG emissions within the sector. If biogas is produced from livestock effluents, anaerobic digestion helps to reduce the impact of farms on the climate, by capturing methane, but also of issues related to nitrogen pollution.

Offshore wind farms and renewable marine energy

Offshore wind power (fixed and floating)

The commercial development of the fixed offshore wind power sector was initiated by the launch of two calls for tenders in 2011 and 2013 and the allocation of nearly 3,000 MW spread over six wind farms off the coast of Normandy, Brittany and Pays de la Loire. A third offshore wind tender was launched off Dunkirk in December 2016. It was awarded in June 2019 for a capacity of 600 MW. Regarding floating wind farms, a technology at a less advanced stage of maturity, four pilot projects of 24 MW each were designated the winners of a call for projects launched by ADEME in 2017 as part of the Investments for the Future Programme: one in southern Brittany and three in the Mediterranean. Initial commissioning is scheduled for 2021.

Renewable marine energies (other than offshore wind turbines)

Each of these sectors has a degree of maturity and specific development prospects in the relatively long term. Since 2009, several Calls for Expression of Interest (CEI), run by ADEME, have been launched by the Government as part of the Investments for the Future Programme on marine energies.

Regarding tidal power, three different offshore hydrokinetic demonstrators were successfully submerged in Ouessant (October 2018, Sabella, 1 MW), Etel (February 2019, Guinard Energies, 250 kW) and Paimpol-Bréhat (April 2019, OceanQuest demonstrator on a site operated by EDF, 1 MW). All these machines were connected to the electric grid and have been producing energy ever since. These tidal turbines were all designed and manufactured in France.

The tidal power plant at Rance has an annual gross output of around 500 GWh for 240 MW installed.

	Situation in 2016	Target in MEP_{2016} installed capacity in 2018	Target in MEP_{2016} installed capacity in 2023	Target in MEP_{2016} capacity allocated by tenders in 2023
Installed capacity for offshore wind generation	0	500 MW	3,000 MW	Between an extra 500 and 6,000 MW
Installed capacity for renewable marine energy generation	240 MW[64]		440 MW	Between an extra 440 and 2,240 MW

Targets set by the MEP adopted in 2016 for installed capacity of electricity generation from bioenergy (MW)

64. The MEP mentions only the extra capacity (100 MW). For the sake of uniformity with other pathways, the capacity of the Rance plant has been added.

Maximum supply potential

Regarding offshore wind farms: the technical potential for installed wind power is 90 GW according to ADEME. Due to limitations related to reconciliation with other marine uses, the potential is currently estimated as 16 GW. The technical potential for floating wind farms is 155 GW according to ADEME, of which 33 GW is accessible taking into account the limits related to reconciliation with other marine uses.

To develop offshore wind energy, consultations have been held with all stakeholders within the framework of drafting the strategic documents on the shoreline, which notably cover the determination of zones that could accommodate offshore wind power projects. Given the success of the consultation in that forum, the first calls for tenders for floating wind farms will be in southern Brittany, followed by the Mediterranean. The next wind energy tender will be launched in Normandy. As of January 2024, calls for tenders will be launched for extensions to previously awarded projects for offshore wind farms, with pooled connection.

Box 8: North Seas Energy Cooperation

France is a member of a cooperation related to wind energy in the North Sea, which aims to support the deployment of cross-border wind projects and to share processes and methods to accelerate the development of offshore wind energy among the member countries. The cooperation includes France, Belgium, the Netherlands, Denmark, Ireland, Germany, the United Kingdom, Norway, Sweden and Luxembourg. France has used the information shared in this group to radically modify its framework for the development of offshore wind projects, giving a reinforced role to the Government upstream of any calls for tenders (performance of advance studies and participation by the public, in particular to identify the zone for the call for tender, under the aegis of the National Commission for Public Debate). This group is also involved in developing a shared framework for assessing the cumulative impacts of offshore wind farms, and France will build on that knowledge. Lastly, France has committed to providing the group with the planned calendar for its tender procedures, to give industrial players a consolidated view of coming calls for tenders and to identify possible overlaps to avoid.

Regarding the tidal (marine current) sector, France, which has some of the strongest currents in the world, has an exploitable technical potential, without taking into account usage constraints, of 3 to 5 GW, and thus a third of Europe's resources. The potential sites are located mainly off the coast of Raz-Blanchard in Normandy and in the Fromveur Passage in Brittany. The Government believes that the conditions for launching a commercial call for tenders are not met, and therefore has no plans for such a process in the period covered by the MEP. The Government will closely monitor the demonstrator projects that might be pursued and the performance of the sector in the coming years.

Regarding wave energy, these activities are still at the demonstration stage. There is no reliable estimate of exploitable technical potential, given the pathway's immaturity.

Regarding tidal energy, France is currently a pioneer in this technology through the Rance plant, but it is not planning to develop it further in the short term, especially in view of the substantial environmental challenges presented by this technology at new sites.

Regarding ocean thermal energy, the potential sites are located primarily in overseas territories where temperature gradients between warm surface waters and deep cold waters are greater than in metropolitan France.

Socioeconomic, industrial and environmental issues

Offshore wind power (fixed and floating)

With wind speeds that are more sustained and more consistent than onshore wind farms, a wind turbine at sea can generate on average twice as much energy as one on land. The load factor is around 40%

(about 3,500 h/year). In addition, offshore wind farms currently have an average capacity of 500 MW (compared to an average of 10 MW for onshore wind farms); current projects are now on average between 700 MW and 1 GW.

The grid manager is involved upstream in calls for tenders to identify the capacity of the grids and to propose offshore grid-linking options, ideally through cost sharing. It provides overall control and management of the connection of wind farms and the engineering of underwater connections, and finances the costs for those wind farms resulting from tender procedures.

Current and foreseeable costs

The costs of offshore wind turbines installed have been declining for several years in Europe and are currently reaching average prices in the range of €60/MWh, excluding connection (in 2019). Connection adds a cost of between €10 and €20/MWh depending on the site. The most recent call for tenders for an offshore wind project (around 600 MW off the coast of Dunkirk) was awarded for a price of €44/MWh.

A sharp decrease in costs for commercial floating wind farms is expected, with a tariff of about €150/MWh for the first projects commissioned by 2028, and a convergence of the tariffs for fixed and floating wind turbines in the medium term.

As regards tidal turbines, the studies and demonstrators commissioned show that this sector has matured, even though production costs are still high compared to other technologies such as offshore wind turbines.

In its 2015 Medium-Term Renewable Energy Market Report, the International Energy Agency[65] *suggests that investment costs for 3 MW of wave energy would be about €15,400/kW. Investment costs for a 10 MW installation using marine currents would be around €12,500/kW. For ocean thermal energy, investment costs would be higher, potentially reaching €38,500/kW. In total, for all offshore renewable energy sources, 20 R&D projects have been funded, with total funding exceeding €190 million.Jobs.*

According to the ADEME study 'Study on the offshore wind energy sector: assessment, prospects and strategy' [66] published in September 2017, the structuring of the sector is crucial in generating a significant number of jobs during subsequent tenders. All ongoing projects could eventually represent up to 15,000 direct and indirect jobs, including the several thousand that already exist. The development of offshore wind turbines without the structural organisation of a national sector would lead to a limited increase in jobs.

Environmental challenges

Offshore wind turbines (fixed and floating) present environmental issues related to the biodiversity of the sites, with impacts mainly on marine biodiversity (marine mammals, seabed) in the construction phase (with fixed wind having a greater impact than floating), impacts mainly on bird life during the operation phase, and relatively significant landscape impacts depending on the distance of the wind farms from the coast. There are also conflicts of use with professional fishing and recreational craft.

All of these issues are governed by the Environment Code's regulations relating to environmental authorisation. To enable more comprehensive consideration of these issues for future tenders, the

65. Medium-term Renewable Energy Market Report 2016, available at: https://www.iea.org/newsroom/news/2016/october/medium-term-renewable-energy-market-report-2016.html

66. Study on the French wind energy sector: assessment, prospects and strategy, ADEME, September 2017, available at: http://www.ademe.fr/etude-filiere-eolienne-francaise-bilan-prospective-strategie

Government will carry out studies and involve the National Commission for Public Debate upstream of calls for tenders, in order to organise public consultation on these wind farm resources.

Geothermal electricity

State of play in the sector

Deep geothermal energy production consists of exploiting a resource that has a sufficient temperature to generate electricity, where necessary supplemented by heat recovery by cogeneration, or to generate heat for district heating purposes. The geothermal electricity sector in Metropolitan France remains very marginal today, with only one industrial installation located in Alsace, in Soultz-sous-Forêts. This project, originally built as a pilot for a scientific trial in the mid-1980s, became an industrial site in 2017, with gross electrical power of about 1.5 MW, which represents around 7,800 MWh/year supplied to the power grid.

Situation in 2016	Target in MEP_{2016} for 2018	Target in MEP_{2016} for 2023
1	8	20 to 40

Targets set by the MEP adopted in 2016 for installed capacity of electricity generation from geothermal energy (MW)

Maximum supply potential

Deep geothermal energy only develops in certain regions that have geological contexts favourable to the significant production of a high-temperature water resource. This activity requires a thorough knowledge of the subsoil at great depths, up to 5,000 m.

In 2018, 15 exclusive research permits in Metropolitan France covered an area of just over 10,000 km². This exploration phase, which is a prospecting phase with high financial risk, sometimes carried out for more than 10 years, makes it possible to understand the geological context and reduce the geological risk associated with the discovery of the resource and its characterisation in terms of temperature and flow. The geological contexts favourable to the development of this deep geothermal energy exist in France in the Alsatian Upper Rhine Plain, in the Auvergne and in particular in the Limagne basin, the Rhône Valley and the Aquitaine basin.

Thermoelectric conversion efficiency remains limited, at around 10%. One way to improve the performance of these units is to recover the waste heat produced, in particular by supplying district heating systems.

Socioeconomic, industrial and environmental issues

This emerging sector is mobilising several industrial players in Metropolitan France.

Major investments through research permits and the long exploration phase required to classify the resource and minimise geological risks make it difficult to develop the sector rapidly. The establishment of the GeoDeep Guarantee Fund, which is being pre-notified to the European Commission, is a mechanism for covering geological risk during the drilling phase, consisting of equal parts of private and public funding.

The legislative and regulatory framework has enabled significant development of district heating systems in Île-de-France, a region with favourable geological characteristics.

Current and foreseeable costs

The main technological barriers concern the discovery, evaluation and understanding of geothermal reservoirs. Significant cost reductions are expected as geoscience studies lead to a better understanding of geological potential. This gain in competitiveness will also be made possible by the depreciation of boreholes and, to a lesser extent, by the gains in efficiency and yield of binary-cycle units.

In France, the cost of generating electricity from the Bouillante power station in Guadeloupe – the only volcanic-operated unit – is more than €100/MWh[67], which is higher than the international price of generation positioned between €38 and €62/MWh for an installed capacity of between 20 MW and 50 MW. This is partly due to the island nature of the plant and its current small size (15 MW). According to ADEME, deep geothermal installations in Metropolitan France will have a generation cost ranging from €173 to €336/MWh.

The Decree of 13 December 2016 allows installations using energy extracted from geothermal deposits to generate electricity to be paid additional remuneration on the feed-in tariff, based on the reference rate of €246/MWh.

The characteristics of the sector in terms of employment

According to a study[68] published in 2019, the deep geothermal sector – a sector in development – could represent about 1,200 direct jobs in 2017, both in investment and in production and maintenance. The total turnover of the deep geothermal sector was estimated as €142 million in 2017 (source: ADEME). Of that turnover, 20% represents high-energy activities.

Environmental challenges

The phases during which a deep geothermal site can cause the most nuisance and impact are the drilling and production test phases. The Mining Code and the Energy Code strictly regulate this activity, thus making it possible to control the environmental risks related to the sector. Deep geothermal energy in Metropolitan France operates in closed circuit with re-injection of the geothermal fluid into the same formation as it is generated. Aquifers exploited for their geothermal resources do not contain drinkable or drinking water. The exploitation of a geothermal site may produce induced micro-seismicity, but monitoring networks can be used to analyse the data. These projects must be accepted by local stakeholders because they recover a local resource, which is permanently available and generally located in urban areas. The carbon footprint of deep geothermal energy is very close to neutral because the total CO_2 emissions calculated over the life of a project vary between 17 and 60 g/kWh.

General outlook for changes in the electricity mix

The table below shows the electricity generation resources for the MEP timelines when the measures laid down in this MEP will be adopted.

		2023	2028 Scenario A	2028 Scenario B
Nuclear		393	382	371
Fossil	**Coal**	0	0	0

67. Special report from the Court of Auditors, Articles L. 1433 and R. 1431 of the Financial Jurisdictions Code, No 71058, October 2014.
68 http://www.entreprises.gouv.fr/etudes-et-statistiques/filieres-industrielles-la-valorisation-energetique-du-sous-sol-profond

	Fuel oil / **Gas**	34	32	32
Renewable	**Hydro**	62	62	62
	Onshore wind	52	77	81
	Photovoltaic	24	43	53
	Bioenergies	9	9	10
	Offshore wind farms and renewable marine energy	9	20	21

Electricity mix that the MEP will make it possible to achieve in 2023 and 2028 (TWh)

In 2023, the MEP should lead to the generation of around 155 TWh of electricity from renewable sources, 34 TWh of electricity from thermal sources and 393 TWh from nuclear sources, i.e. 27% of electricity generation from renewable sources and 67% from nuclear sources.

In 2028, the MEP should lead to the generation of between 210 and 227 TWh of electricity from renewable sources, 32 TWh of electricity from thermal sources and between 382 and 371 TWh from nuclear sources, i.e. between 33% and 36% of electricity generation from renewable sources and between 59% and 61% from nuclear sources.

4.2.2.5. General outlook for changes in the energy mix in 2023, 2028 and 2030

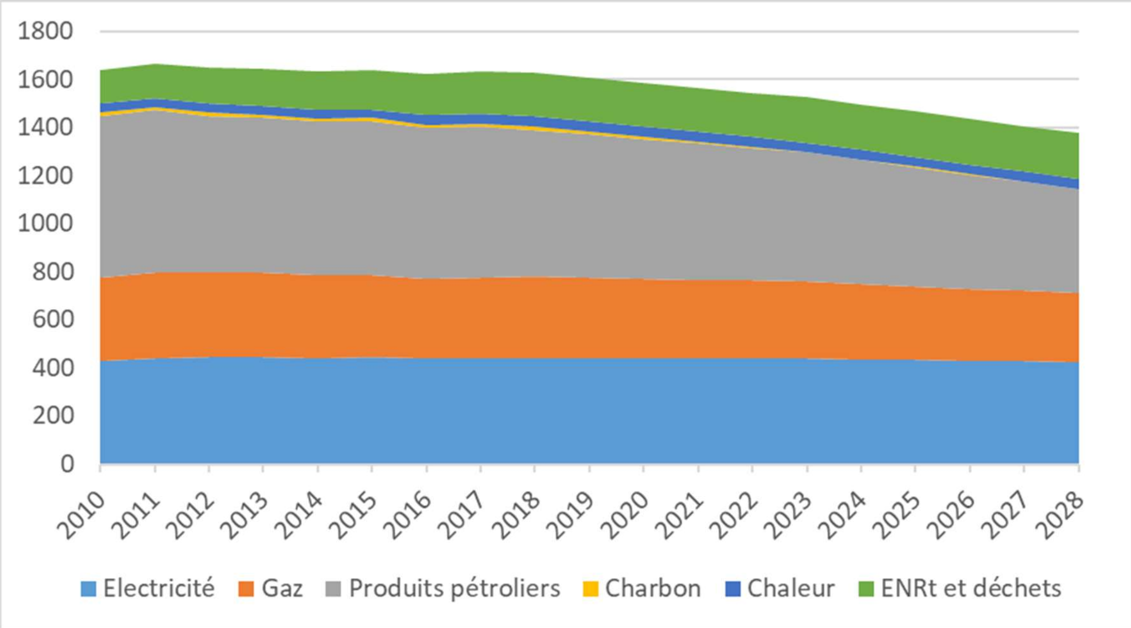
The tables below show the mix that should result by 2023 and 2028, expressed as final energy and broken down by sector in accordance with needs.

	Final energy consumed in 2023 (TWh)		**Final energy consumed in 2028 (TWh)**	
	Total	**Including renewable**	**Total**	**Including renewable**
Coal	2	0	1	0
Oil	537	33	433	35
Gas	319 (LHV) 357 (HHV)	5 (LHV) 6 (HHV)	284 (LHV) 318 (HHV)	13 to 20 (LHV) 14 to 22 (HHV)
Electricity	440	155	426	210 to 227

Heat (including biomass and biogas)	227	196	233	219 to 247
Total	**1525**	**389**	**1378**	**477 to 529**

Final energy consumed in 2023 and 2028 by source (TWh)

Figure 42: Change in the energy mix, actual (2010–2018) and projected (2019–2028) by energy vector



Electricité	Electricity
Gaz	Gas
Produits pétroliers	Oil products
Charbon	Coal
Chaleur	Heat
ENRt et déchets	Renewable thermal energies and waste

	Coal	Refined petroleum products	Gas	Thermal renewable energies and wastes	Electricity	Heat sold	Total
Industry	2	19	119	24	114	13	291
Transport	0	412	6	35	21	0	473
Residential	0	55	126	105	148	17	450
Tertiary	0	20	64	21	148	9	262
Agriculture	0	33	5	2	9	0	49

Final energy consumption	2	537	319	187	440	40	1525

Final energy consumed in 2023 by sectors (TWh)

In 2023, final energy consumption should be in the region of 1,525 TWh, i.e. 7.6% less than in 2012. Gross final energy consumption (including network loss and energy sector consumption in particular) should be 1,637 TWh. Renewable energy will provide 389 TWh, covering 24% of final consumption.

	Coal	Refined petroleum products	Gas	Thermal renewable energies and wastes	Electricity	Heat sold	Total
Industry	1	13	106	29	108	12	269
Transport	0	347	12	37	31	0	427
Residential	0	31	112	98	138	20	399
Tertiary	0	14	50	24	140	9	237
Agriculture	0	28	5	3	9	0	46
Final energy consumption	1	433	284	192	426	41	1378

Final energy consumed in 2028 by sectors (TWh)

In 2028, final energy consumption should be 1,378 TWh, i.e. 16.5% less than in 2012. Gross final energy consumption (including network loss and energy sector consumption in particular) should be 1489 TWh. Renewable energy will supply between 477 and 529 TWh, thus providing between 32% and 35% of gross final energy consumption.

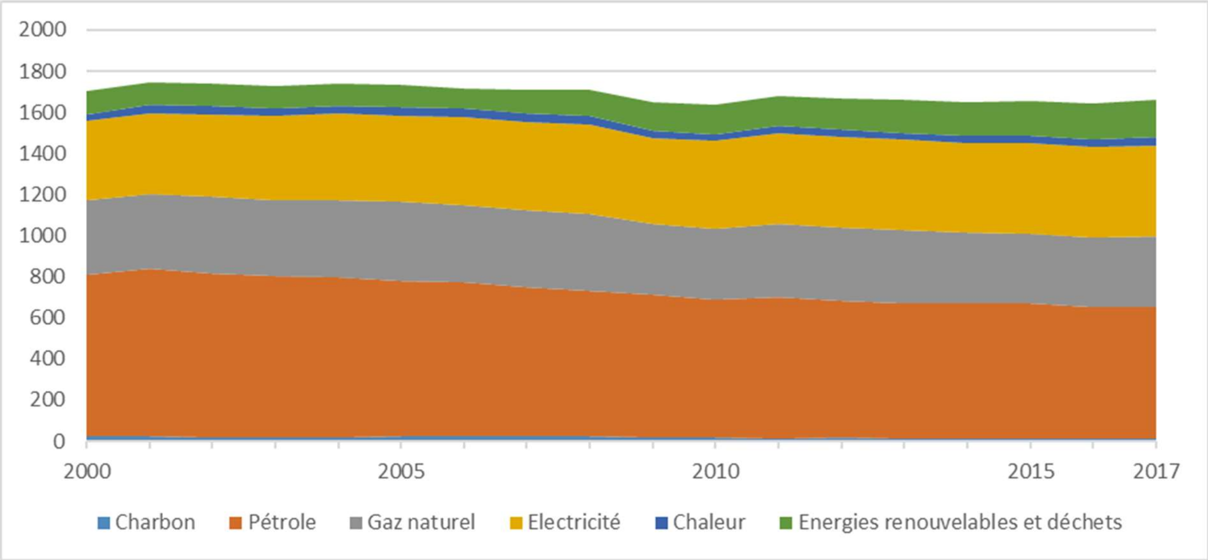
According to the target set by the Energy Climate Law for 2030, 33% of gross final energy consumption should be provided by renewable energy.

4.3. Energy efficiency

4.3.1. Final energy consumption in the economy and by sector (including industrial, residential, services and transport)

France's final energy consumption grew steadily until 2001. Since 2001, it has stabilised, reflecting the changes in the French economy and the effectiveness of public policies to improve France's energy efficiency. Since 2009, as a result of the economic crisis in particular, final energy consumption for energy purposes has decreased slightly. Energy-demand control policies have stopped the rise in energy consumption due to population growth and economic growth, but have not yet resulted in a sustainable reduction in overall consumption.

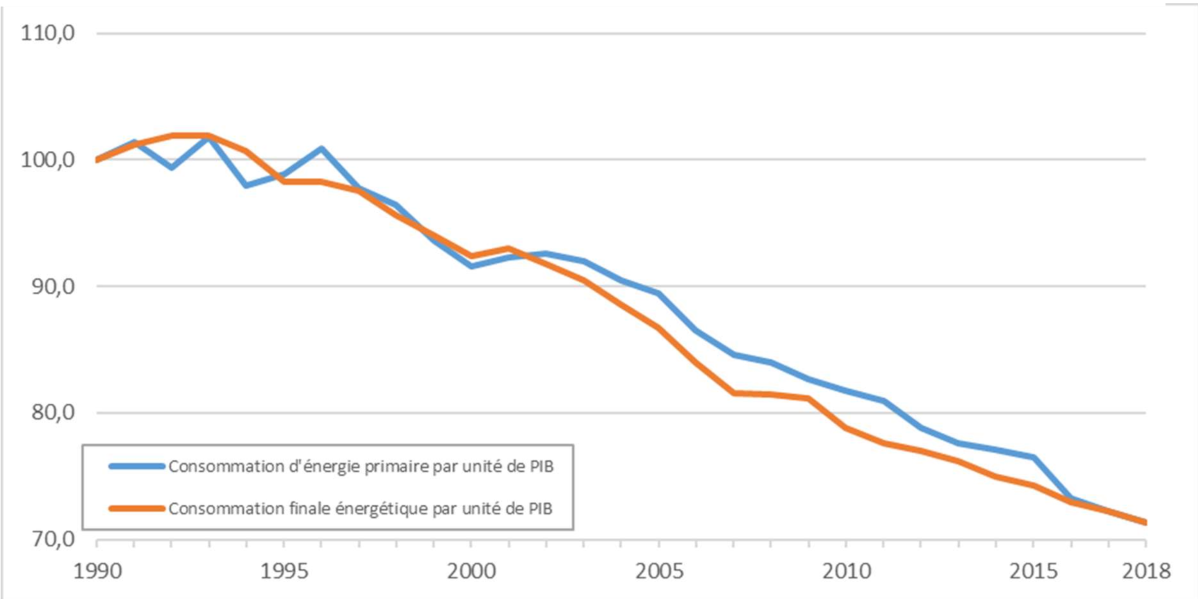
Figure 43: Final consumption for energy purposes by form of energy – Data adjusted for climate variations, in TWh Source: SDES calculations, on the basis of sources per form of energy



Electricité	Electricity
Gaz naturel	Natural gas
Pétrole	Oil
Charbon	Coal
Chaleur	Heat
Energies renouvelables et déchets	Renewable energies and waste

The average annual decrease in energy intensity since 2004 is 1.4%.

Figure 44: Change in final and primary energy intensity 1990–2018 (index) Source: SDES, Insee

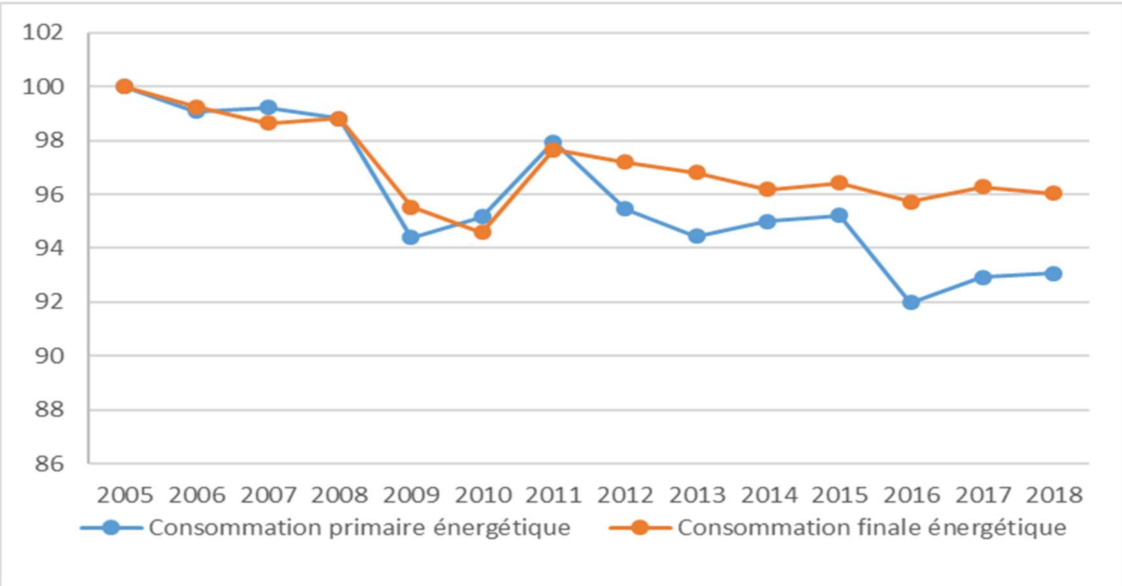


Consommation d'énergie primaire par unité de PIB	Primary energy consumption by unit of GDP
Consommation finale énergétique par unité de PIB	Final energy consumption by unit of GDP

In application of Article 3 of Directive 2012/27/EU on energy efficiency, France has set the double target of reducing its energy consumption to 1,528 TWh (131.4 Mtoe) of final energy and 2,557 TWh (219.9 Mtoe) of primary energy by 2020 (excluding international bunkers and non-energy uses).

In 2018, final energy consumption for energy use (excluding international bunkers), adjusted for climatic variations, was 1,628 TWh, and primary energy consumption (excluding international bunkers) was 2,890 TWh. The graph below shows the progress made towards achieving the targets (data adjusted for climate variations, expressed in base 100).

Figure 45: Change in final energy consumption and primary energy consumption (base 100 index in 2005) – Source: SDES



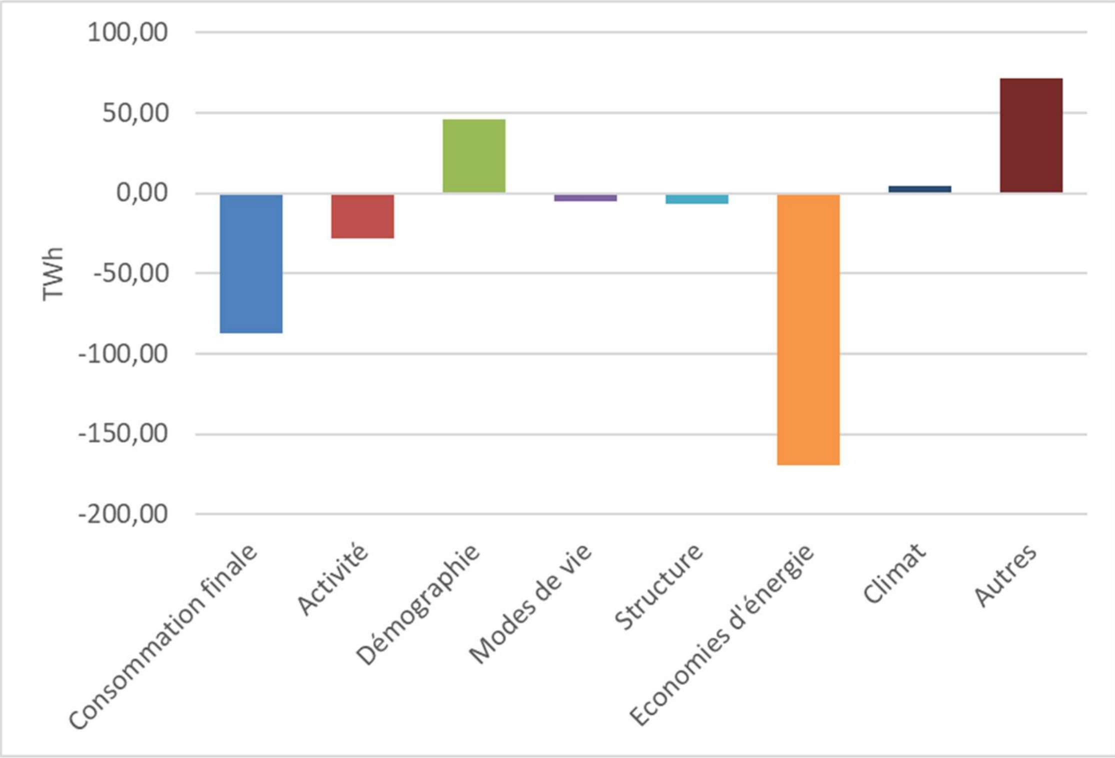
Consommation primaire énergétique	Primary energy consumption
Consommation finale énergétique	Final energy consumption

While France is generally involved in a process of reducing its final energy consumption, the current pace is insufficient to reach the 2020 target in the Energy Efficiency Directive. The reference scenario specifies that the target for 2020 will not be reached until 2023. Current measures would have to be rapidly stepped up or new measures adopted if the 2020 targets are to be achieved.

Analyses that can be used to break down the factors driving the progression of final energy consumption show that energy efficiency policies have led to significant volumes of energy savings that offset the effects of rising demographics or GDP growth (see figure below) [69].

69. http://www.indicators.odyssee-mure.eu/decomposition.html

Figure 46: Breakdown of the change in final energy consumption in France between 2006 and 2016 (in Mtoe) (Source: Odyssée, 2019)



TWh	TWh
Consommation finale	Final consumption
Activité	Activity
Démographie	Demographics
Modes de vie	Lifestyles
Structure	Structure
Économies d'énergie	Energy savings
Climat	Climate
Autres	Other

The sectors do not all have the same impact on final energy consumption: the two major contributors are transport and residential-tertiary, followed by industry. Energy consumption in industry declined in 2008, during the crisis, and has been stable since. Energy consumption in transport and residential-tertiary is stable.

In 2018, the situation relating to energy by sector was the following:

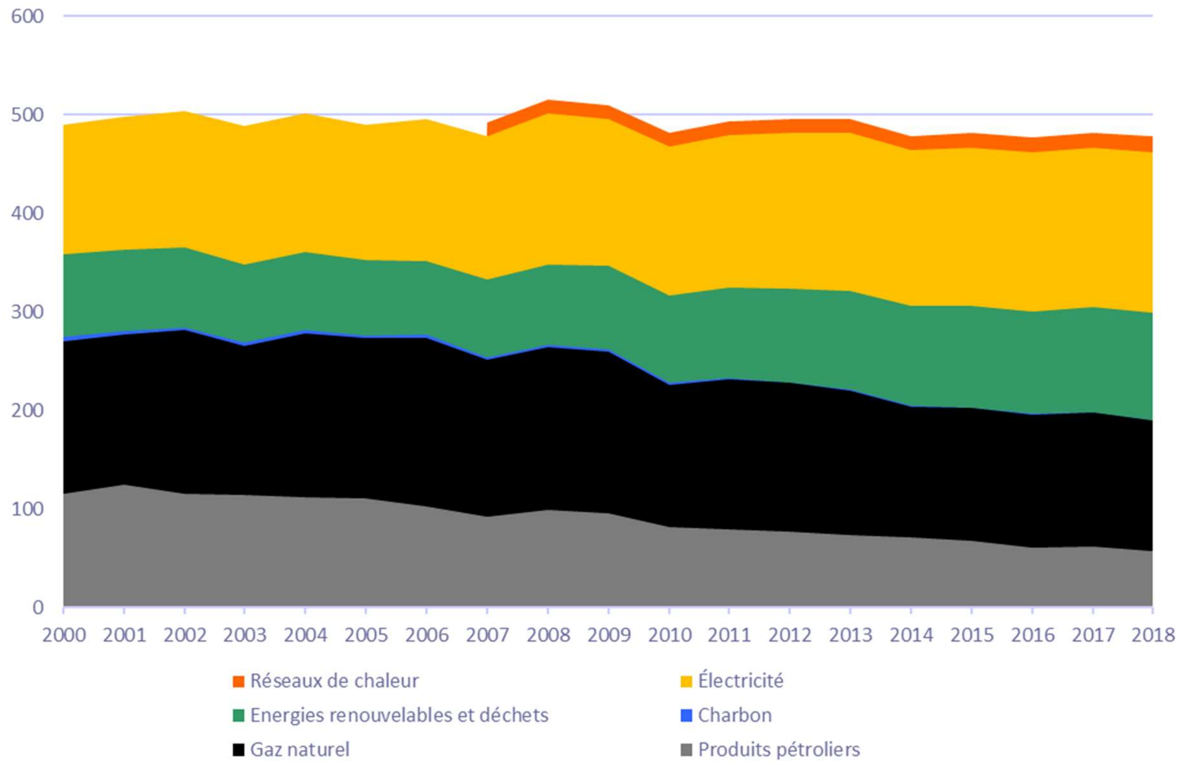
Industry	Transport	Residential	Tertiary	Agriculture	Total
318	504	473	282	50	1628

Final energy consumption by sector in 2018 (TWh), adjusted for climate variations – Source: SDES

4.3.1.1. Residential sector

Final energy consumption in the residential sector has been stable for 10 years. The downward effects of improved energy efficiency in new buildings and the renovation of existing buildings are offset by the increase in the number of occupied dwellings (population growth, family undoubling, etc.).

Figure 47: Final energy consumption in the residential sector – Data adjusted for climate variations, in TWh
Source: SDES calculations, according to sources per form of energy.



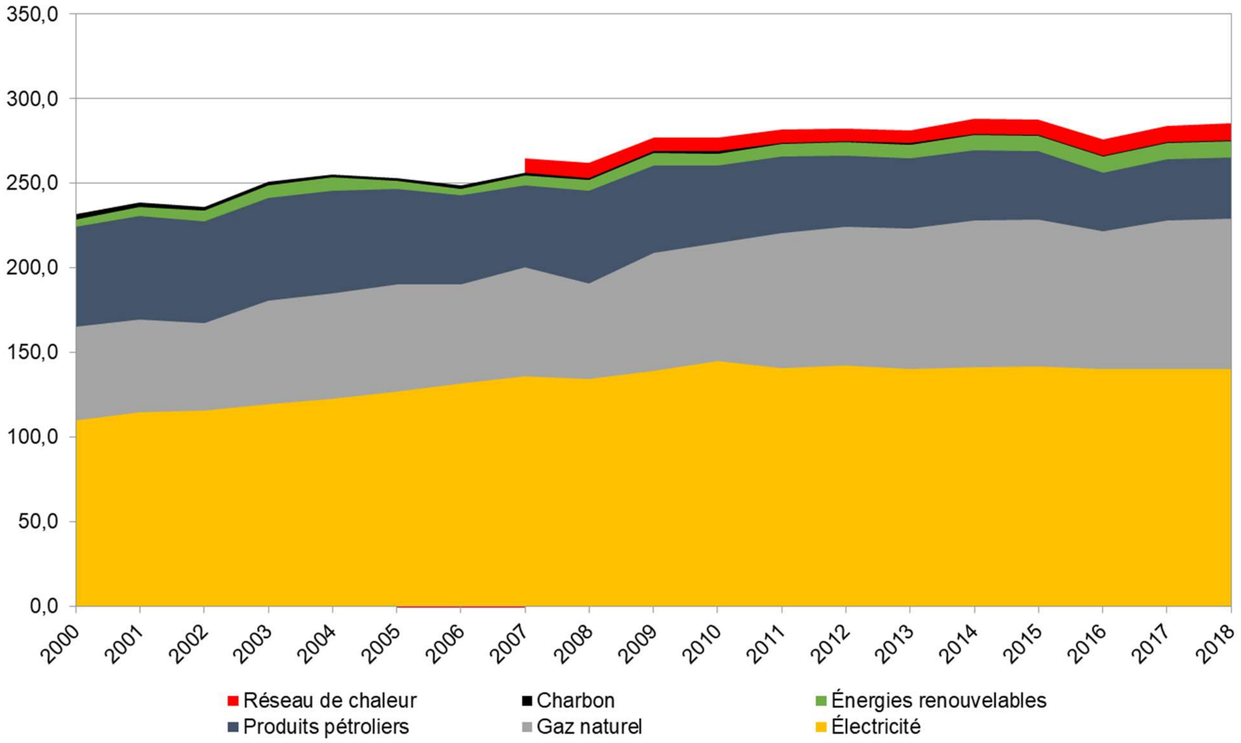
Énergies renouvelables et déchets	Renewable energies and waste
Produits pétroliers	Oil products
Charbon	Coal
Gaz naturel	Natural gas
Électricité	Electricity
Réseaux de chaleur	District heating systems

In 2018, real energy consumption in the residential sector, which was largely related to heating needs, decreased by 3.1% due to milder weather than in 2017. It stood at 449.6 TWh. Adjusted for climate variations, it was 473.7 TWh, a decrease of 0.7%.

4.3.1.2. Tertiary sector

Energy consumption in the tertiary sector grew until 2011, when energy efficiency policies stabilised demand. Since then, there has been a fairly stable, slightly downward trend.

Figure 48: Final energy consumption in the tertiary sector – Data adjusted for climate variations, in TWh Source: SDES calculations, according to sources per form of energy



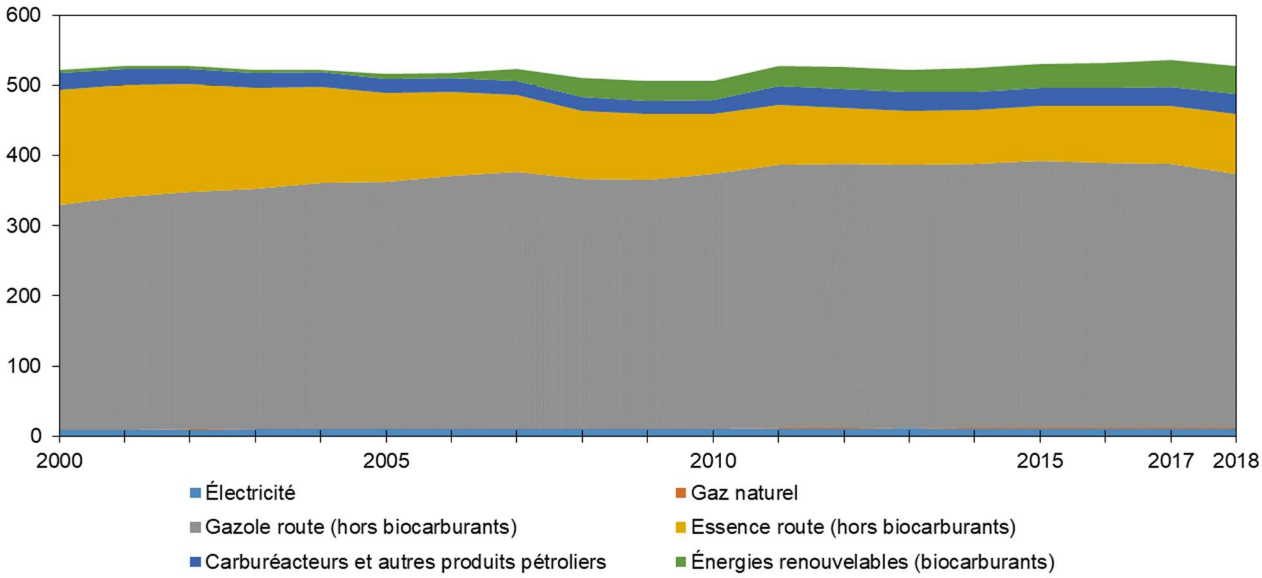
Énergies renouvelables	Renewable energy
Produits pétroliers	Oil products
Charbon	Coal
Gaz naturel	Natural gas
Électricité	Electricity
Réseau de chaleur	District heating system

In 2018, real energy consumption in the tertiary sector decreased by 1% to 273.5 TWh. Adjusted for climate variations, it was 282.2 TWh, an increase of 0.5%.

4.3.1.3. Transport sector

After a period of continuous growth between 1990 and 2001 (+1.5% annual average), final energy consumption for transport uses decreased slowly, by 0.3% per year on average, between 2001 and 2013, before rebounding between 2013 and 2015. In 2018, final energy consumption for transport uses was down compared to 2017, at 504.2 TWh. This fall followed a year of growth (+0.8% between 2016 and 2017).

Figure 49: Final energy consumption in transport, in TWh Source: SDES calculations, according to sources per form of energy



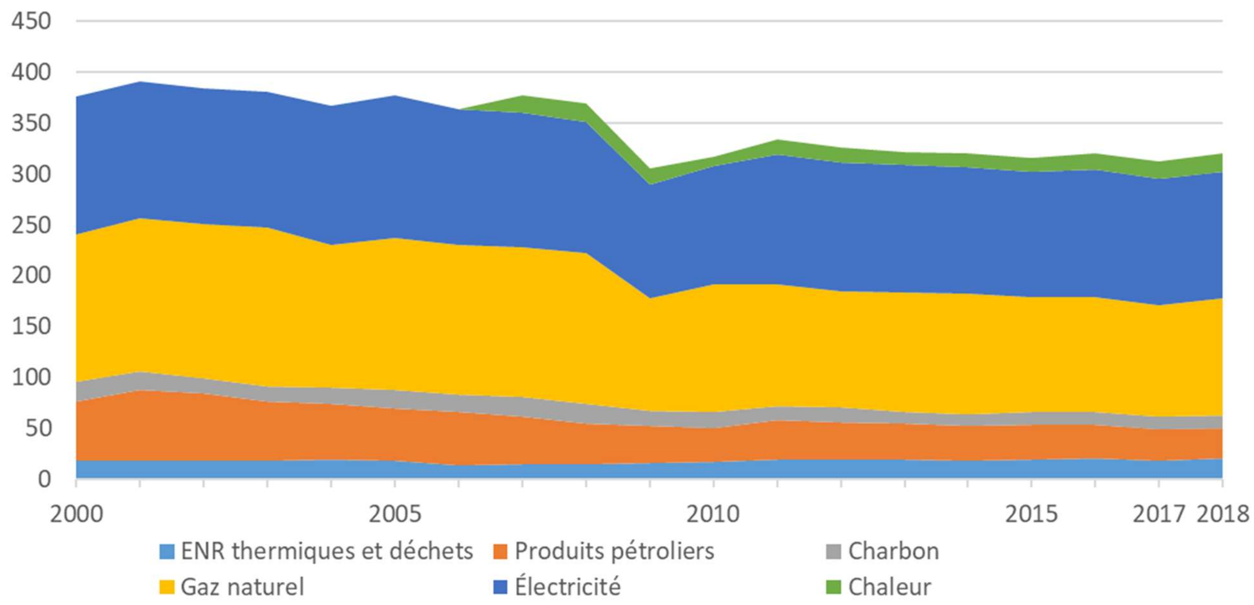
Électricité	Electricity
Gaz naturel	Natural gas
Gazole route (hors biocarburants)	Road diesel (excluding biofuels)
Essence route (hors biocarburants)	Road petrol (excluding biofuels)
Carburéacteurs et autres produits pétroliers	Jet fuels and other oil products
Énergies renouvelables (biocarburants)	Renewable energies (biofuels)

Energy consumption in transport is also relatively stable, which shows the importance of improving the system as a whole, because of major growth in mobility needs.

4.3.1.4. Industrial sector

Between 1990 and 2007, energy consumption in the industry remained relatively stable. There was a significant reduction in consumption related to the 2008–2009 economic crisis, followed by a rebound between 2009 and 2011. Energy consumption in industry has since been on a downward trend.

Figure 50: Final energy consumption in the industrial sector – Data adjusted for climate variations, in TWh Source: SDES calculations



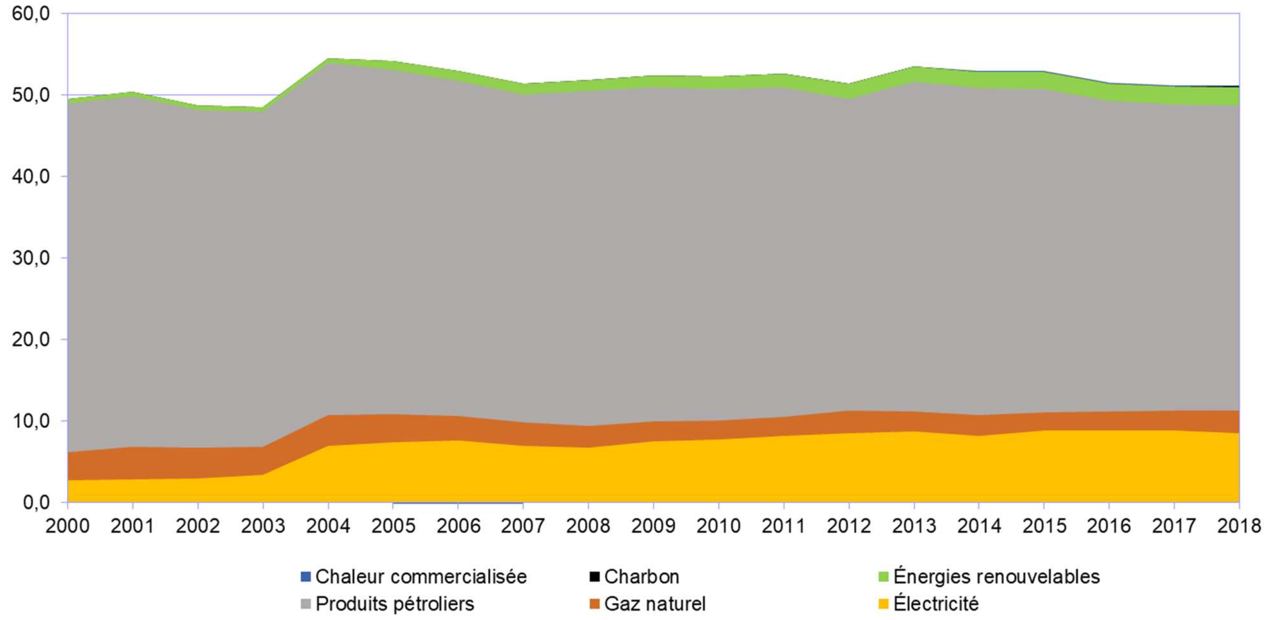
ENR thermiques et déchets	Thermal RE and waste
Produits pétroliers	Oil products
Charbon	Coal
Gaz naturel	Natural gas
Électricité	Electricity
Chaleur	Heat

In 2018, real final energy consumption in industry stood at 314.7 TWh (317.8 TWh adjusted for climate variation), one of its lowest levels since 1990, but nevertheless a rebound compared to 2017 (+1.9%).

4.3.1.5. Agriculture sector

The final energy consumption in the agriculture-forestry sector has been stable for a decade and in particular seems to be fairly unresponsive to fluctuations in agricultural production, which experienced an increase of 5.7% in value in 2016. In 2018, the sector's final consumption was 50.2 TWh.

Figure 51: Final energy consumption in the agriculture-fisheries sector, in TWh Source: SDES calculations, according to sources per form of energy

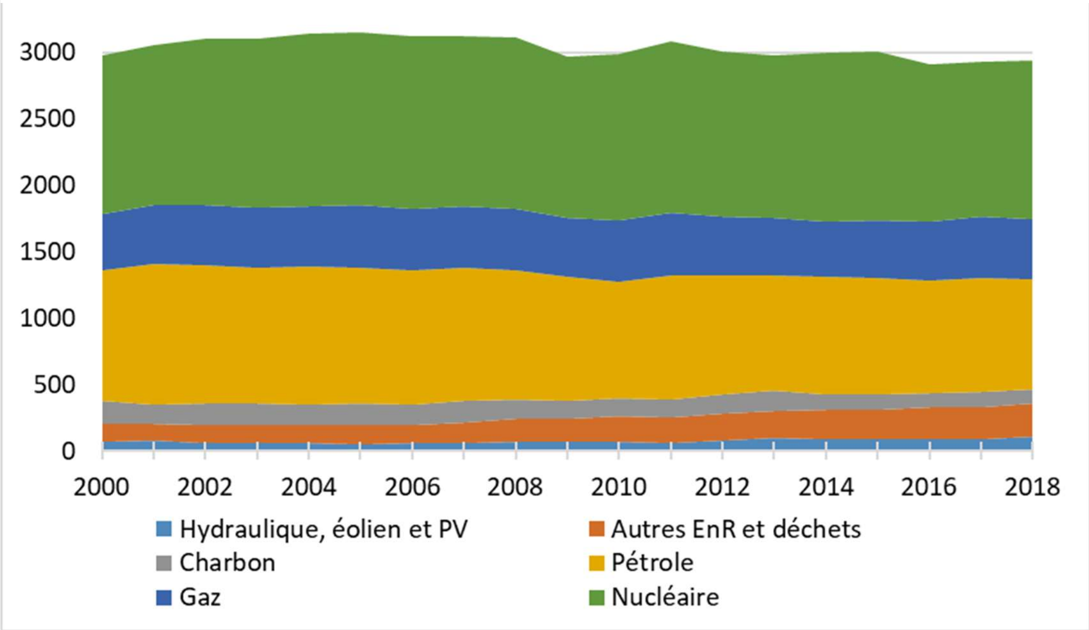


Chaleur commercialisée	Heat marketed
Produits pétroliers	Oil products
Charbon	Coal
Gaz naturel	Natural gas
Énergies renouvelables	Renewable energy
Électricité	Electricity

4.3.2. Primary consumption of fossil fuels

The energy mix is changing slightly: renewable energies are growing at the expense of fossil fuels. However, this change is taking place slowly. The consumption of natural gas is relatively stable.

Figure 52: Primary consumption by form of energy – Data adjusted for climate variations, in TWh, Source: SDES calculations, on the basis of sources per form of energy

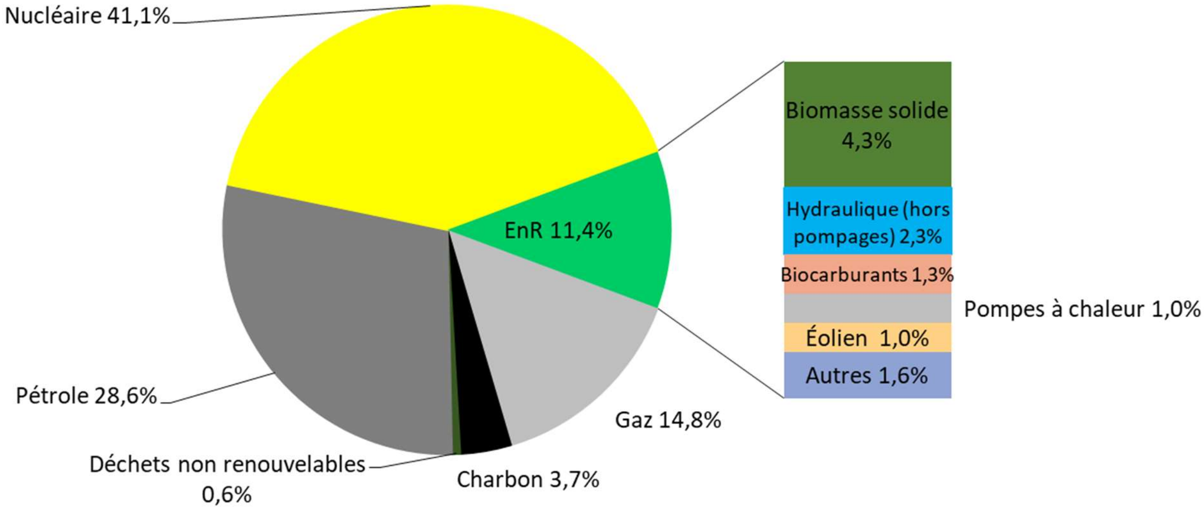


Hydraulique, éolien et PV	Hydro, wind and PV
Autres EnR et déchets	Other RE and waste
Charbon	Coal
Pétrole	Oil
Gaz	Gas
Nucléaire	Nuclear

In 2018, primary energy consumption, excluding non-energy uses, amounted to 2,693 TWh, a decrease of 0.7% compared to 2017. Adjusted for climate variations, it increased by 0.5%, a result of increased losses during energy transformation. This rebound can be explained by nuclear production and losses in heat incurred (for every kilowatt hour of electricity generated by a nuclear power plant, two kilowatt hours of heat are lost).

Overall, the real primary energy mix in Metropolitan France consists of 41.1% nuclear, 28.6% oil, 14.8% natural gas, 3.7% coal and 11.4% renewable energies and waste (see figure below). The energy independence rate is 56.1%.

Figure 53: Real primary energy mix in 2018 (Source SDES, according to sources per form of energy)



Nucléaire 41,1%	Nuclear 41.1%
EnR 11,4%	RE 11.4%
Gaz 14,8%	Gas 14.8%
Charbon 3,7%	Coal 3.7%
Déchets non renouvelables 0,6%	Non-renewable waste 0.6%
Pétrole 28,6%	Oil 28.6%
Biomasse solide 4,3%	Solid biomass 4.3%
Hydraulique (hors pompages) 2,3%	Hydro (excluding pumping) 2.3%
Biocarburants 1,3%	Biofuels 1.3%
Pompes à chaleur 1,0%	Heat pumps 1.0%
Éolien 1,0%	Wind 1.0%
Autres 1,6%	Other 1.6%

RE: renewable energies
Nuclear: nuclear energy at production (heat degraded by nuclear reaction, then converted into electricity), following deduction of the remaining exportable electricity

With the increase in the use of fossil fuels for electricity generation and rising demand for petroleum products, CO_2 emissions related to the combustion of energy increased by 3% in 2017 in real terms and by 4% at constant values. Adjusted for climate variations, emissions remain 17% lower than in 2005, having fallen steadily between that date and 2016.

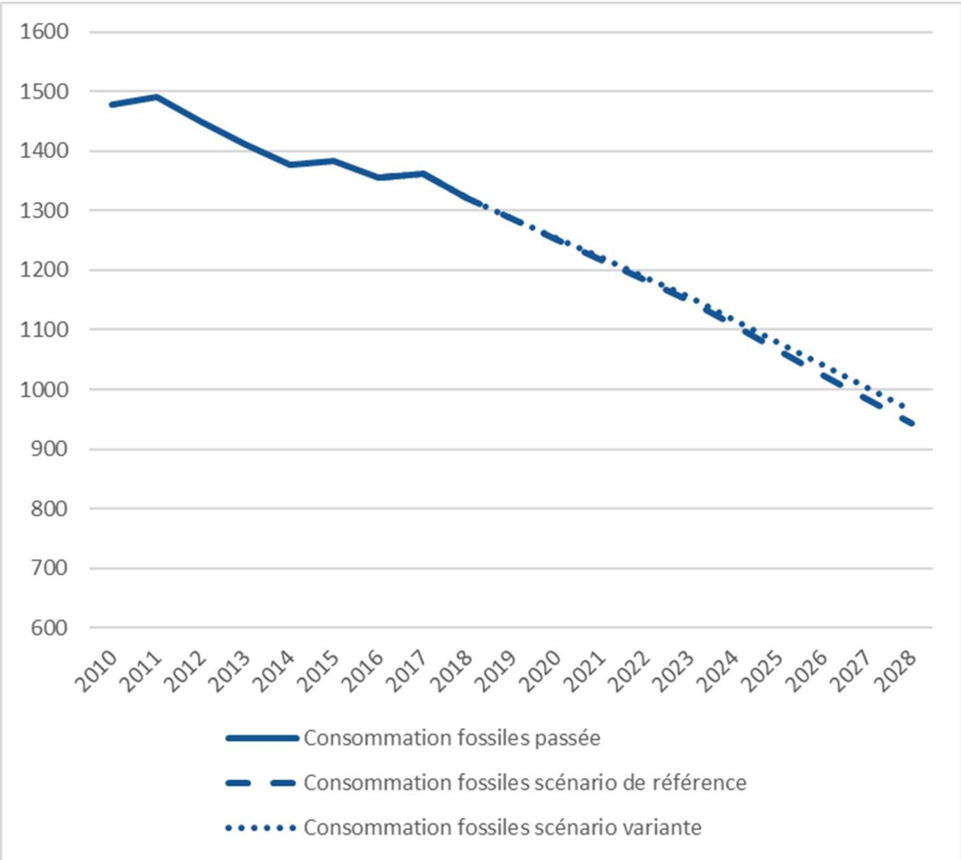
In 2018, France mobilised 3,046 TWh to meet final consumption (not corrected for climate variations) of 1,781 TWh. The difference consists of internal losses and uses of the energy system, net electricity exports, and international air and marine bunkers, conventionally excluded from consumption.

The real final energy mix is still dominated by oil. In 2018, petroleum products accounted for 38% of final energy consumption, followed by electricity (27%), gas (20%), renewable energies and waste (11%), heat (3%) and coal (1%). In line with the trend observed since the mid-2000s, the share of fossil fuels in the energy mix fell by 1% in 2018, while electricity and renewable energies increased. Heat, which shows no clear long-term trend, also grew in 2018.

Measures to control energy demand will enable an overall reduction in the consumption of fossil fuels. However, some additional measures will be required so that the reductions in consumption start with fossil fuels, especially more carbon-rich fossil fuels. The target tables by energy show particular fuel-specific measures where the effect will supplement the energy control measures.

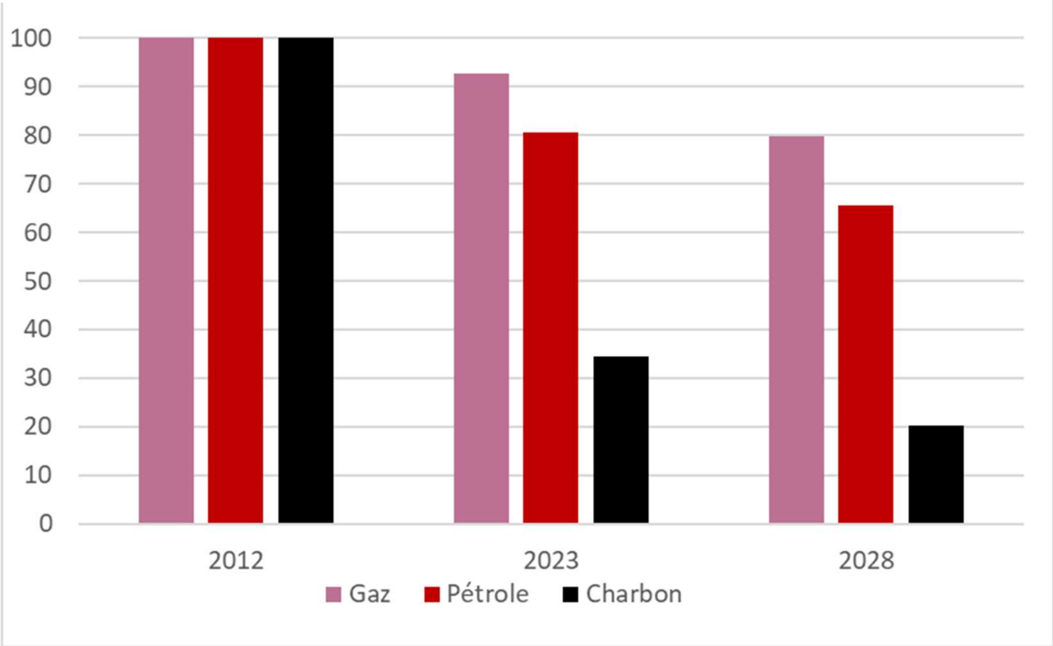
The integration of the measures presented below into the energy scenario makes it possible to obtain the decrease shown in the figure below. The figure shows the area in which the primary energy consumption of fossil fuel would be, with the curves indicating the extreme values linked to different macroeconomic conditions.

Figure 54: Past trend (2010–2018) and future scenario (2019–2028) of primary energy consumption of fossil fuels following MEP implementation (TWh)



Consommation fossiles passée	Past fossil consumption
Consommation fossiles scénario de référence	Reference scenario fossil consumption
Consommation fossiles scénario variante	Variant scenario fossil consumption

Figure 55: Future change in the primary energy consumption of fossil fuels following implementation of the MEP (base index 100 in 2012), reference scenario

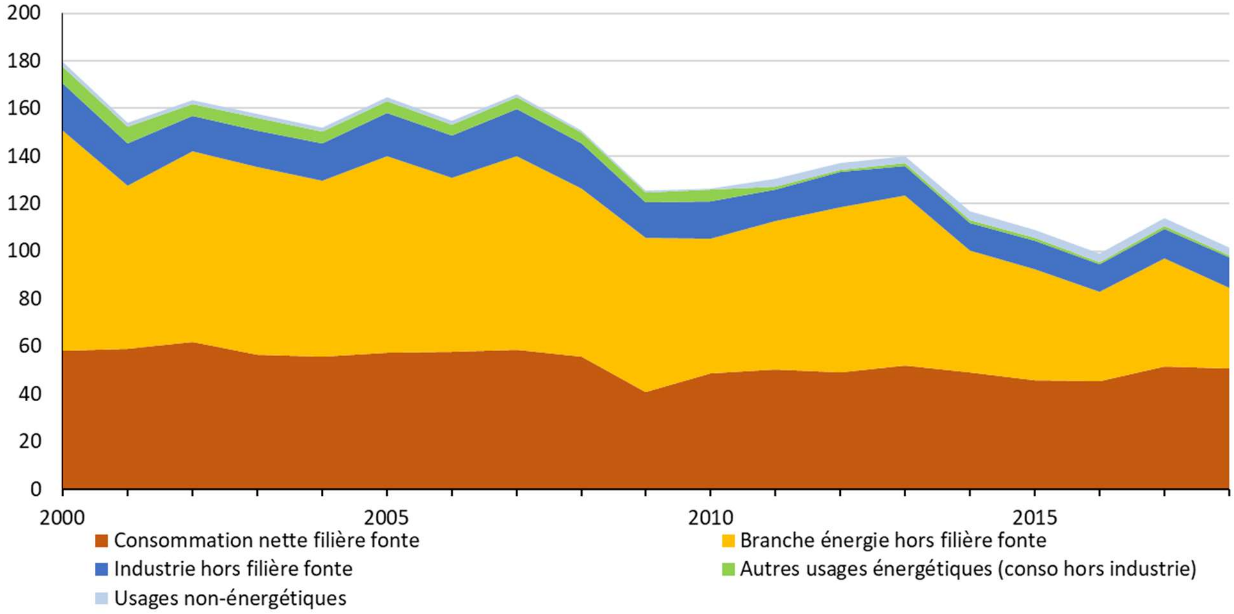


Gaz	Gas
Pétrole	Oil
Charbon	Coal

4.3.2.1. Primary consumption of coal

After a historic low in 2016, at 100 TWh, consumption (adjusted for climate variations) shot up again in 2017. In 2018 it returned to its long-term trendline, returning to 99 TWh. The smelting sector has been the main consumer of coal in France since 2014, representing 48% of total consumption in 2018. It is followed by power and heat generation, which only represents 30% of consumption (compared to 48% in 2012), showing a particularly substantial fall in 2018 (-29% in a year). Final consumption (essentially by non-blast heat manufacturing) represented 16% of all primary resources consumed in 2018, an increase of a point and a half over a year (the difference corresponds to the statistical gap).

Figure 56: Primary consumption of coal (excluding statistical deviation) adjusted for climate variations (in TWh)
Source: SDES calculation, from EDF, Uniper France Power, FFA, Insee, Customs, COCIC and SNCU



Consommation nette filière fonte	Smelting sector net consumption
Branche énergie hors filière fonte	Energy excluding smelting sector
Industrie hors filières filière fonte	Industry excluding smelting sector
Autres usages énergétiques (conso hors industrie)	Other energy uses (non-industry consumption)
Usages non-énérgétiques	Non-energy uses

The total consumption of coal-derived compounds (mainly coke) in industry was estimated in 2018 as 30 TWh. A total of 87% of these uses are concentrated in the iron and steel industry.

The Grand Est and Nord-Pas-de-Calais regions account for more than half of coal-using industries. Metropolitan France has 126 industrial sites consuming coal in 11 regions: the Grand Est region (39 sites), Hauts-de-France (29) and Auvergne-Rhône-Alpes (20). The other regions each account for fewer than 10 coal-consuming industrial sites.

Industrial sectors	**Total consumption**	**Raw materials**	**Energy**
Steel	30.9	8.7	22.1
Chemistry (including plastics)	5.8	-	5.8
Agrifoods industry	3.9	-	3.9
Non-metallic materials (glass, cement, tiles, bricks, etc.)	3	-	3
Mechanical engineering, electronics and metalworking (including smelting)	1.6	0.2	1.4
Paper, cardboard	0.2	-	0.2
Automotive and aircraft construction	0.07	-	0.07
Non-ferrous materials	0.02	0.01	0.01
Total	45.4	8.9	36.5

Coal consumption by type of industry and use

Year 2016, Final energy (TWh), Source: ADEME (2019), according to Ceren.

Uses of coal in industry

As regards heat, there are already possible alternative uses of waste or biomass for industrial needs. For cement and plaster manufacturers, given the constraints in terms of temperature, waste could be recycled to cover 80% of demand. Biomass, solid recovered fuel (SRF) or biogas could be used in other industries including agrifood, cardboard, sugar, and beet and alfalfa drying.

Increasing the share of renewable and recovered energy in district heating systems or for the supply of industrial platforms could also reduce coal consumption.

The industrial process of the iron and steel industry combines the use of coal **as a fuel and as a chemical agent**[70]. In this sector, operational methods for the mass substitution of coal do not yet exist. Various solutions are being tested to reduce coal consumption and to reuse or store CO_2 emissions. Recycling steel is also important, because used steel can replace cast iron produced in a blast furnace and therefore reduce the consumption of ferrous minerals and coal. Entirely substituting coal would involve finding an alternative to coal as a reducing agent in the production of steel. Coal-free production technologies using hydrogen or electrolysis are currently being developed.

70 Steel is manufactured from blast furnace combustion of iron ore and coke.

For all these industries, improving energy efficiency, particularly the recovery of waste heat, should also be integrated.

Non-energy uses of coal

Industry today consumes a large amount of fossil fuels for non-energy uses. In particular, the manufacture of plastic in chemistry requires naphtha, fertiliser production requires hydrogen produced from reformed natural gas, and the iron and steel industry requires coal in the manufacture of steel. For coal, this represented an equivalent consumption of 3.4 TWh in 2018 according to the energy balance sheet.

Energy uses of coal in the residential sector

There are 10 coal-fired district heating networks: in 2016, their consumption was 238,575 tonnes of coal, equivalent to about 1.9 TWh, or 6% of inputs.

Once major energy sources, fuel oil and coal have continued their decline, and now represent only 5% of the energy mix for district heating systems (compared to 60% in 1990).

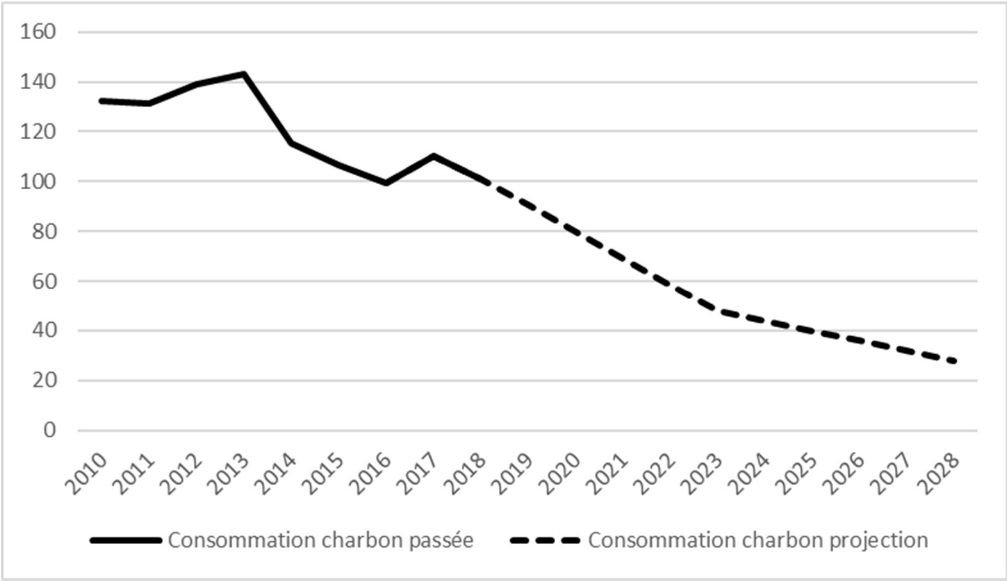
Coal consumption in the residential sector is estimated as 0.31 TWh. This consumption is equivalent to 20,000 dwellings. The ANGDM estimates that the vast majority of coal-heated dwellings are in the Hauts-de-France region, mainly because of its mining and industrial past. The use of coal as heating energy accounts for 3% of all dwellings in that region. In particular, the ANGDM has identified between 500 and 1,000 households that are heated mainly by coal-fired stoves. The occupants are former miners or widows of miners. The ANGDM estimates that the share of coal in collective dwellings is decreasing because of the conversion operations being rolled out.

Given that the vast majority of households use a coal stove and not a boiler, the most accessible alternative technologies are wood or pellet stoves, electric heaters, or air-to-air heat pumps. For reasons of investment and usage costs, it is proposed that we prioritise replacing coal heating with biomass stoves.

The integration of the measures described here into the energy scenario makes it possible to obtain the decrease shown in the figure below. The scenario is not dependent upon the macroeconomic context.

Figure 57: Past trend (2010–2018) and future scenario (2019–2028) of primary consumption of coal following

MEP implementation (TWh)

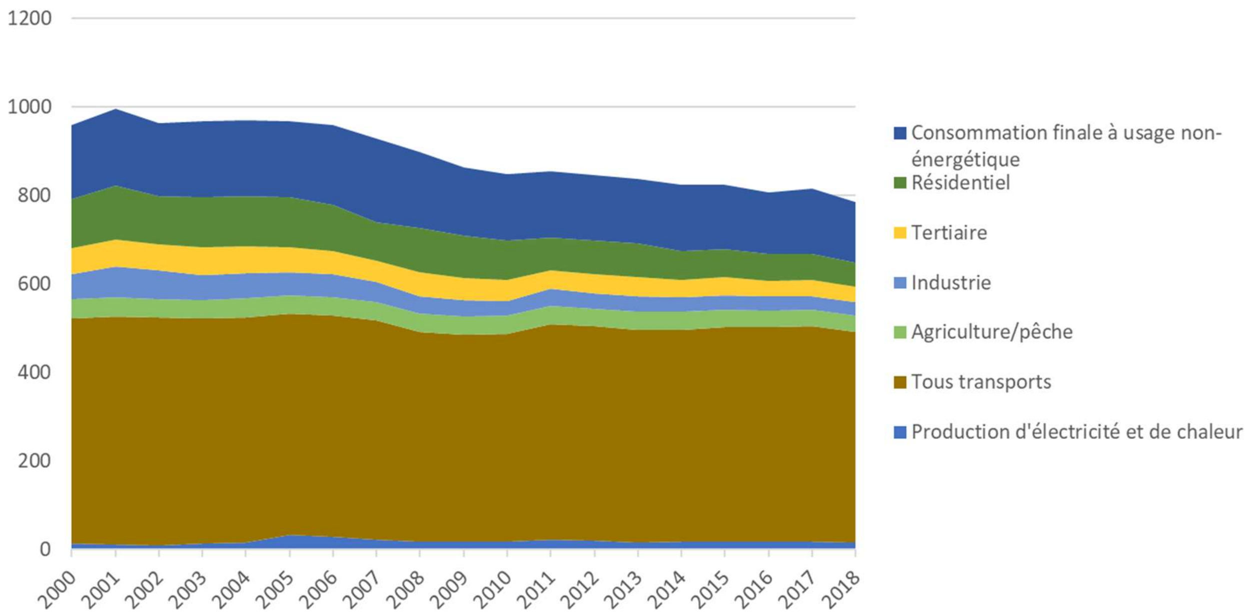


Consommation charbon passée	Past coal consumption
Consommation charbon projection	Projected coal consumption

4.3.2.2. Primary consumption of oil

In 2018, domestic consumption of refined petroleum products (excluding biofuels) was 785 TWh, down by 3.6%. 2018 continues the long-term downward trend that began in the early 2000s (see figure below).

Figure 58: Total consumption of refined petroleum products by sector (excluding biofuels) (TWh)



Source: SDES calculations, from CFBP, Citepa, CPDP, DGDDI, DGEC, DGFIP, DPMA, EDF, Insee, LyondellBasell, French Ministry of the Armed Forces, SFIC, SNCF, SNCU, SSP, Uniper

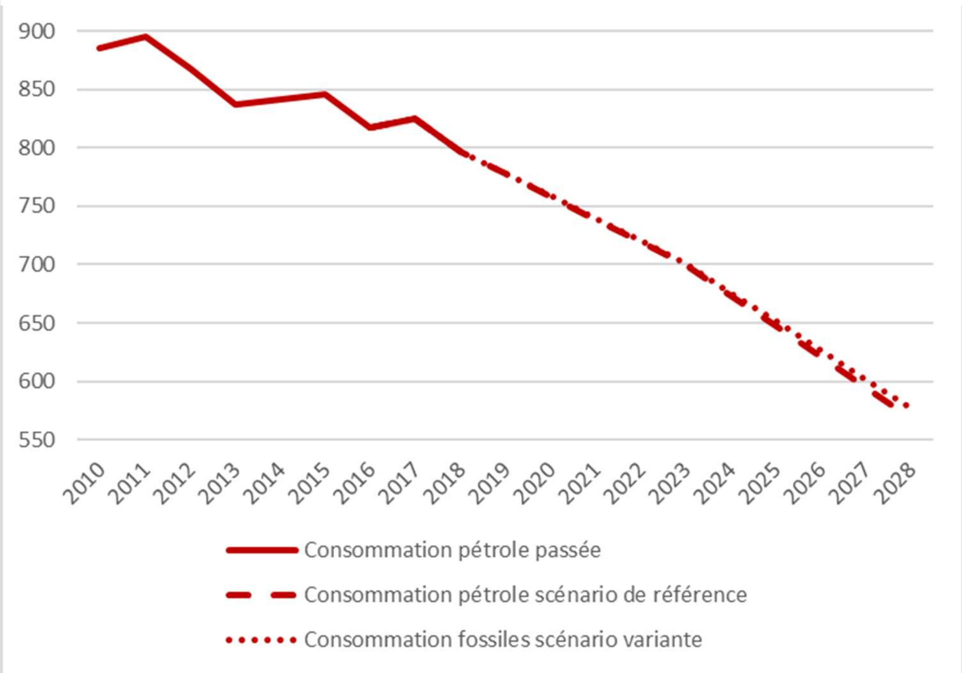
Consommation finale à usage non-énergétique	Final consumption for non-energy use
Résidentiel	Residential

Tertiaire	Tertiary
Industrie	Industry
Agriculture/pêche	Agriculture/fisheries
Tous transports	All transport
Production d'électricité et de chaleur	Electricity and heat production

Oil is the fossil fuel that produces the most greenhouse gas emissions after coal, during use. Reducing its use is therefore an important issue. The aim is to replace a million private oil-heating units by the end of 2023 and 3 million by 2028. Sectoral measures to control energy demand will play a role in reducing the demand for oil, including carbon contribution, along with all measures taken to reduce energy consumption in transport. Certain specific measures that complement these steps are also planned.

The integration of the measures described here into the energy scenario makes it possible to obtain the decrease shown in the figure below. The figure shows the area in which the primary consumption of petroleum products would be, with the curves indicating the extreme values linked to different macroeconomic conditions.

Figure 59: Past trend (2010–2018) and future scenario (2019–2028) of primary consumption of oil following MEP implementation (TWh)



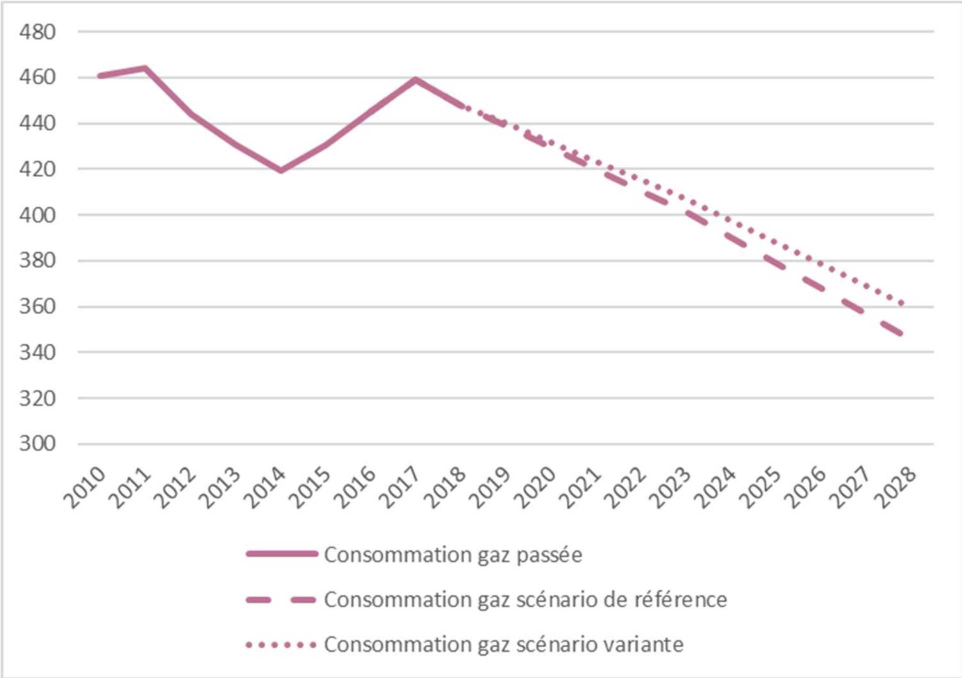
Consommation pétrole passée	Past oil consumption
Consommation pétrole scénario de référence	Reference scenario oil consumption
Consommation pétrole scénario variante	Variant scenario oil consumption

4.3.2.3. Primary consumption of natural gas

Natural gas is a fossil fuel and, as such, will have to be removed from the energy mix by 2050. However, it is the fossil fuel that causes the lowest greenhouse gas emissions, which explains why the temporary transfer of some uses of coal or oil to natural gas is a relative improvement. This explains why there are no specific measures to reduce natural gas use. The demand for this energy will be reduced due to demand control measures, particularly in building works. The outcomes of natural gas demand scenarios are presented in the following table.

The energy control operations should make it possible to change the final natural gas consumption as shown in the figure below. The figure shows the area in which the primary consumption of natural gas would be, with the curves indicating the extreme values linked to different macroeconomic conditions.

Figure 60: Past trend (2010–2018) and future scenario (2019–2028) of primary consumption of oil following MEP implementation (TWh)



Consommation gaz passée	Past gas consumption
Consommation gaz scénario de référence	Reference scenario gas consumption
Consommation gaz scénario variante	Variant scenario gas consumption

4.3.3. Current potential for the use of high-efficiency cogeneration and district heating and cooling systems

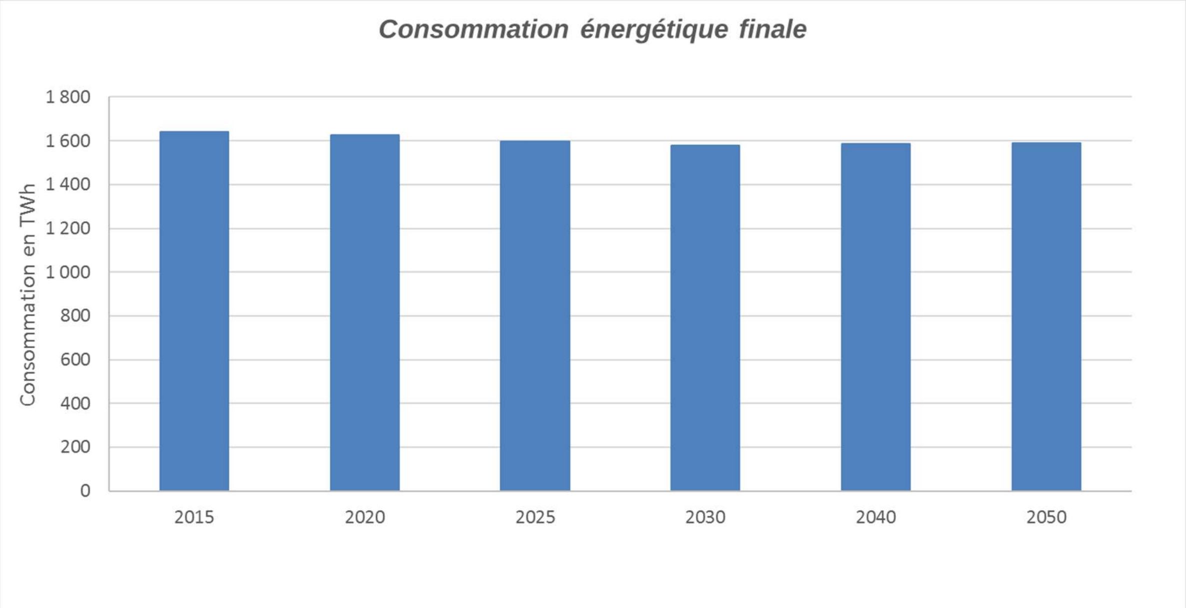
In application of Article 14 of and Annex VIII to Directive 2012/27/EU, France has sent the European Commission an analysis of its potential for the use of high-efficiency cogeneration and district heating and cooling systems. This analysis is still applicable and will be updated in accordance with Directive 2012/27/EU by 31 December 2020. It is available from the website of the Ministry for Ecological and Inclusive Transition[71].

4.3.4. Projections on the basis of existing policies, measures and programmes in relation to energy efficiency for primary and final energy consumption in each sector at least until 2040 (including 2030)

[71]Website: https://www.ecologique-solidaire.gouv.fr/besoins-chaleur-et-froid

Projections of energy consumption to 2050, on the basis of the policies and measures existing in 2018, have only been established for final energy consumption. These result in a drop in final energy consumption from 1,641 TWh (141.1 Mtoe) in 2015 to 1,589 TWh (136.6 Mtoe) in 2050, and thus a decrease of 3.2%. However, after reaching a minimum in 2030 of 1,580 TWh (135.9 Mtoe), and thus a fall of 3.7% compared to 2015, consumption will increase once again, as the effect of the measures becomes less marked over time. It will therefore reach a value of 1,584 TWh (136.3 Mtoe) in 2040.

Figure 61: Final energy consumption – Scenario with existing measures

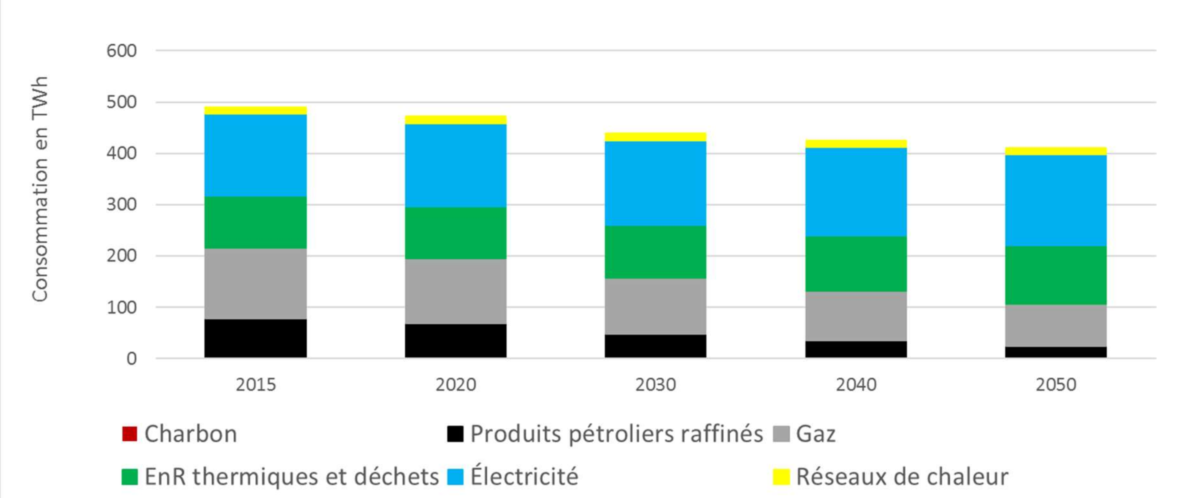


Consommation énergétique finale	Final energy consumption
Consommation en TWh	Consumption in TWh

4.3.4.1. Residential sector

Final energy consumption in the residential sector will see a sustained fall until 2050, although this will be slowed significantly after 2030 with the decreasing effect of the measures. It will therefore fall from 490 TWh in 2015 (42.2 Mtoe) to 410 TWh (35.2 Mtoe) in 2050, a fall of 16% over the period, with intermediate values of 439 TWh (37.7 Mtoe) in 2030 and 424 TWh (36.5 Mtoe) in 2040.

Figure 62: Final energy consumption in the residential sector – Scenario with existing measures

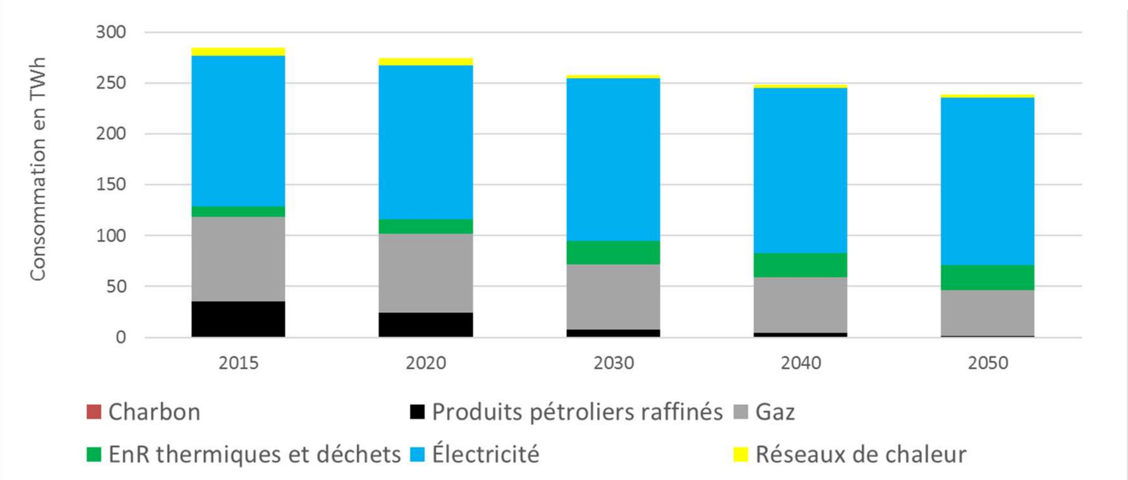


Consommation d'énergie finale le secteur résidentiel	Final energy consumption in residential sector
Consommation en TWh	Consumption in TWh
Charbon	Coal
Produits pétrolier raffinés	Refined oil products
Gaz	Gas
EnR thermiques et déchets	Thermal RE and waste
Électricité	Electricity
Réseaux de chaleur	District heating systems

4.3.4.2. Tertiary sector

Final energy consumption in the tertiary sector will experience a sustained decrease until 2050. It will therefore fall from 285 TWh in 2015 (24.5 Mtoe) to 238 TWh (20.5 Mtoe) in 2050, a fall of 16% over the period, with intermediate values of 258 TWh (22.2 Mtoe) in 2030 and 248 TWh (21.3 Mtoe) in 2040.

Figure 63: Final energy consumption in the tertiary sector – Scenario with existing measures



Consommation d'énergie finale le secteur tertiaire	Final energy consumption in tertiary sector
Consommation en TWh	Consumption in TWh
Charbon	Coal
Produits pétrolier raffinés	Refined oil products
Gaz	Gas
EnR thermiques et déchets	Thermal RE and waste
Électricité	Electricity
Réseaux de chaleur	District heating systems

4.3.4.3. Transport sector

In this scenario, final energy consumption in the transport sector will increase from 509 TWh (43.8 Mtoe) in 2015 to 522 TWh (44.9 Mtoe) in 2050, a rise of 2.6% over the period. However, after reaching a minimum in 2030 of 500 TWh (43 Mtoe), and thus a fall of 1.7% compared to 2015, consumption will increase once again, as the effect of the measures becomes less marked over time. It will therefore reach a value of 511 TWh (44 Mtoe) in 2040.

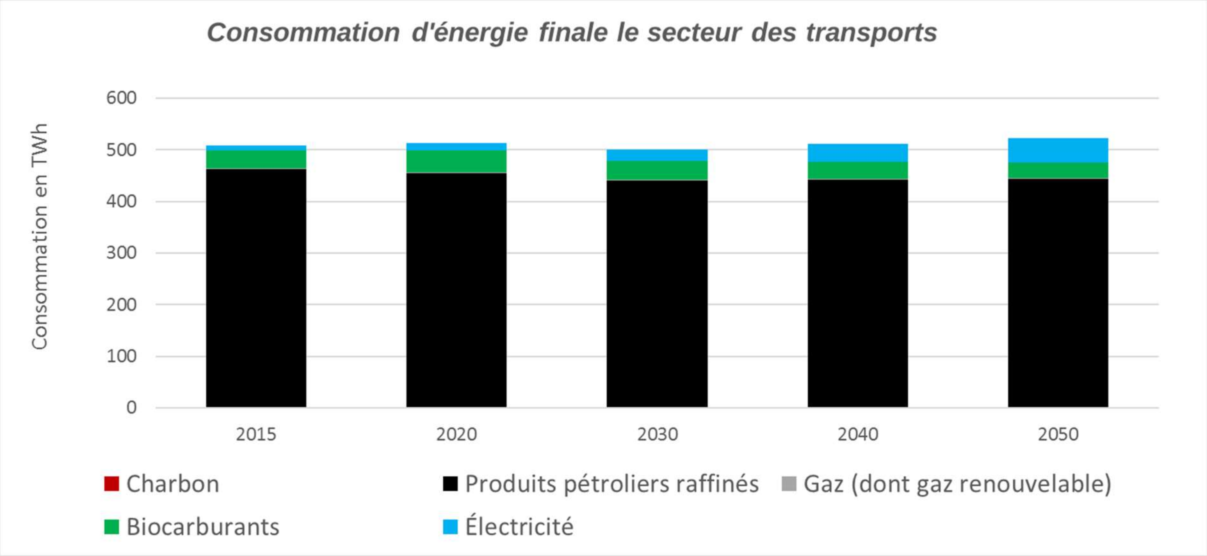


Figure 64: Final energy consumption in the transport sector – Scenario with existing measures

Consommation d'énergie finale le secteur des transports	Final energy consumption in transport sector
Consommation en TWh	Consumption in TWh
Charbon	Coal
Produits pétrolier raffinés	Refined oil products
Gaz (dont gaz renouvelable)	Gas (including renewable gas)
Biocarburants	Biofuels
Électricité	Electricity

4.3.4.4. Industrial sector

The industrial sector will grow continuously from 2015 to 2050. Final energy consumption in the sector will increase from 305 TWh (26.2 Mtoe) in 2015 to 375 TWh (32.2 Mtoe) in 2050, an increase of 23%, with intermediate values of 335 TWh (28.8 Mtoe) in 2030 and 355 TWh (30.5 Mtoe) in 2040.

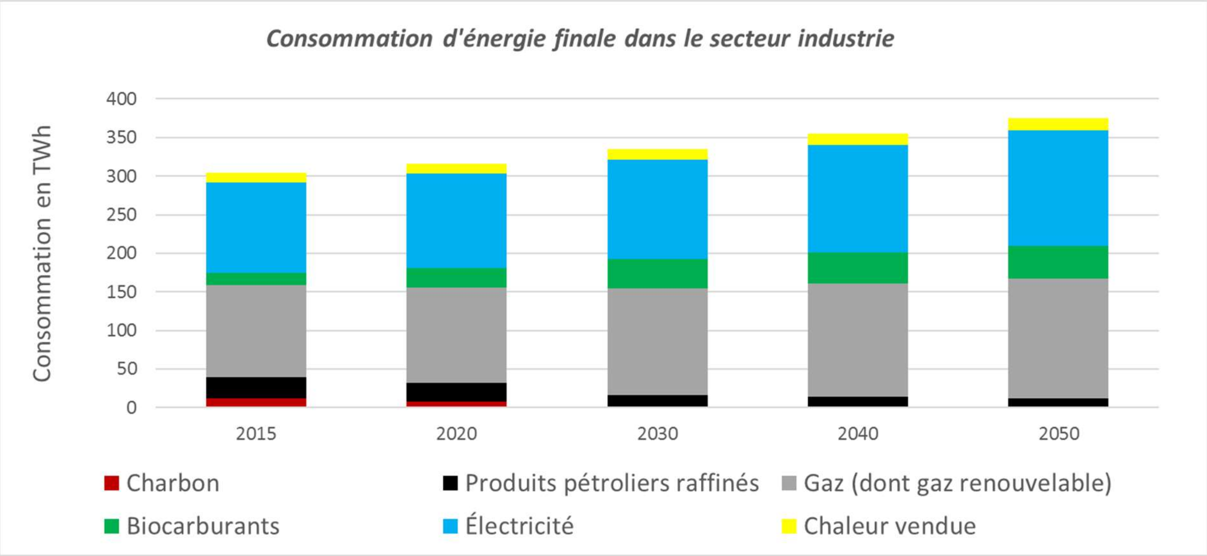


Figure 65: Final energy consumption in industry – Scenario with existing measures

Consommation d'énergie finale le secteur industrie	Final energy consumption in industrial sector
Consommation en TWh	Consumption in TWh
Charbon	Coal
Produits pétrolier raffinés	Refined oil products
Gaz (dont gaz renouvelable)	Gas (including renewable gas)
Biocarburants	Biofuels
Électricité	Electricity
Chaleur vendue	Heat sold

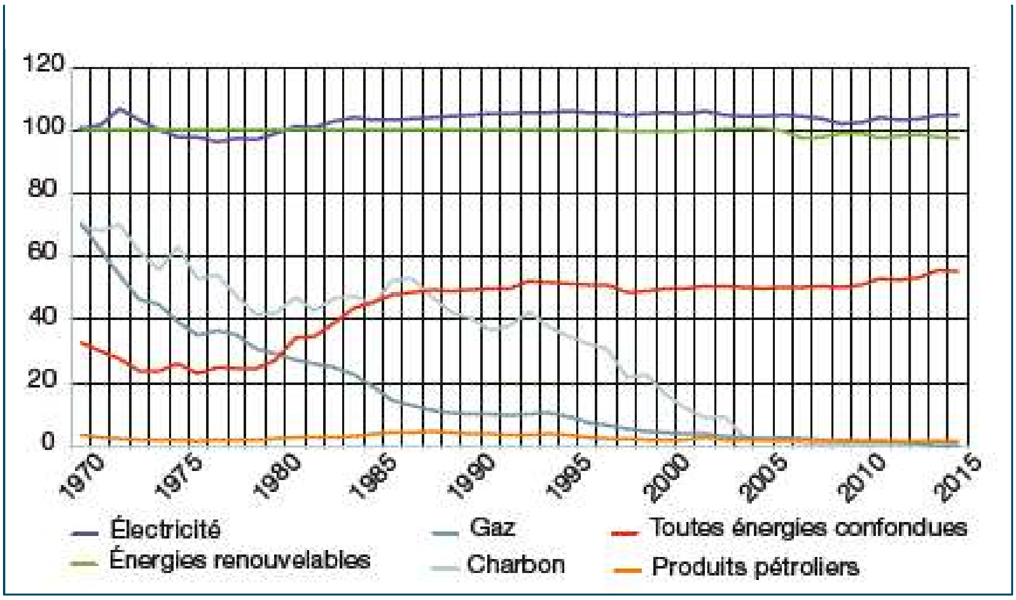
4.3.5. Cost-optimal levels of minimum energy performance requirements resulting from national calculations, in accordance with Article 5 of Directive 2010/31/EU

In application of Article 5 of Directive 2010/31/EU, France has undertaken a comparative analysis of the cost-optimal levels of minimum energy performance requirements and the levels actually set. This analysis was sent to the European Commission in 2018.

4.4. Energy supply security

Supply security therefore has a geopolitical dimension in terms of continuity of supply from exporter countries: we depend on the countries that have resources, and if a political crisis leads a country to cease exporting suddenly, that could put France's supply in jeopardy.

*Figure 66: Energy independence – Source: SDES**



En %	In %
Électricité	Electricity
Gaz	Gas
Toutes énergies confondues	All energies combined
Énergies renouvelables	Renewable energy
Charbon	Coal
Produits pétroliers	Oil products

The importing of resources does not necessarily conflict with the nation's security of supply requirements: procurement from abroad can be secure, if it uses reliable, diversified suppliers, i.e. originating in more than one country. Exclusively domestic supply can also present vulnerabilities if technical or industrial problems arise. The fall in consumption and the increase in the generation of renewable energies contribute to reducing dependence on other countries.

The changes in the stock of production installations will have impacts on supply security that must be anticipated.

4.4.1. Oil

4.4.1.1. Crude oil production in France

National production of hydrocarbons amounted to 0.8 Mt in 2018 and only represents about 1% of national consumption. The law putting an end to the exploration and exploitation of conventional and non-conventional hydrocarbons[72] will lead to a gradual halt in domestic production by 2040. In 2023 and 2028, production is estimated to be 0.7 Mt and 0.6 Mt, respectively.

In a context where domestic hydrocarbon extraction covers only a very small portion of national requirements, France is almost totally dependent on oil imports for domestic consumption. To improve the security of its oil supply lines, France is diversifying the regions from which it imports crude oil. In 2018, these imports came from the Middle East (25%), Russia (14%) and Kazakhstan (15.5%), Africa (33.1%) and Norway (5.6%).

4.4.1.2. Refining

In France, the refining sector was marked by the closure of several facilities in the early 2010s. France now has only seven oil refineries on its mainland. They have an annual refining capacity of about 62 Mt of crude oil per year. They are supplied mainly by shipping or by pipelines. Apart from the production of fuels, refining enables the production of non-energy products such as lubricants and bitumen. Refining is also of particular importance for supplying the petrochemical industry.

In 2018, national production of refined products, net of refiners' own consumption, amounted to 55 Mt. French refineries mainly produce diesel (35% of total production in 2018), super-fuels (20%), heavy fuel oil (10%) and non-energy products (15%). Domestic fuel and kerosene each represent 8% of the total domestic production of refined products, LPG 3% and all other products 2%. This distribution has been stable in recent years.

Refineries must continually adapt to meet demand while improving environmental performance and energy efficiency in their industry.

Refining contributes to employment in France in the energy sector: its activities represent more than 7,000 direct jobs, plus about 30,000 indirect jobs.

In addition, the French Government is mindful not only about limiting the consumption of fossil energy but also in terms of importing fossil fuels with the least environmental impact.

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72. Law No 2017-1839 of 30 December 2017 putting an end to the exploration and exploitation of hydrocarbons and enacting several provisions relating to energy and the environment, available at https://www.legifrance.gouv.fr/affichTexte.docidTexte=JORFTEXT000036339396&dateTexte=&categorieLien=id

Article 8 of the Hydrocarbons Law provides that the Government must provide Parliament with a report on the origin of imported hydrocarbons consumed in France. This report must study the environmental impact of extracting and refining conventional and non-conventional hydrocarbons, and in particular it must:

- classify the environmental footprints arising from the extraction and refining of oil;
- identify the variability criteria of greenhouse gas emissions associated with the extraction and refining of oil;
- assess the feasibility of differentiating oil products according to the origin of the crude oil from which they were made;
- propose areas of progress for the measurement of greenhouse gas emissions arising from oil extraction, and for the traceability of physical flows of hydrocarbons.

4.4.1.3. Local issues: intermediate stocks and service stations

Today, hydrocarbons account for nearly 90% of energy consumption in the transport sector. Consumption projections for petroleum products foresee a decrease of almost 25% in 2028 compared to current consumption levels. Ongoing vigilance is needed to enable the adaptation of petroleum logistics in order to guarantee supply security: lower consumption will make it difficult to maintain the entire network of secondary depots necessary for quality supply.

Only the most profitable depots will be able to remain active, thus leading to a concentration of activity in these depots. There are 200 main depots today, and there is a risk of a sharp decrease if there is a fall in consumption. The launch of studies to obtain a future vision of the necessary network for oil storage and the minimum number required forms part of supply security activities.

It is necessary to maintain a sufficient geographical network for the following reasons.

- To guarantee the availability of supplies. The excessive concentration of storage premises entails risks of shortages for consumers if one of these sites is inaccessible and the others cannot support the activity of the missing site, or if extended travel time no longer makes it possible to guarantee an adequate supply.
- To ensure proximity between storage and consumption sites in order to avoid an increase in the number of tankers on the roads for the distribution of fuels.

In addition, the rules on risk prevention make it difficult to create new storage capacity in the most competitive depots. Storage capacity lost in closed depots cannot easily be redeployed elsewhere.

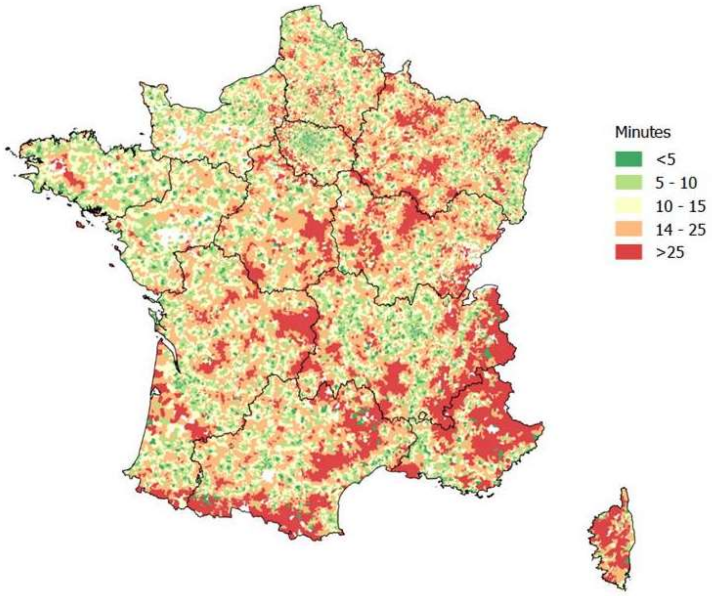
This subject therefore requires special attention.

The number of French petrol stations fell by nearly 75% between 1980 and 2017. Nevertheless, France still has a number of petrol stations providing an efficient service within its territory. Fuel sales are increasingly concentrated in high-throughput stations, in particular those owned by large and medium-sized supermarkets. The geographical distribution of the stations in the country is satisfactory for most citizens:

- 90% of households can get to a petrol station within 20 minutes and 16 km;
- 50% within 6 minutes and 3 km;
- on average, a household takes 9 minutes and 20 seconds to access a station;
- fewer than 2.5% of households are more than 30 km away from a petrol station.

The average time to get to a petrol station by department is used as an indicator to monitor changes in the network, and 90% of individuals can get to a petrol station in under 25 minutes. In 2018, fewer than 4.3% of households had a journey of more than 25 minutes.

Figure 67: Home-petrol station journey time (IRS network), source: DGEC



Minutes	Minutes

4.4.2. Gas

4.4.2.1. State of play and outlook for national natural gas

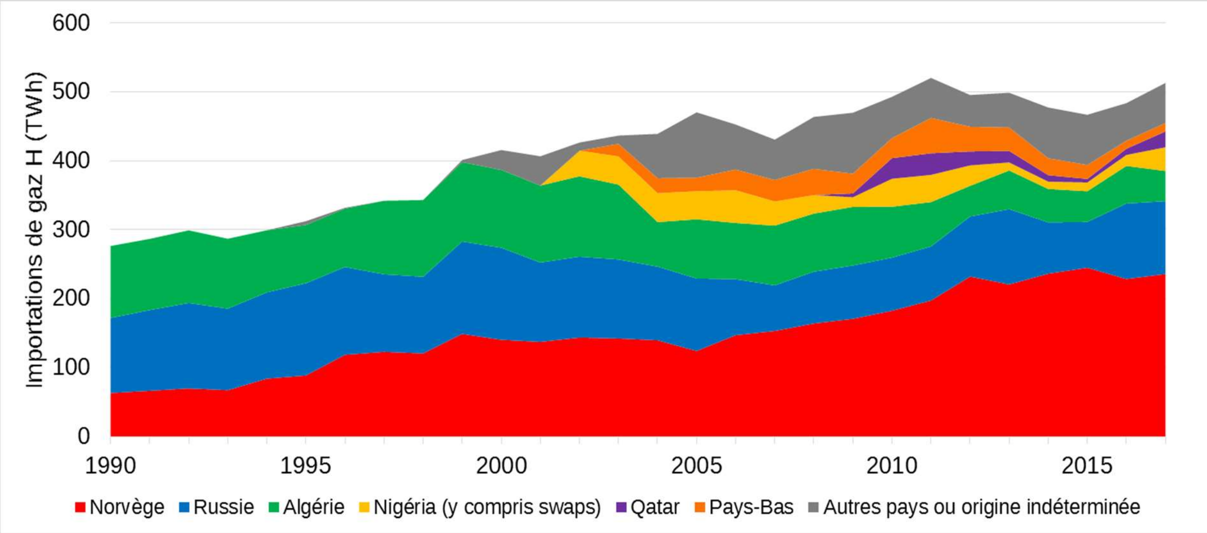
France has few conventional natural gas resources across its territory. The commercial operation of the Lacq field – the main French natural gas field – is currently limited, and since 2013, its output is no longer injected into the grid but is instead directly consumed on site. Law No 2017-1839 of 30 December 2017 also provides for the gradual cessation of exploration and exploitation of new resources.

4.4.2.2. Natural gas supply

In the absence of significant domestic production, the supply of natural gas is based on imports. Two types of natural gas are distributed in France through separate networks, namely gas with a high calorific value or H gas, for 90% of consumption, and gas with a low calorific value or L gas. To ensure a high level of supply security for H gas, France is equipped with an infrastructure consisting of five interconnectors for imports and four LNG terminals. This infrastructure provides access to diversified sources of natural gas.

Norway is France's largest supplier of natural gas, supplying nearly half of French H gas imports (43% in 2018). The remaining imports are broadly diversified among various suppliers: Russia (22% of H gas imports in 2018), Algeria (8%), Nigeria (7%) and Qatar (3%). Interconnectors and LNG terminals also provide access to other smaller suppliers, as well as to gas that is more difficult to trace, from international gas markets, in gaseous or liquefied form.

Figure 68: Origin of French natural gas imports of high calorific value since 1990 (Source: SOeS and GRTgaz)



Importations de gaz H (TWh)	H Gas imports (TWh)
Norvège	Norway
Russie	Russia
Algérie	Algeria
Nigéria (y compris swaps)	Nigeria (including swaps)
Qatar	Qatar
Pays-Bas	Netherlands
Autres pays ou origine indéterminée	Other countries or unknown origin

Although it is still diversified, France’s supply in recent years has been concentrated between Norway and Russia, with these two countries now accounting for nearly 70% of imports, compared to around 50% at the start of the decade. This trend is also noticeable in terms of infrastructure: more than 80% of natural gas imports currently pass through three interconnectors located in the north-east of France.

French natural gas imports in the future will be marked by the decline of European gas production, which will be offset by an increase in gas pipeline imports from non-European countries, and in liquefied form (LNG). Indeed, Norway is expected to reach a production plateau between 2020 and 2030. The decline in European production, particularly in the Netherlands, is expected to accelerate. This fall in the share of European producers could be offset by an increase in imports of Russian gas or LNG, depending in particular on the relative competitiveness of these two types of supply. The French gas infrastructure seems able to cope with either of these two prospective scenarios.

Gas operators obtain natural gas over-the-counter from a producer through medium- and long-term contracts, or through purchases on marketplaces. Long-term contracts – generally 15 to 25 years – mean that buyers can secure their supplies and producers can secure outlets, through take or pay clauses, over a period defined so as to amortise investments in exploration, development of gas fields, production and transportation.

In 2018, the majority of France’s natural gas supply was provided through long-term contracts for delivery on the national grid. A significant proportion of these contracts will expire over the period of the MEP. France’s supply structure is therefore likely to change depending on whether suppliers active in the French market are able and wish to renew their existing long-term contracts and to enter into new ones. The increasing interest of suppliers in flexible purchases on the marketplaces and their preference for gas deliveries to the borders of the European Union, so that they can more easily take advantage of price opportunities within the European internal market, could lead to a fall in the proportion of supplies covered by long-term contracts providing for delivery to the French grid.

Box 6: Environmental impact of imported natural gas

To be eligible for injection into the French grid, natural gas must meet certain standards, particularly in terms of composition. These are applicable to all gas sources. The natural gas consumed in France therefore emits a similar amount of greenhouse gases during combustion, regardless of its origin and extraction method.

However, the environmental impact associated with natural gas consumption is not limited to its combustion. Production and transport to France must also be considered.

Natural gas production has environmental impacts in terms of energy consumption and greenhouse gas emissions that vary depending on the fields. These variations depend in particular on the production methods used, the quality of the gas extracted and the climatic conditions. This issue of environmental impacts associated with natural gas production is a particular focus of discussion for non-conventional production in the United States, where strong growth is creating opportunities for exports to Europe in the form of LNG.

The transport of natural gas must also be taken into account. For LNG transport, liquefaction and regasification operations use energy and therefore have a significant impact in terms of greenhouse gas emissions. Natural gas transportation by pipeline also requires energy to operate the compressors that mobilise the gas. Methane can also leak during transportation – a particular problem for the transport of natural gas in the Russian transmission system.

In accordance with the provisions of the article of Law No 2017-1839 putting an end to the exploration and exploitation of hydrocarbons, a report will be produced to evaluate the environmental impact of natural gas supplied for consumption in France, based in particular on its origin, the type of resource, and its extraction and transportation conditions.

Tools for ensuring the security of natural gas supply can be classified into three broad categories:

- obligations for gas operators, especially suppliers;
- tools for sizing the gas system, from a forward-looking perspective;
- safeguarding measures for gas crises.

4.4.2.3. Obligations on gas operators

Continuity of supply obligations

Natural gas suppliers are required to provide continuity of supply for all their customers, with the exception of customers with an interruptible contract, at the level corresponding to the supply security target.

In addition, natural gas suppliers are under an obligation to ensure continuity of supply to these same consumers, including in the event of disappearance of the main source of supply for a maximum of six months under average weather conditions. The supply of gas on the French market is subject to ministerial authorisation. Proof enabling confirmation of compliance with the continuity of supply obligations may be requested when the supply authorisation is updated each year.

Diversification obligations

Beyond a certain market share, a natural gas supplier is required to diversify the entry points of its supply into national territory. The terms of this obligation are laid down in Article R. 121-1 of the Energy Code. So as not to penalise new entrants, this measure does not apply below a 5% market share.

Obligations for the continuity of delivery

Operators of natural gas transmission and distribution systems must size their infrastructures so that natural gas can be delivered at the level corresponding to the supply security target.

Infrastructure operators are also required, with regard to their public service obligations, to give advance notice of the dates when their infrastructure will be unavailable to enable suppliers to ensure continuity of supply.

4.4.2.4. The special case of low calorific natural gas

Natural gas consumers from a large area of the Hauts-de-France region are supplied, through a separate grid, with low calorific natural gas, known as L gas. All L gas is imported from the Netherlands, the vast majority of it from the Groningen gas field.

After operating for more than 50 years, this major gas field has now entered a phase of decline. Moreover, following the finding of an increase in the frequency and intensity of seismic activity around the Groningen field, in an area hitherto classified as seismic, the Dutch Government has announced a reduction in the production ceiling of the field and a cessation of L gas exports from 2029.

To ensure continuity of supply to the 1.3 million L gas consumers, a gradual conversion of the H gas grid is being launched. This is a large-scale operation requiring improvements to natural gas transmission and distribution systems, and work at each consumption site to address the possibility of different gas appliances (boilers, water heaters, furnaces, ovens and industrial equipment, etc.) to be supplied with H gas. Some equipment will need adjustment, adaptation and, in some cases, replacement, to guarantee the safety of people and property.

The conversion of the low-calorific gas grid began in 2018 and will be completed by 2029 at the latest. It will be implemented on successive sections of the L gas grid. In view of the risk of faster-than-expected declines in deliveries of L gas to France, an acceleration of the conversion operation will be sought.

4.4.2.5. Gas system sizing, storage

The current sizing of the gas system ensures that French consumers are supplied. Given the prospects for a decline in natural gas consumption, optimisation of the use of existing infrastructures or even their reduction will be pursued. This optimisation of the use of existing infrastructures relates particularly to underground natural gas storage infrastructures. Article L. 421-3-1 of the Energy Code therefore requires that a definition be provided, in the MEP, of the storage facilities that guarantee medium- and long-term supply security.

Over the period covered by this MEP, no disruptions are expected to natural gas import infrastructures. Uncertainty about the future use of the Fos-Tonkin terminal, in the event that natural gas suppliers do not sign up for any new capacity, does not change the liquefied natural gas import capacity on the Mediterranean coast, which can be fully covered by the single Fos-Cavaou terminal.

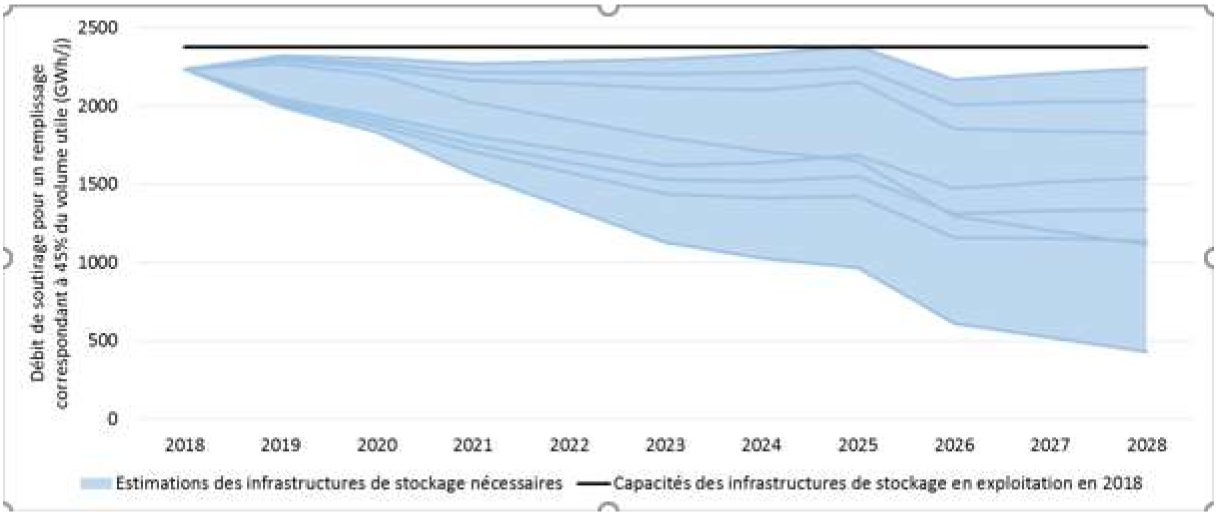
The main expected change in the gas system relates to the gradual conversion from the low calorific gas (L gas) network to the high calorific gas (H gas) network. The roll-out of this conversion requires that Gournay's entire storage infrastructure be reserved for the storage of L gas until 2025, despite the gradual decline in numbers of consumers supplied with this grade of gas. The future of the two pipes that make up the Taisnières B interconnection point is uncertain at this time, the options being conversion to H gas transmission and abandonment.

Over the period covered by the MEP, natural gas underground storage infrastructures will continue to play a key role in ensuring the continuity of delivery over the grids, especially in the event of a continued concentration of supplies from north-eastern France, by building up natural gas stocks downstream of potential congestion fronts. They will also continue to be necessary to ensure that the gas system is able to meet demand in line with the objective of supply security, without jeopardising the transmission of natural gas to other EU Member States or to Switzerland.

The MEP confirms the outlook for a fall in natural gas consumption, but there is uncertainty about the pace of this decline. Furthermore, the contribution of LNG terminals during a cold snap depends not only on emission capacities, but also on the level of tank filling, which has varied considerably in recent years, and for which the fluctuation outlook must be taken into account. While Articles L. 431-6-2 and L. 431-6-3 of the Energy Code set the objective of developing the interruptibility of natural gas consumption, the potential for this development is difficult to estimate at present.

The underground natural gas storage infrastructures necessary for medium- and long-term supply security have been identified by incorporating these uncertainties into analyses of potential needs, to ensure transmission on the natural gas transmission system and the ability of the network to meet demand.

Figure 69: Estimation of the underground storage capacities needed to ensure the network's ability to meet demand, including L gas and back-up stocks



Débit de soutirage pour un remplissage correspondant à 45% du volume utile (GWh/j)	Take-off flow for filling corresponding to 45% of useful volume (GWh/day)
Estimations des infrastructures de stockage nécessaires	Estimates of necessary storage infrastructures
Capacités des infrastructures de stockage en exploitation en 2018	Storage infrastructure capacities in operation in 2018

Over the next 10 years, there is no need for new underground natural gas storage infrastructures or for the reactivation of any of the three currently mothballed underground storage facilities. The uncertainty up to 2023 means that the underground storage infrastructures currently being used must be kept in operation for this time frame.

Between 2019 and 2023, the underground natural gas storage facilities that must remain in operation to ensure medium- and long-term supply security are those listed below, representing a usable volume of 138.5 TWh and an extraction capacity of 2,376 GWh/day, which meets 45% of usable volume needs:

Infrastructure	Operator	Year of commissioning	Storage type
Beynes	Storengy	1956	Aquifer
Céré-la-Ronde	Storengy	1993	Aquifer
Cerville-Velaine	Storengy	1970	Aquifer
Chemery	Storengy	1968	Aquifer
Etrez	Storengy	1980	Salin
Germigny-sous-Coulomb	Storengy	1982	Aquifer
Gournay	Storengy	1976	Aquifer
Lussagnet/Izaute	Teréga	1957	Aquifer
Manosque	Géométhane	1993	Salin
Saint-Illiers-la-Ville	Storengy	1965	Aquifer
Tersanne/Hauterives	Storengy	1970	Salin

Gas storage facilities to remain in operation until 2023

Between 2024 and 2028, storage needs will decrease following the end of the mobilisation of the Gournay infrastructure for the storage of L gas, scheduled for the end of winter 2025–2026. Based on current assumptions, by that time, the list of storage facilities could be reduced by an extraction capacity of at least 140 GWh/day at 45% of usable volume. Given the above-mentioned uncertainties, the assessment of the necessary volumes will have to be confirmed in 2023 and the next MEP will identify the storage infrastructures that would no longer be needed to ensure the security of natural gas supply in the medium and long term.

4.4.2.6. Safeguarding measures for gas crises

In the event of a crisis, and when preventive measures are insufficient to guarantee the supply of natural gas to French consumers, specific mechanisms may be activated:

- recommendation by the public authorities for moderation of energy demand;
- activation of interruptibility contracts for natural gas consumption;
- as a last resort, reduction of supply to certain consumers by the network operator to which they are connected;
- a call for European solidarity if these measures are not sufficient to maintain supply to domestic consumers and essential social services.

Interruptibility contracts for natural gas consumption

The Law on Energy Transition for Green Growth provides for the possibility of putting interruptibility schemes in place so that certain consumers can sign up with system operators to reduce their consumption if necessary. To achieve flexibility of approximately 5% of consumption in a cold snap, development of interruptibility of natural gas consumption of at least 200 GWh/day is expected by 2023.

Load shedding and natural gas consumption

Insufficient gas at a point in the network could lead the manager of that network to reduce supply to certain consumers (load shedding). These measures, which may be local or national, aim to compel a consumer to reduce or suspend their consumption. It is not possible to perform automatic supply shutdown remotely, so the network operator must contact the natural gas consumer directly to ask that individual to reduce or suspend their natural gas consumption. The effectiveness of the load-shedding mechanism therefore depends on whether the consumer in question complies with the load-shedding order. To reinforce the effectiveness of the load-shedding procedure, clarification of the legislative and regulatory framework will be undertaken by 2023.

Calls for European solidarity

Regulation (EU) No 2017/1938 of the European Parliament and of the Council provides for the establishment of a Union solidarity mechanism in the event of a gas crisis. In extreme situations, if demand from domestic customers and essential social services cannot be satisfied, even after loads are curtailed to all other consumers, France could use the mechanism to obtain the natural gas needed from neighbouring Member States. Conversely, Germany, Belgium, Spain or Italy could use this mechanism, which would lead to loads being curtailed for industrial consumers, with the payment of compensation. The procedures for this European solidarity mechanism will be specified by 2023.

4.4.3. Electricity

The purpose of ensuring security of the electricity system is to avoid localised power cuts or blackouts on a larger geographical scale. The security of the electrical system is based on two separate pillars:

- *Electricity system reliability*, which refers to the capacity of the electricity system to convey electricity from producers to consumers. This is achieved in particular by keeping infrastructures in good working order and by carrying out short-term balancing. Operating reliability also covers events such as major storms or system imbalances owing to an incident abroad that may cause large-scale power cuts. The associated issues will not be addressed in this section.
- *Security of the electricity supply*, which refers to the balance between supply and demand; at any given time, the quantity of electricity consumed must be equal to the quantity of electricity generated and injected into the system, making allowances for the uncertainties associated with both generation and consumption. A balance must be achieved both at an operational management level and in the long term. This involves managing two different kinds of phenomena:
  - handling consumption peaks which, because of the sensitivity to temperature of electricity consumption in France, requires sufficient capacity to be available during the relevant periods (either production or load shedding);
  - managing rapid fluctuations in supply and demand; compensating for these fluctuations requires an adequate number of flexibility tools to be available within the electricity system. These tools include demand management, storage, interconnections and controllable production units.

This section examines the various determinants of electricity supply security and how it can be provided satisfactorily.

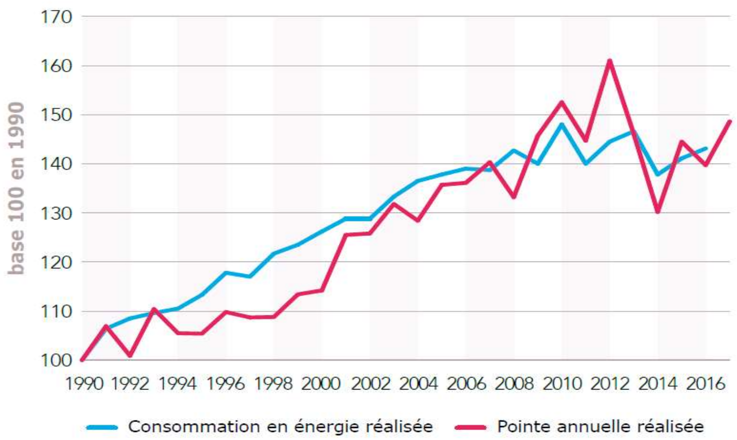
4.4.3.1. Controlling and handling consumption peaks

In Metropolitan France, the main risk to the security of electricity supply is peak winter consumption. Demand peaks occur during cold snaps that far exceed average power consumption: power demand then increases by about 2.4 GW for every 1 °C drop in temperature. To date, the maximum power demand nationally was approximately 102.1 GW, reached on 8 February 2012, during an exceptional cold snap.

The national power generation infrastructure and all flexibility tools must therefore be designed to be able to meet peak consumption and not average annual demand.

During the 2000s, power demand at peak consumption increased twice as fast as annual consumption. Since then, peak consumption has tended to stagnate overall, but with significant changes from one year to the next, depending on the severity of the climate, as shown in the following figure.

Figure 70: Change in annual electricity consumption and peak demand – Source: RTE 2018



base 100 en 1990	baseline 100 in 1990
consommation en énergie réalisée	energy consumption achieved
Pointe annuelle réalisée	Annual peak achieved

The long-term trend in peak electricity demand depends essentially on the trend in temperature-sensitive uses of electricity, and primarily electric heating. The implementation of the 2012 heating regulation (RT2012) has led to a decrease in the market share of electric heating in new collective housing and a reduction in heating needs in these dwellings. In electric heating systems, the strong growth of electric heat pumps, with lower, more regular power demand and high thermal inertia, also helps to reduce the demand for electricity at consumption peaks.

Considering the entire stock of residential and tertiary buildings, the trend in peak electrical consumption will largely depend on the pace of energy retrofits of buildings, but also on the trend in consumption: new comfort and leisure habits, new equipment and transfers of use (such as electric cooking). The development of individual electric mobility could also have a significant impact, which will be discussed later in this document.

Given these developments, the trend in peak consumption should become aligned with the trend in total electricity consumption in the coming years, while remaining extremely sensitive to temperature.

RTE's 2017 forecast report thus envisages changes in peak consumption similar to the trend in consumption by 2035, which would therefore reflect a stagnation or indeed a fall in peak power demand in France[73].

The capacity mechanism

To ensure compliance with the disruption criterion and ensure that demand peaks can be managed, the NOME law[74] introduced a capacity obligation mechanism in France, which effectively applies as of 1 January 2017. The principle behind this capacity mechanism is an obligation for each electricity supplier to provide evidence that the consumption of its customers can be covered in all situations intended to be covered by the system, even during cold snaps, with sufficient capacity guarantees.

The number of capacity guarantees that each supplier must have is determined in such a way as to meet the disruption criterion. It is based on calculations made by RTE, using a methodology consistent with the work carried out as part of the forecasting process. Capacity guarantees are released by RTE for generation and curtailment capacities, during a certification process, with suppliers committing to ensuring that these capacities will be available in the future during peak periods of the year in question. In order to meet their obligations, suppliers can therefore:

- use the guarantees they hold based on their own means of generation or curtailment; or,
- obtain generation or curtailment capacity guarantees from other operators.

Certificate trading in a "capacity market" enables suppliers to cover their obligations at the best cost, by selecting the most competitive capacities, and this system provides transparent information about capacity prices.

The energy market ensures that the use of the generation and curtailment capacities of the various players is optimised, but the unrestricted operation of this market would not guarantee compliance with the supply security criterion. The addition of the capacity market to the energy market ensures that this criterion is met.

The introduction of the capacity mechanism on 1 January 2017 required approval by the European Commission, which determined that the capacity mechanism, like all capacity mechanisms implemented within the EU, was covered by European legislation on State aid. The approval of the scheme by the European Commission was contingent on France's commitment to:

- Introducing an annual call for tenders, to guarantee a fixed capacity price over seven years for new capacities, in order to promote – when economically advantageous – the market entry of new generation or curtailment capacity. The calls for tenders are therefore conducted so as to ensure an economic benefit for the community and to minimise the impact of these long-term contracts on the operation of the current system. They include stringent environmental conditions (winners must be able to emit less than 200 gCO_2/MWh).
- Allowing foreign contributions from bordering Member States to participate directly in the capacity mechanism and obtain the corresponding capacity certificates starting in 2019. Previously, these contributions were only taken into account implicitly.

[73] Forecast report on the balancing of electricity supply and demand in France, 2017 Edition, RTE, 2017 available at https://www.rte-france.com/sites/default/files/bp2017_complet_vf.pdf.
[74] Law on new structure of the electricity market.

The Decree of 15 November 2018 and the subsequent revisions to the rules governing the capacity mechanism have helped to delineate these commitments and move the system in France in this direction.

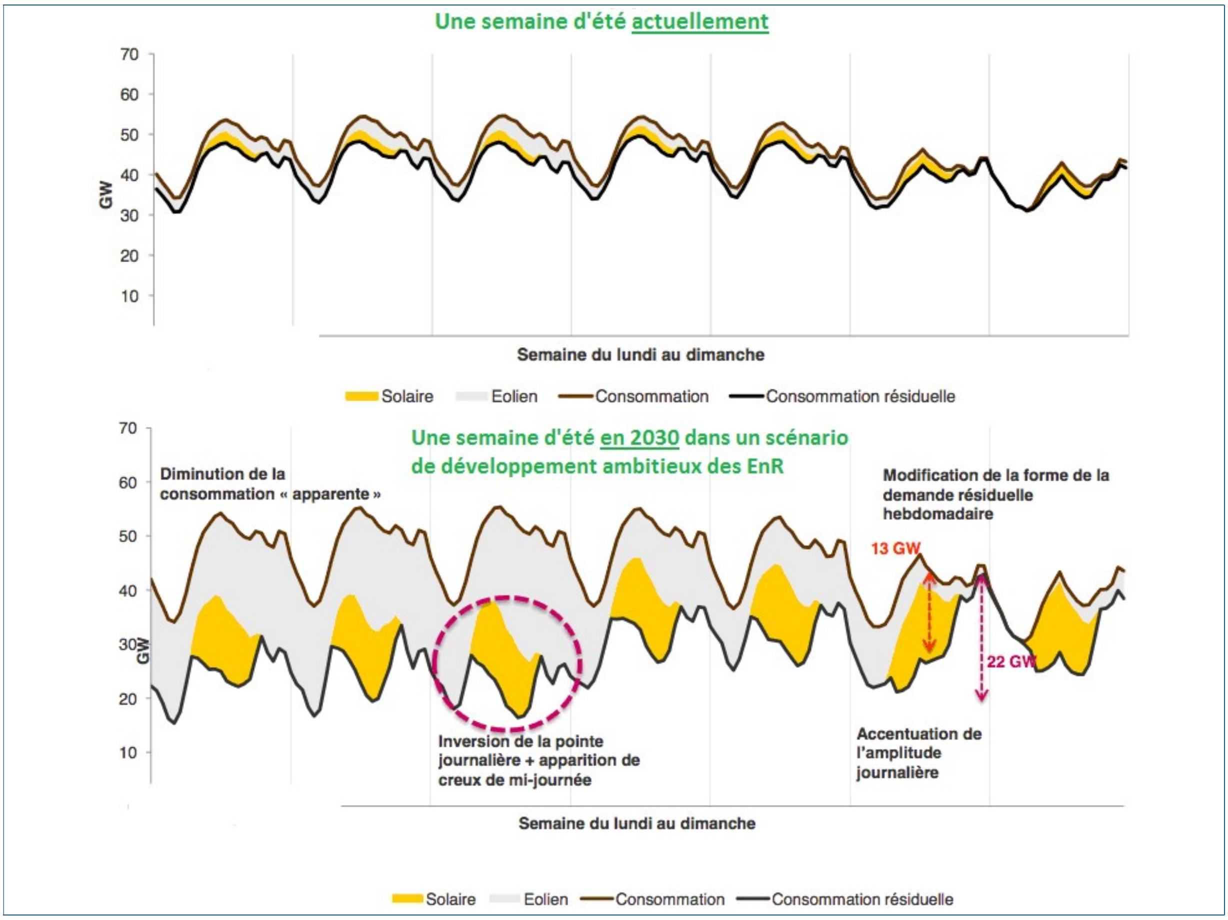
The coming months should focus on:

- Continued integration of the mechanism at European level, with the conclusion of agreements between the French electricity transmission system manager (RTE) and its European counterparts, to further the opening of the European market begun in 2019.
- Requests for feedback on the early phases of the mechanism, three years after its initiation in 2017, with the aim of assessing whether any reforms to its operation are appropriate.
- Adaptation of the mechanism to new requirements resulting from the Clean Energy for All Europeans package adopted last summer, which includes several provisions on capacity mechanisms operating in the European Union.

4.4.3.2. The rise of renewable electricity

The French electricity system is sufficiently flexible in its current operation to be able to respond to short-term fluctuations in supply and demand, over hourly, daily or weekly periods. But in the long term and beyond the time frame of the MEP, the incorporation of a large proportion of non-controllable renewable energies will require adaptations in order to continue to ensure the supply-demand balance, both in terms of supply security and for balancing services. The simulations performed by RTE in its 2015 forecast report on the balancing of electricity supply and demand have been used to assess the need for flexibility generated by the development of photovoltaic and wind power: wind power primarily creates a need for weekly flexibility, while photovoltaic systems create a need for hourly and daily flexibility.

Figure 71: Illustration of electricity demand and residual demand variability today and in a scenario involving the significant development of renewable energy in 2030 – Source: RTE, 2015



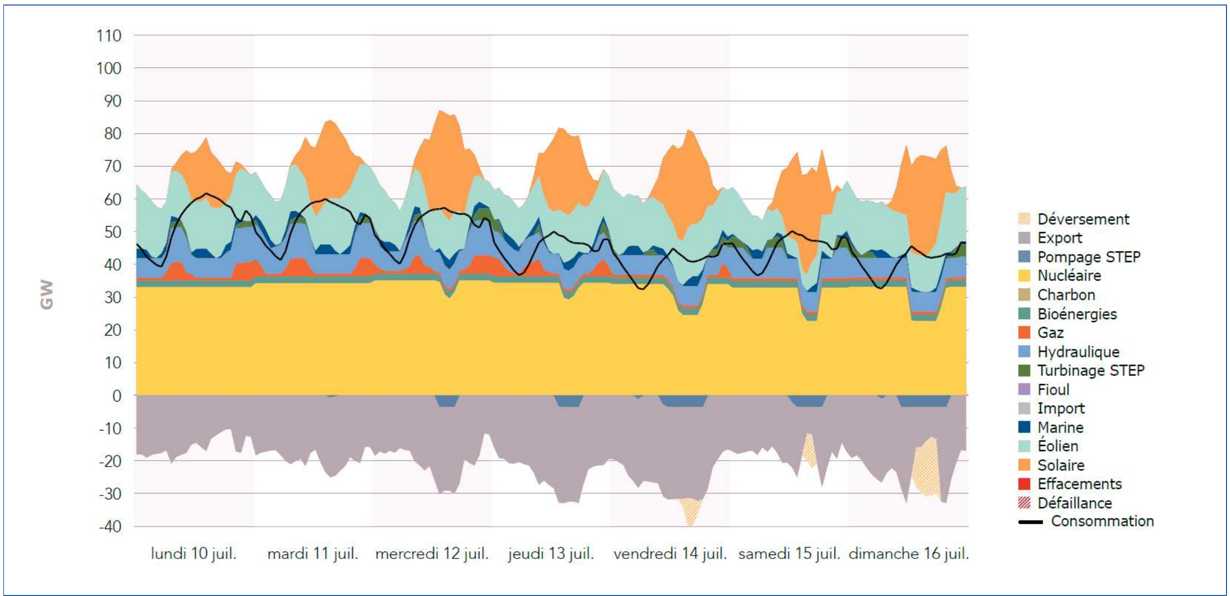
Une semaine d'été actuellement	One week of summer currently
Semaine du lundi au dimanche	Week from Monday to Sunday
Solaire	Solar
Éolien	Wind
Consommation	Consumption
Consommation résiduelle	Residual consumption
Une semaine d'été en 2030 dans un scénario de développement ambitieux des EnR	One week in summer in 2030 in an ambitious RE development scenario
Diminution de la consommation « apparente »	Decrease in 'apparent' consumption
Modification de la forme de la demande résiduelle hebdomadaire	Modification in the form of weekly residual demand
Inversion de la pointe journalière + apparition de creux mi-journée	Reversal of the daily peak + appearance of mid-day dip
Accentuation de l'amplitude journalière	Accentuation of daily range
Semaine du lundi au dimanche	Week from Monday to Sunday
Solaire	Solar
Éolien	Wind
Consommation	Consumption
Consommation résiduelle	Residual consumption

In its forecast of the balance of electricity supply and demand for 2017, RTE devised several scenarios (see below). The Ampere and Volt scenarios are based on major development of photovoltaic and wind power, leading by 2035 to installed capacity levels, respectively, of 67 GW of wind power (including 15 GW of offshore wind) and 48 GW of photovoltaics for the Ampere scenario; and 50 GW (including 10 GW of offshore wind) and 36 GW respectively for the Volt scenario. These installed capacity levels for wind and photovoltaic power are of the same order of magnitude as the entire French electricity infrastructure in 2018, for all sources combined, which is 101 GW.

These massive developments of non-controllable capacities should change the pace of residual consumption, i.e. the net electricity consumption of waste (residual) renewable energy generation. Forecasts anticipate a reversal of the daily peak and the appearance of a trough in residual demand at midday, reflecting peak photovoltaic production. The daily amplitude of residual consumption is increasing, while the form of weekly residual demand has changed.

In the two Ampere and Volt scenarios, the high levels of solar and wind power generation in summer feed exports, which reduces the need for the development of flexibility at national level. Occasional dumping appears by 2035. This refers to situations when generation fails to find outlets in France or for export.

Figure 72: Illustration of generation, consumption and exports in a summer week in 2035 (Ampere scenario) – Source: RTE, 2017



Déversement	Dumping
Export	Export
Pompage STP	STP pumping
Nucléaire	Nuclear
Charbon	Coal
Bioénergies	Bioenergies
Gaz	Gas
Hydraulique	Hydro
Turbinage STP	STP turbining
Fioul	Fuel oil
Import	Import
Marine	Marine
Éolien	Wind
Solaire	Solar
Effacements	Curtailments
Défaillance	Disruption
Consommation	Consumption
lundi 10 juil.	Monday 10 Jul

mardi 11 juil.	Tuesday 11 Jul
mercredi 12 juil.	Wednesday 12 Jul
jeudi 13 juil.	Thursday 13 Jul
vendredi 14 juil.	Friday 14 Jul
samedi 15 juil.	Saturday 15 Jul
dimanche 16 juil.	Sunday 16 Jul

Other sources of renewable electricity have characteristics that are generally beneficial for supply security. In addition to hydroelectricity plants with pumped-energy transfer stations (STEPs) and hydroelectricity plants on lakes, which are already essential sources of flexibility for the electrical system, pondage electricity generation has a regular generation profile with room for manoeuvre to vary generation over the course of the day. ROR power generation provides no flexibility, but does offer a regular generation profile.

The production of electricity by cogeneration from solid biomass or biogas has a basic generation profile (generation that is substantially constant throughout the year) or a semi-basic profile. Like pondage hydropower, these systems even offer a certain intraday flexibility to help them achieve the supply-demand balance.

The analyses carried out by RTE in preparing its forecast report conclude that the integration of significant renewable energy capacities (more than 100 GW installed by 2035 in the Ampere scenario) will not require the development of new flexibilities to ensure a balance between supply and demand. This development of non-controllable renewable electricity nonetheless creates new challenges that can be addressed using all existing flexibility levers, including flexibility of demand, storage and interconnections.

The scenario selected by the Government in the context of the MEP results in wind energy levels of 33.2 to 34.3 GW and photovoltaic levels of 35.6 to 44.5 GW in 2028. According to RTE studies, these levels do not require additional flexibility over the MEP time frame.

Other countries, including European countries, have much higher variable renewable energy penetration rates than France, without suffering disruptions due to supply-demand imbalances (see the example of Ireland below).

4.4.3.3. The closure of fossil thermal generation plants[75]

In 2016, French electricity generation facilities still included 6.67 GW of oil-fired electricity generation capacity and 2.93 GW of coal-fired generation capacity. On 31 March 2018, EDF closed its last large oil-fired power plant in Cordemais for economic reasons. The Government has announced its intention to close coal plants by 2022 or to support their conversion towards less carbon-intensive solutions, as part of the Climate Plan. This target was confirmed in the Law on Energy and Climate promulgated in November 2019. The Government has also announced that there will be no new gas plant projects.

The cumulative disappearance of these capacities between 2016 and 2022 will result in a decrease in flexibility of electricity supply and a greater need to mobilise other means of flexibility.

Studies carried out in late 2017 by RTE and updated in 2018 and 2019 confirmed the possibility of closing the last coal-fired power plants by 2022, while meeting supply security criteria both nationally

75 See also Chapter 3.4.9. Fossil fuel infrastructures

and locally in the reference scenario used in the MEP. This would mean bringing the Flamanville EPR on line by 2022 at the latest.

The delays to the EPR in Flamanville announced in summer 2019 prompted RTE to adjust these analyses in its 2019 forecast report, which concludes that the first coal-fired plants can be closed in 2020, but that the shut-down of all plants by 2022 would entail additional measures, particularly in terms of controlling peak consumption. The Government committed to implementing these measures to secure the shut-down of coal-based power generation by 2022.

RTE also highlighted specific security of supply difficulties for the west of France in the absence of the Flamanville EPR and concludes that 'the Cordemais power station is, as it stands, essential for maintaining the current level of security (in the west in general and Brittany in particular) until the long-term entry into service of the Flamanville EPR' (RTE 2019 Forecast Report). Among the levers identified by RTE to maintain a satisfactory level of security of supply in the most degraded configurations, the Ecocombust project to convert to biomass from B wood, driven by EDF, makes it possible to address these difficulties.

In any case, the objectives for security of the electricity supply will be met. RTE's analyses have in fact demonstrated that the framework laid down by the law on energy and climate, with the aim of encouraging the operators of the last French coal-fired power plants to halt their operations by 2022, and the Decree of 26 December 2019 setting the emission ceiling for electricity generation installations, are compatible with the security of supply objectives.

4.4.3.4. Supply security challenges until 2028

RTE forecasts on the supply-demand balance

In its 2017 forecast report, RTE undertook a major forecasting exercise, presenting five electricity system scenarios with assumptions relating to generation, consumption, flexibility and interconnection, up to 2035, with milestones at 2025 and 2030.

All scenarios show stagnation or a slight decline in annual electricity consumption, even in the case of a significant development of electric mobility. In all scenarios, the downward effects produced by energy efficiency equal or exceed the upward effects associated with transfers of use. This decrease makes it possible to utilise long-term margins for manoeuvre in terms of supply security. The scenarios also show that it is possible to achieve renewable electricity generation in excess of 40% in 2035 without jeopardising the electrical system.

The recent closure of oil-fired power plants, the delay in commissioning the Flamanville EPR, and the prospect of the closure of coal-fired power plants by 2022 with a gradual increase in renewable energies make the 2022–2023 period the most difficult in terms of supply security. This issue is covered more extensively in the previous section on the closure of fossil fuel plants.

RTE showed that the simultaneous closure of coal-fired power plants and nuclear plants within 40 years would lead to a failure to meet the criterion, unless there is massive development of new means of generation within a very short period. The development of thermal plants would have generated an increase in greenhouse gas emissions and the long-term profitability of these facilities would not have been guaranteed due to the development of renewable energies in France and in Europe, which will continue beyond 2025.

In terms of extending the lifespan of the nuclear reactors beyond 40 years, this would need to meet two types of requirements: regulatory requirements (compliance with the cap on nuclear capacity installed in France and with the threshold of 50% generation of nuclear origin in the electricity mix) and security requirements. With regard to the security issues, EDF is beginning a regular review of its 900 MW reactors. To do this, EDF has chosen to apply a general policy of tending towards the nuclear security targets set for third-generation reactors, for which its reference facility is the EPR. Meeting this target will mean that the installations will first need to meet the applicable rules, based on the introduction of targeted checks, in particular on cooling and core rescue systems, investigations to identify and remedy potential weaknesses in the maintenance programmes, and an exhaustive analysis of the handling of compliance deviations.

More long term, the nature of the risks to supply security changes with the development of renewable energies: episodes of tension may last for shorter periods and may involve smaller volumes of energy, but could happen more often and especially in non-winter periods. These forecasts confirm the need for the development of flexibilities and interconnections to ensure long-term supply security, utilising the proliferation of renewable energies at European level.

The scenario chosen by the Government considers all of these constraints and proposes a calendar for the closure of coal-fired power plants and nuclear reactors in order to guarantee the security of supply. The law on energy and climate therefore pushed back the reduction in the share of nuclear to 50% to 2035.

The participation of nuclear in supply security

Around the world, nuclear reactors most often operate at a constant power level for economic reasons: it is more profitable to operate reactors at full power than not to use them because there is no economic gain in terms of fuel when a reactor is shut down, unlike fossil fuels.

Conversely, in France, nuclear plants were designed to operate in load monitoring mode and thus to continuously adjust electricity generation for consumption. Today, the average load factor in the French system is therefore relatively low when compared to other international figures: this is around 72% in France while the facilities operated by Exelon in the United States have a load factor of 90%. In addition to the technological and operational challenges that this load monitoring operation involves, the French system has adjusted economically.

With the increasing integration of renewable energies, nuclear installations in the future will have to adapt to new factors of variability, in a context in which the concomitant growth of interconnections will make it possible to derive greater benefit from the flexible capacities of our European neighbours for our own supply security.

With regard to the participation of nuclear in supply security in the medium and long term, based on the technologies currently available, it is not possible to determine with certainty which technologies will be the most competitive in guaranteeing our electricity mix over that time frame, whether nuclear or renewable energies associated with storage and other flexibility solutions.

The ability of the electricity grids to integrate intermittent energy sources, the maturity of electricity storage technologies (including between seasons) and the economic performance of the different pathways on a full-cost basis will be decision-making factors. Between 2030 and 2050, these parameters will need to be combined to develop the new energy landscape in France and the respective shares of nuclear and renewable energies: a range of scenarios will be explored, from 100% renewable to a scenario where nuclear remains an electricity generation source sustainably integrated into the electricity mix for reasons of competitiveness and the need to control power generation. Because of this uncertainty, there is a need to preserve a capacity to construct new nuclear reactors supported by national industrial capacity and technology.

Interactions between the supply security of electricity and gas

The electricity and gas systems are interdependent:

- During cold snaps, gas and electric heating are both subject to high demand. It must not be possible to interrupt the supply of gas plants that are in high demand.
- An electrical crisis can lead to gas delivery difficulties, as the gas network, from the transmission system to end-customer installations, cannot function properly without electricity.

This interdependence is expected to increase with the commissioning of a new gas plant at Landivisiau and the shut-down of oil and coal power plants. However, with peaks in electricity consumption on very cold winter days, which coincide with peaks in gas consumption, a lack of gas supply combined with a cold snap may have an impact on electricity supply.

The dependencies between the two systems may also be local, as in Brittany or Provence-Alpes-Côte d'Azur where the electricity grid is limited, making the operation of some gas plants necessary. Gas supply to power plants can currently be interrupted under the interruptibility clauses of their supply contracts.

The existing coordination between GRTgaz/Teréga (formerly TIGF) and RTE needs to be increased to enable a more detailed examination of the dependency links between electricity and gas crises, and in particular the consequences of a gas crisis on the electricity system, due to its effect on gas-fired plants, given that electricity demand is much more variable over the day than gas demand, and that load shedding can be more easily implemented, locally and on a rotating basis, for electricity.

4.4.3.5. Developing the electrical system to integrate a growing share of renewable energies

Changes being implemented at European level

The Third Energy Package for the internal market, adopted by the EU Member States in 2009, introduced a number of tools to facilitate the construction of European electricity. In particular, it lays out the development of 'grid codes', which aim to harmonise European practices in the field of networks, in order to improve electrical safety in a context of rapid development of renewable energies. These codes were all approved in late 2016, and are being integrated into the French regulatory framework. Three of these grid codes are designed to harmonise the technical requirements for the connection, respectively, of generation and consumption facilities and very-high-voltage direct current lines. These elements also aim to improve integration of renewable energies into the operation of the electricity system through appropriate connection to electricity grids.

Construction of the electrical system of tomorrow

In national terms, the changes in generation methods in the electrical system will not result in new technical constraints over the time frame of the MEP. In the longer-term, many questions will need to be answered about the potential of renewable energies to ensure the stability of the electricity system. Regardless of the scenario adopted beyond this programme, changes in the electricity mix will be based on a reduction in controllable thermal systems within France and Europe and replacement by renewable energies, and especially wind and photovoltaic systems. In the long term, these renewable energies will make up a significant part of the electricity mix, supplemented by hydroelectricity and possibly by nuclear generation. The challenges posed by the penetration of renewable energies essentially relate to:

- the decentralisation of the electrical system, in particular with more and more installations connected at HVA or LV, which will change flow management practices and will raise important planning issues for the accommodation of new generation capacity;
- the management of variability and maintenance of supply quality;

- interfacing of these generation activities, particularly through power electronics, to ensure the security of the electrical system.

Providing system services with renewable energy

System services, in terms of voltage and frequency (adjustment, balancing, etc.) are currently provided mainly through traditional generation resources. Renewable energies can already provide some of these services today. New generation facilities will also be required to have the capacity to perform these services, under the grid codes that will soon be applicable throughout the European Union. On the other hand, the issue is still open for other services provided to the grid, as it does not currently seem possible to provide these services due to power electronics interfacing.

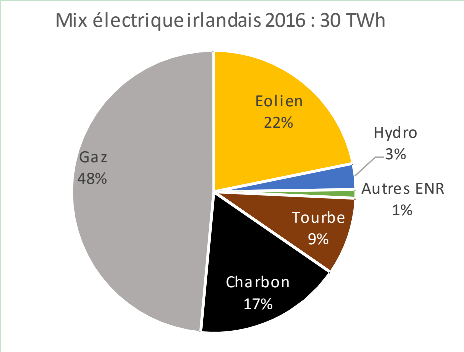
Work will be undertaken with the grid operators and the IEA to study in detail the services that can be provided by renewable energies interfaced by power electronics. It will also assess possible changes in the management of the electrical system that might be required to guarantee the same level of security and quality of supply in a system with a significant share of renewables.

Several examples from around the world show that it is possible to ensure the stability of the electrical system at high rates of variable renewable energy penetration through the adaptation of existing balancing services and the introduction of new services, as the example of the Irish case shows.

<u>Box 14:</u> Integration of renewable energies into the Irish electricity mix

In 2016, Ireland produced 30 TWh of electricity, of which 26% came from renewable energies. Its installed facilities represent just over 7 GW.

With variable wind power generation accounting for 22% of national generation and with a target of 42.5% renewable energy by 2020, Ireland must continually adapt the operation of its grid to integrate a growing share of intermittent renewable energies. Ireland has very limited interconnections and therefore needs flexibility to ensure its supply-demand balance at all times.



Mix électrique irlandais 2016 : 30 TWh	2016 Irish electricity mix: 30 TWh
Gaz	Gas
Eolien	Wind
Hydro	Hydro
Autres ENR	Other RE
Tourbe	Peat
Charbon	Coal

In 2010, Eirgrid and SONI (the Irish and Northern Irish transmission system operators, respectively) identified a first limit of 50% intermittent instantaneous renewable electricity penetration to enable the system to operate reliably and efficiently following a disruption or frequency-impacting event. The first problems that a grid operator has to address result from the high rate of frequency change due to low synchronous inertia and a lack of production stability.

In order to gradually increase this 50% limit, Eirgrid and SONI have implemented the ‘Delivering a Secure Sustainable Electricity System (DS3)’ programme. This programme gradually introduces services that address potential problems in the system (e.g. variability of generation, lower inertia, difficulty in maintaining frequency), identified through technical analysis. These services include the following:

- the establishment of technical requirements for the facilities, for example a requirement for wind farms to provide ‘synthetic’ inertia (aimed at recreating some of the inertia provided by rotating machinery, thanks to the wind turbine blades);
- the development of new balancing products, such as the supply of dynamic reactive power or a ramping margin, which – for a given generation unit – involves defining a margin of generation that can be guaranteed for a certain period of time and that evolves over time depending on the degree of certainty of generation.

These different mechanisms have made it possible to limit the loss of wind generation (by capping or due to congestion) to around 4% of annual wind production, without resorting to significant storage volumes.

Since May 2018, Eirgrid has thus pushed its renewable energy penetration limit to 65%. Eirgrid aims to reach 70% in 2019 and 75% in 2020.

4.4.3.6. Security of uranium supply

For the purposes of nuclear-based power generation, the French nuclear system uses various types of uranium-based nuclear fuels (UOx, MOx or ERU). France has therefore adopted a policy of reprocessing of its spent fuel, a strategy that presents a major challenge in terms of reducing the volumes of radioactive wastes produced. This strategy will be continued until the 2040s, when the bulk of the installations and workshops required for reprocessing will reach the end of their life cycles.

EDF, which operates the entire stock of French nuclear reactors, is responsible for uranium security of supply.

Uranium needs mainly depend on:

- changes to nuclear installations and their operating methods;
- the spent fuel recycling strategy, particularly with the use of MOX fuel, which means that the procurement of natural uranium can be reduced.

EDF's consumption for the French nuclear industry represents around 8,000 tonnes of natural uranium per year, i.e. 13% of the global consumption of 59,000 tonnes (2017 data).

Accessible global reserves are estimated at 4.6 Mt, which corresponds to nearly 80 years of global consumption. These reserves are generally well distributed throughout the world, notably in Australia (1.7 MtU), Africa (0.9 MtU), Central Asia (0.8 MtU) and North America (0.5 MtU). There is, therefore, a relatively low risk of shortage, while the uranium market has remained depressed since the Fukushima-Daiichi disaster, with a very low average price of about USD 25 per pound in 2019.

To bolster its supply security, EDF uses several levers:

- Geographical and commercial diversification of sources of supply for each stage of the fuel cycle (mining, conversion, enrichment and assembly manufacturing). This diversification is particularly important in mining, as EDF is mainly supplied by five countries (Niger, Kazakhstan, Canada, Australia and Russia).
- Long-term contractual certainty for EDF. EDF's needs for each stage of the cycle are generally covered for about 10 years by its main suppliers.
- Stock management. EDF retains significant stocks of uranium over the entire nuclear fuel cycle (mining, conversion, enrichment, new fuel, reactor fuel, reserve fuel). These stocks make it possible to operate the French nuclear reactors over several years, thus addressing the risk of supply disruption.

However, the supply of uranium is not the only issue for supply security: the robustness of industrial processes used for fuel fabrication and the storage capacities associated with these activities can also be critical. Indeed, a long interruption to certain plants in the cycle or the saturation of spent fuel storage capacities could lead to a forced temporary shut-down of some nuclear reactors in the whole country.

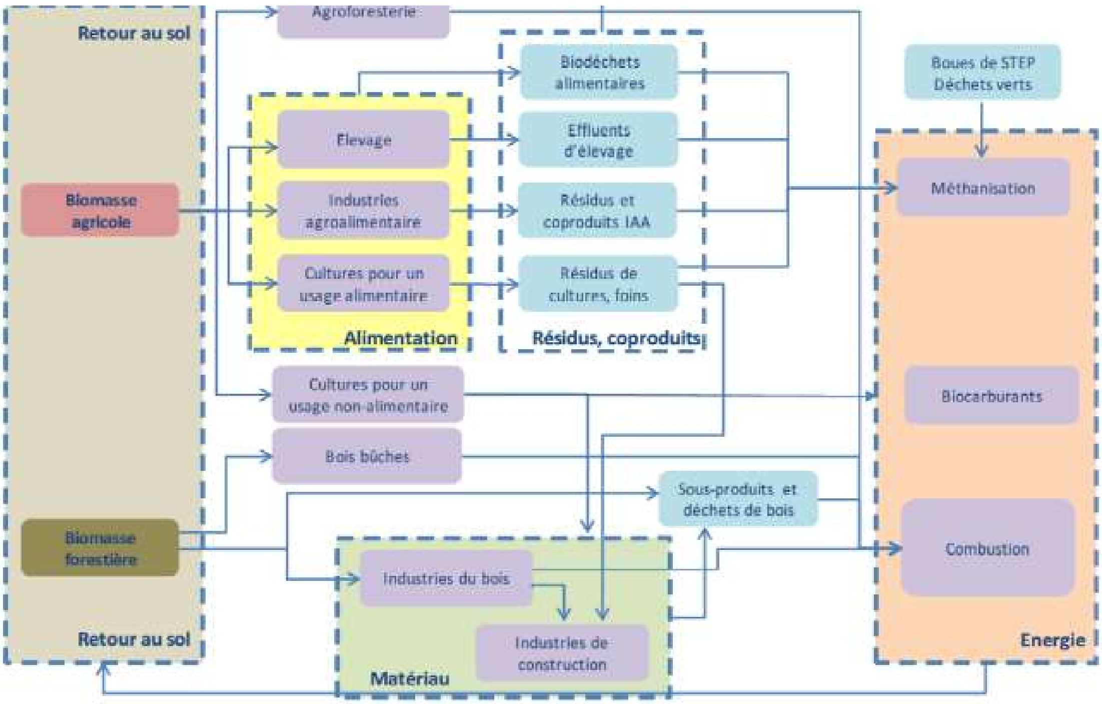
A reduction in nuclear capacities has consequences for the fuel cycle. In particular, the strategy to reprocess/recycle nuclear fuel is a major challenge in terms of reducing the volumes of radioactive wastes produced. This strategy will therefore be continued throughout the time frame of the MEP and beyond, until the 2040s, when the bulk of the installations and workshops of the Hague plant will reach the end of their life cycles. Because of this situation, and to offset the closure of the 900 MW 'MOXed' reactors over the period, a sufficient number of 1,300 MW reactors will be 'MOXed' to ensure the long-term viability of the French cycle.

4.4.3.7. Security of biomass supply

Energy transition and the green economy require control of the use of fossil resources in all areas and better use of nationally available renewable resources, especially biomass, given the assets available to France in this sphere. The SNBC envisages a five-fold increase in non-food uses of biomass in the long term (wood-construction, green chemistry, biomaterials, bioenergies, etc.). In this context, the implementation of strategies (nationally and regionally) for biomass mobilisation is sensible.

Energy recovery from biomass has its place within other uses. The diagram below illustrates the fact that energy recovery is part of a hierarchy of biomass resources that prioritises food uses, then biofertilisers, then materials, then molecules, then liquid fuels, then gas, then heat, then electricity. This hierarchy is based on the principle of the cascading use of biomass: products used in materials can be used in energy at the end of their service lives.

Figure 73: Diagram of the main uses of biomass. Source: Diagram taken from the National Biomass Mobilisation Strategy.



Retour au sol	Soil return
Agroforesterie	Agroforestry
Biodéchets alimentaires	Food biowaste
Boues de STEP Déchets verts	STEP slurry Green wastes
Élevage	Livestock
Effluents d'élevage	Livestock effluents
Méthanisation	Anaerobic digestion
Biomasse agricole	Agricultural biomass
Industries agroalimentaires	Agrifood industry
Résidus et coproduits IAA	Waste and agrifood by-products
Cultures pour un usage alimentaire	Food crops
Résidus de cultures, foins	Crop residues, hay
Alimentation	Food

Résidus, coproduits	Residues, by-products
Cultures pour un usage non-alimentaire	Non-food crops
Biocarburants	Biofuels
Bois bûches	Wood logs
Sous-produits et déchets de bois	Wood waste and by-products
Biomasse forestière	Forest biomass
Industries du bois	Wood industries
Combustion	Combustion
Industries de construction	Construction industries
Retour au sol	Soil return
Énergie	Energy
Matériau	Material

Identification of resources

On the basis of studies conducted nationally (see box below), the National Biomass Mobilisation Strategy (SNMB) estimates additional non-methanised biomass supply for all non-food uses combined up to 2028 to be around 72 TWh (compared to 2014), of which 36 TWh is from forestry, 28 TWh from agricultural resources and 7.8 TWh from waste.

<table>
<tr><th></th><th></th><th></th><th>2023</th><th>2028</th></tr>
<tr><td rowspan="6">Non-methanised biomass</td><td colspan="2">Forest biomass</td><td>21.9</td><td>36.8</td></tr>
<tr><td rowspan="3">Agricultural biomass</td><td>Crops (perennial and Intermediate Crops for Energy Purposes)</td><td>0.23</td><td>0.29</td></tr>
<tr><td>Crop residues</td><td>22.8</td><td>23.4</td></tr>
<tr><td>Agroforestry</td><td>1.5</td><td>2.5</td></tr>
<tr><td rowspan="2">Waste and other residues</td><td>Waste (including end-of-life wood), by-products, pruning, cutting</td><td>3.4</td><td>4.3</td></tr>
<tr><td>Composting refuse</td><td>2.1</td><td>3.5</td></tr>
</table>

Additional biomass supply (TWh). Non-methanised biomass is in primary energy.

The total supply of solid biomass not usable for methanation up to 2028 is estimated as 251 TWh, of which 120 TWh is forest biomass.

			2016	2023	2028
Non-methanised biomass	**Forest biomass**		84	106	120
	Agricultural biomass	**Crops (perennial and Intermediate Crops for Energy Purposes)**	63[76]	86	89
		Crop residues			
		Agroforestry	27[77]	28.5	29.5
	Waste and other residues	**Waste (including end-of-life wood), by-products, pruning,**	5	8.4	9.3
		Composting refuse		2.1	3.5

Total biomass supply (TWh). Non-methanised biomass is in primary energy.

These figures, particularly those related to forest biomass, are taken from the SNMB (approved in 2018), which itself is based on the latest studies and available data, including a 2015 IGN-FCBA[78] study on forest availability for energy and materials until 2035. The SNMB to 2023 describes the usable volumes for various products associated with forest biomass (softwood lumber, industry/energy lumber, wood scraps, sawmill products). These data should be revisited in the light of the latest available studies, particularly those done as part of regional programmes for forestry and lumber management[79]. To that end, a consolidation study was launched in mid-2019.

Regarding methanisable biomass, the SNMB evaluates the additional supply of methanisable biomass without destabilisation of other existing sectors as 30 TWh, and thus total resources of 40 TWh.

			2023	2028
Methanised biomass	**Agricultural biomass**	**Crops (perennial and Intermediate Crops for Energy Purposes)**	2.3	2.4
		Crop residues	6.7	11.3
	Waste and other by-products	**Green wastes**	1.2	1.9
		STEP slurry	0.2	0.4
		Waste and agri-food by-products	0.2	0.5
	Effluents		7.8	13.3

76. For 2016, the figure of 63 TWh includes crops (primary, perennial and intermediates for energy purposes) and crop residues.
77 DGEC estimate based on Agreste data on forest harvesting for energy purposes.
78 'Available wood resources for energy and materials up to 2035', 2015, ADEME-IGN-FCBA.

79 Just four of these were officially confirmed in late September 2019: Eastern France, Brittany, Occitanie and Burgundy-Franche Comté.

Additional biomass supply as final energy (TWh)

Recoverable wood resources that can be recovered as energy are estimated to be 2 Mt, of which 1.1 Mt are already recovered. This means an additional energy resource of about 2 TWh. Measures to increase the mobilisation of biomass resources in accordance with sustainable management practices, in order to coordinate the uses of biomass and linked with the national forest-wood programme, will help support the development of wood for energy purposes. Finally, a wood waste recovery initiative is currently under way within the framework of the Strategic Committee for the Timber Industry.

The aim of the waste recovery policy is to reuse wood waste in material form, instead of incinerating it. The circular economy action plan above all encourages cascading wood use, with several reuse and recycling cycles.

Support systems for energy recovery should not thus provide for the eligibility of wood waste when it is demonstrated that the waste could not be reused or recycled (e.g. diseased wood, creosote waste, etc.).

Non-recyclable wood waste should be eligible for support schemes as a matter of priority, without prejudice to the application of the regulations on classified installations for the protection of the environment. However, the cost impact of the upstream processing of this waste or processing via energy recovery on the level of support necessary must be studied.

If the potential resource is very abundant, mobilising it under satisfactory economic and environmental conditions will require a progressive approach (see the box below). The evaluation of additional biomass supply available shows that by 2023, just over half of the additional needs should be met from agricultural biomass, mainly through the use of crop residues and intermediate crops for energy purposes, but also through agroforestry and, to a lesser extent, by perennial crops. Achieving these SNMB objectives therefore requires the development of suitable instruments to enable the mobilisation of this agricultural biomass. Forestry should contribute less than half of the resources.

A comparison of this supply with the additional demand identified at this stage shows that biogas needs can be covered by domestic resources, but that energy needs overall (biofuels including air, heat and cogeneration) could not be covered without some transitional use of biomass imports. If the figures are on the higher side, the need for non-methanised solid biomass could even be only half met by domestic biomass, thus necessitating major transitional use of imports.

However, it is important to remember that the SNMB specifically seeks to avoid structural recourse to imports, establishing mobilisation conditions for domestic resources that meet the sustainability criteria laid down in the 2018 RED II Directive. Operationally speaking, it should be noted that the Heat Fund specifications require that imported wood come from certified sustainably managed forests. It is also important to note that products made from palm oil are not considered biofuel, and their use is therefore not subject to tax incentives (exclusion provided under Article 266-quindecies of the Customs Code).

Box 13a: National Biomass Mobilisation Strategy

The National Biomass Mobilisation Strategy (SNMB) aims to develop positive externalities related to the mobilisation and de facto use of biomass, especially for the purposes of mitigating climate change. One of its objectives is to enable the supply of energy production facilities: domestic wood-burning appliances, industrial and tertiary collective boilers, and cogeneration units.

To be effective, the SNMB must overcome difficulties in the development of biomass supply, providing acceptable synergies with other existing policies. It has been designed alongside the National Low-Carbon Strategy and the MEP, from which it takes the demand targets for biomass for energy purposes. The SNMB is also supported by the National Forestry and Timber Plan. In geographical terms, it covers 18 regions (Metropolitan France, plus Guadeloupe, Guyana, Martinique, Reunion and Mayotte). It will be coordinated with the regional biomass schemes (SRB) being developed in the regions. It will be revised in the year following the adoption of the new MEP and then every five years.

The SNMB identifies different categories of biomass that could be subject to increased use and sets targets for resource development and mobilisation. It makes 72 recommendations for improving and increasing the mobilisation of domestic biomass, to cover as many identified biomass needs as possible, for energy purposes and for construction or biomaterials and green chemistry. These recommendations also ensure that this mobilisation is sustainable, through initiatives such as promoting material uses and those with high added value (progressive concentration of biomass energy use on end-of-life bio-based products that are not recyclable), restoring sustainable forest management (in close partnership with bio-economics, adaptation to climate change and increased preservation of biodiversity), focusing on strengthening the quality of soils, especially agricultural soils, etc.

The SNMB is based on several national studies intended to quantify resources and estimate additional potential. In particular, it uses the 2015 IGN and FCBA study, the 2013 ADEME study on biomass resources for methanation, and data collected by the National Observatory of Biomass Resources under the leadership of FranceAgriMer. On that basis, the SNMB has established targets up to 2023 for mobilisation of additional forest, agricultural and biowaste resources:

- additional non-methanised biomass (possible use in bio-based materials, green chemistry, biofuels or heat-cogeneration) is estimated as 52 TWh of primary energy equivalent;
- additional biogas production is estimated as 18 TWh.

In the medium term, agricultural biomass would contribute close to 80% of available biomass.

The SNMB is subject to annual monitoring. It is presented to the Information and Orientation Committee (the indicative composition of which is attached to the strategy document) and then made public. This monitoring is undertaken in tandem with the monitoring of the sector-based plans with which the SNMB is coordinated (National Forestry and Wood Plan, agroforestry plan, MEP, waste prevention and management plan, low-carbon strategy, etc.).

Another development factor to be considered for this strategy is the forthcoming completion of regional biomass schemes (SRB) being devised in the regions. The first review of the strategy will be an opportunity to ensure consistency with the SRBs.

Box 13b: National Biomass Mobilisation Strategy

Environmental challenges faced by the SNMB

As regards soil and biodiversity, more frequent use and increased, sustained exporting of wood, scraps and crop residues could result in a loss in chemical (fewer nutrient-rich resources), physical (settling) and biological fertility in the soil, decreased availability of biodiversity habitats, and reduced connectivity (green pathways) in the landscape. These effects should be limited through reasonable use of materials, maintenance of old trees, increased awareness of the issue of soil compacting and the return of nutrient-rich elements (digestates, composts, ash, etc.).

Overall, increased use of nitrogen fertilisers and crop protection products, particularly in agriculture, could impact biodiversity and soil, air and water quality.

The environmental impacts observed will depend to a considerable degree on the implementation of the awareness building, training and reporting measures laid out in the SNMB and the relevant sector-based regulations.

The impact is considered to be neutral in terms of use of natural spaces and landscapes, considering the lack of clear causal links on these issues.

It should be noted that more dynamic management of certain resources (forests, hedges, etc.) can, conversely, have positive effects on the diversity of these environments and their resilience to climate change.

All of these issues, and the measures proposed as a result, are developed in the SNMB environmental assessment report.

Strategic orientation of these resources

Biomass is a scarce resource and will remain so between now and 2050. For this reason, the MEP gives clear guidelines on prioritising it for uses where it is most effective:

- For wood, its use as heat in district heating systems or for the production of industrial heat must be prioritised. Cogeneration should only take place in specific cases and high efficiency cogeneration should be preferred in this case.
- For biogas, biomethane injection must be prioritised. Cogeneration must only take place in specific cases, in particular for generation facilities far away from gas networks.
- For biofuels, the goal is not to increase first-generation fuels but, rather, second-generation (advanced) biofuels.

4.5. Internal energy market

4.5.1. The power grid

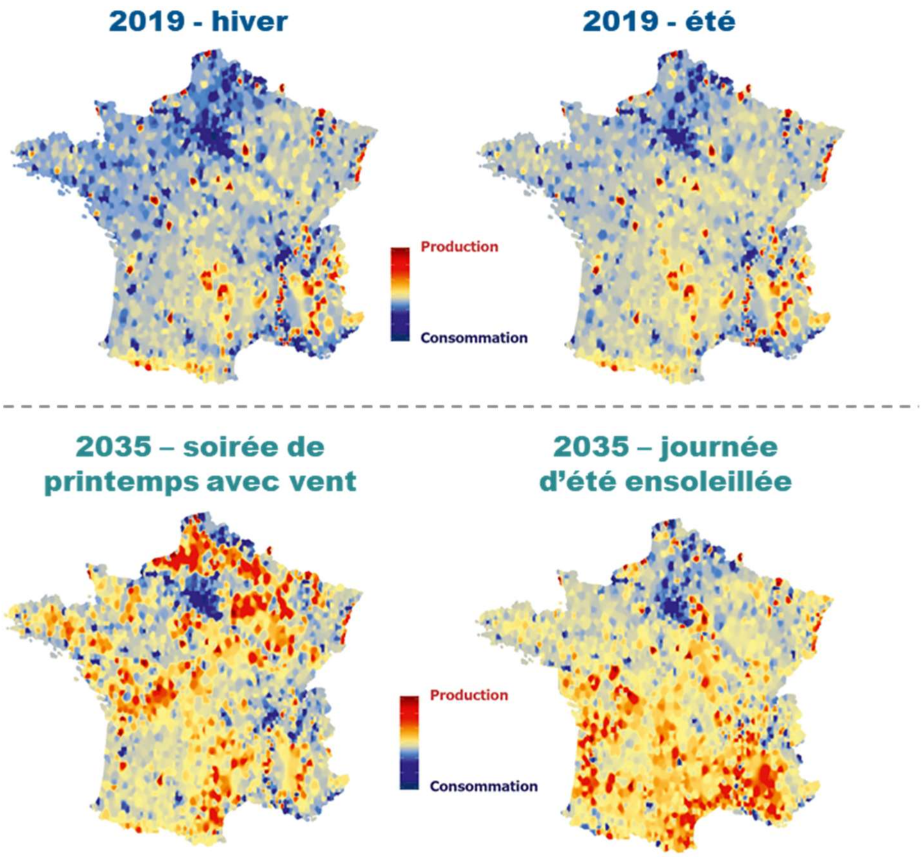
Power grids are a key component of energy transition. They connect producers and consumers, guarantee the quality and continuity of electricity supply and anchor France in the European electricity system through interconnections with six other countries.

The mass development of renewable energies under way is leading to a paradigm shift, with a significant change in electricity flows in the grids.

This leads to:

- different geographical distribution of generation units;
- greater variability of the daily generation.

Figure 74: Change in the geographical distribution of electricity generation/consumption (source: RTE)



2019 – hiver	2019 – winter
2019 – été	2019 – summer
2035 – soirée de printemps avec vent	2035 – spring evening with wind
2035 – journée d'été ensoleillée	2035 – sunny summer day
Production	Production
Consommation	Consumption

The electricity system is evolving from generation that, historically, was almost entirely centralised, consisting of large power plants connected to the transmission grid, and 'descending' towards consumers via the distribution system, to a generation model that is increasingly diffuse and closer to consumption points: for several years now, most new energy generation facilities have been renewable and connected to the distribution system.

At the end of the third quarter of 2019, 433,000 generation sites were connected to the distribution system managed by Enedis, and thus a total of 27.5 GW of installed power. The vast majority of these sites are low-power photovoltaic plants. For its part, although it represents a limited number of sites (around 1,900, of which 1,700 were connected to the distribution system), wind power counts for around 16 GW of cumulative power (of which 13.8 GW is connected to the distribution system).

The different types of renewable electrical energy have very different characteristics, which have variable impacts on the distribution and transmission systems. In addition to differences in plant size, differences in energy sources have an impact on generation profiles (seasonal, daily and hourly variability), predictability, and even the possibility of modulating generation rates[80]. Furthermore, the wave qualities or voltage profiles of these generation systems must be taken into account for effective grid operation. Moreover, self-consumption, with or without injection of the non-self-consumed surplus into the grid and potentially combined with local storage, can significantly modify the consumption profiles of the sites concerned as seen from the grid (extraction). The net acceleration of the development of self-consumption observed in recent times could therefore have impacts on the coordination of the grid.

The large-scale integration of renewable energies and the development of new uses of electricity such as electric vehicles require the adaptation of the electrical system and the development of flexibility and adjustment solutions, which most often involve the grids.

Organisation of power grids

The operation of electricity transmission and distribution systems is a regulated public service.

The public electricity transmission system is used to transport huge quantities of power from one place to another but also as a 'hub', making it possible to pool the available resources and operate them at a reduced cost[81]. It consists of all the lines operated at a voltage greater than 50,000 V in mainland Metropolitan France. It comprises 106,000 km of high- and very-high-voltage power lines (HVB) and 2,700 substations. RTE, a public-owned company limited by shares, is the sole operator and owner.

More than 90% of current French electricity generation is injected into the transmission system, including the bulk of renewable generation (hydropower) and, in the future, offshore wind farms. This grid directly serves several hundred consumers, most of which are large industrial consumers, representing one quarter of national electricity consumption.

RTE, the transmission system operator, is also responsible for specific tasks in the management of the electricity system, particularly through the management of real-time supply and demand balancing mechanisms.

These are public electricity distribution systems, consisting of medium-voltage structures (HVA, between 1,000 V and 50,000 V) and low-voltage structures (LV, less than 1,000 V), connected to the transmission grid, which deliver the electricity to end consumers.

The public distribution of electricity takes place through local concessions. The authorities responsible for electricity distribution, also called concessionary authorities, are local authorities that own grids (municipalities, most often grouped into departmental energy unions, urban communities or metropolitan areas). Enedis, a subsidiary of the EDF group, which covers 95% of Metropolitan France, currently holds more than 600 concessions. Enedis operates 1.4 million kilometres of lines, 778,500 distribution stations (HVA/LV) and 2,700 source stations (HVB/HVA, providing the interface between the transmission and distribution systems). It serves more than 36 million consumers. A total of 5% of Metropolitan France is served by 140 local distribution companies (LDCs) controlled by local authorities.

The main tasks of the public electricity system operators are grid operation (troubleshooting, running and control of the network, connection of new consumers or producers), calculating the quantities of energy injected or taken off, and upgrading infrastructures to ensure that they are kept in operational condition.

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80. Please refer to the chapter on security of the electricity supply for more information.
81 See the introduction to the new TYNDP (Ten-Year Network Development Plan), RTE, September 2019.

Public power grid usage tariffs

Both electricity transmission and distribution are public services with tariffs that are regulated and set by the Energy Regulatory Commission in four-year periods. These tariffs for the use of public power grids (TURPE) represent on average a little less than one third of the amounts billed to consumers (including taxes) and cover the investment and operating costs of the system operators RTE and Enedis. In particular, the tariff levels are set based on the investment forecasts of the system operators, so as to ensure that they have sufficient resources at all times to maintain or improve the infrastructures for which they are responsible. The tariffs are supported by incentive regulation mechanisms, in particular to encourage system operators to better control their costs or to improve the quality of supply.

For local distribution companies (LDC) and for system operators in non-interconnected zones (NIZ), revenues are adjusted to actual costs incurred through the Electricity Equalisation Fund.

The TURPE is based on tariff equalisation principles (an identical tariff throughout the country) and on the 'postage stamp' principle (pricing is independent of the distance covered by the electricity).

The fifth TURPE tariff period, 'TURPE 5', came into force on 1 August 2017 and allows changes to the tariff structure as part of the energy transition process and a specific regulation for the deployment of smart meters. These tariffs include the introduction of a mobile peak option for medium voltage. From 2017, the Energy Regulatory Commission began a consultation process to prepare for the tariff review in 2020 to enable better consideration of the specific constraints of self-consumption and other new uses.

Since November 2017, small renewable energy generation facilities have benefited from coverage by the TURPE of some of the cost of connection to public electricity distribution systems. This tariff reduction – of up to 40%, depending on the capacity of the installation – facilitates the connection of facilities that do not generally have any choice about their location (particularly photovoltaic panels on roofs).

The public power transmission system

Investment-planning tools

Power grids are long-lived infrastructures; they require substantial investments that need to be planned well in advance. This is especially true for the transmission system, which has an investment time frame of around 10 years. Planning is all the more complex as it relies on several documents, drawn up both at national and European level.

The Third Energy Package for the internal market, adopted by the EU Member States in 2009, introduced a coordinated approach to planning transmission system investments: Every two years, the Association of European Network Operators (ENTSO-E) is required to publish a European 10-year plan for the development of the European electricity transmission system (TYNDP[82]). Nationally, each transmission system operator draws up its ten-year network development plan (TYNDP), which must be consistent with the plan developed by the ENTSO-E. It is based on existing supply and demand and on reasonable medium-term assumptions of changes in electricity generation, consumption and cross-border grid trade. It describes the primary transmission infrastructures to be constructed or significantly modified over the 10-year period, lists the investments already decided on and the new investments to be made within three years, with a timetable for all the investment projects. Each year, the 10-year plan

82 Ten-Year Network Development Plan; See http://tyndp.entsoe.eu/

is updated and submitted for consideration by the Energy Regulatory Commission, which may require changes.

Continuing the development of interconnections

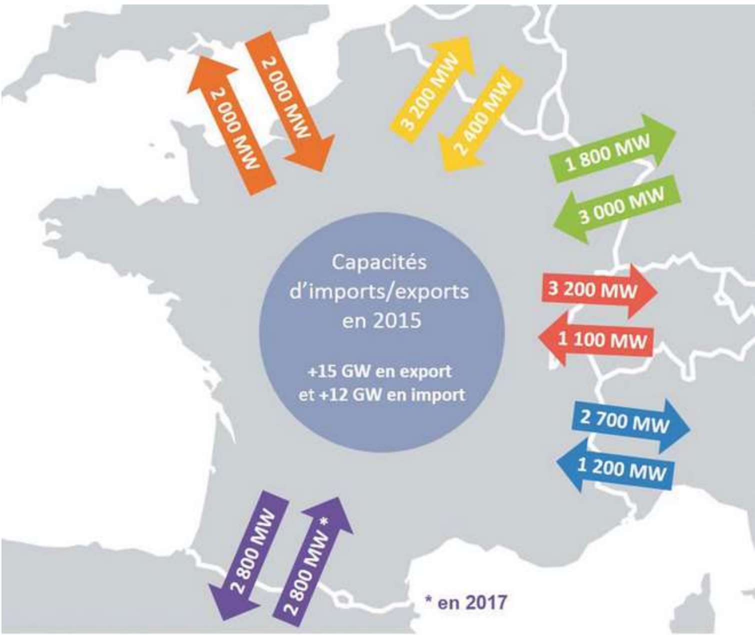
The construction of cross-border interconnections has historically been a response to a supply security rationale and enables the export use of French electricity generation surpluses, especially at night and in summer.

Interconnections also offer the possibility of importing electricity from a neighbouring country in the event of a strain on domestic supply, which is an economically efficient solution. Interconnections mean that France does not need to invest in additional capacity to ensure its supply security, and to facilitate the pooling of production investments with neighbouring countries. Cross-border exchanges thus make it possible to have capacity available abroad, with an average contribution of between 8 and 10 GW. In the short term, the planned developments will lead to an increase in import capacity from 11 GW for winter 2016–2017 to 13 GW for winter 2020–2021.

With a total of 48 interconnection lines and 12 additional projects by 2030, including three under construction, France is very well interconnected with its neighbours. In 2019, France's total interconnection capacity was 17.4 GW in exports and 12.5 GW in imports, representing an interconnection rate of around 11.4%. The capacities actually used on average are lower (around 8 to 10 GW), because of the characteristics of the interconnection lines, their availability and the internal constraints on the power grids of each country. By 2030, this is expected to exceed 26 GW of interconnections, reaching at least 16.5%.

The French public power transmission system is currently interconnected with six countries (Great Britain, Belgium, Germany, Italy, Spain and Switzerland), as the following figure illustrates.

Figure 75: Interconnection capacities in 2017



Capacités d'imports/exports en 2015	Import/export capacities in 2015
+15 GW en export et + 12GW en import	+15 GW exports and +12 GW imports

en 2017	in 2017

The construction of cross-border interconnections has historically been a response to a supply security rationale and enables the export use of French electricity generation surpluses, especially at night and in summer. Interconnections also offer the possibility of importing electricity from a neighbouring country in the event of a strain on domestic supply, which is an economically efficient solution at European level, especially during periods of peak consumption.

Interconnections enable bulking of the geographical risks between countries, and this is all the more effective where the specific attributes of each country reduce the correlations of the risks and mitigate the consequences of the occurrence of national tensions. The primary risk uncertainty in France today is the temperature-sensitive nature of demand, and this will continue to be the case over the MEP period; the risk associated with the intermittent nature of renewable energies is currently the major concern in countries with the greatest penetration rate for these renewable energies (Denmark, Germany); the risk associated with hydropower production is dominant in countries where it has a major generation role (Norway, Switzerland, Portugal). Interconnections avoid the need for France to invest in additional capacity to ensure its supply security.

Finally, the development of interconnections facilitates the integration of the European electricity market; it allows neighbouring countries to access electricity at the lowest cost by taking advantage of the complementary nature of their generation mix.

The 10-year development plan for the power transmission system drawn up by RTE in 2019 provides for a doubling of the exchange capacity by 2035 (up to 8 GW by 2025) to reach a capacity of around 30 GW. These figures are consistent with the scenarios in the 2017 RTE forecast report: two of these assume an import capacity of 27 GW and an export capacity of 33 GW to ensure that the system is balanced by 2035.

Given the flexibility challenges of the French and European electricity system, it seems essential to continue work on the development of the interconnections identified in RTE's 10-year network development plan, and to study the appropriateness of developing new interconnections on the basis of a cost-benefit and project acceptability analysis.

Major investment guidelines

The transmission system currently faces a number of trends. The stabilisation observed in consumption nationally masks significant disparities between regions, related in particular to demographic changes; the development of renewable energies is also highly variable locally, in particular in respect of weather patterns. The change in the geographic distribution of generation units caused by the transformation of the electricity mix results in a modification of flows through the grid, which plays an increasing back-up and solidarity role between territories, in particular through an expected reinforcement of flows on very-high-voltage lines, up to 400,000 V. As a consequence, the transmission system is key to enabling the integration of large quantities of variable-generation renewables, leading to uncertainties associated with more volatile instantaneous power, in France and in Europe, and the need to manage variations in consumption.

To address these issues and allow the change of mix planned by the MEP, RTE presented a strategy for the transformation of the grid in 2020–2035 in September 2019 as part of its 10-year plan. The Minister of Ecological and Inclusive Transition wrote to RTE on 13 November 2019 to approve this strategy, which sets out French energy policy in operational terms. She also asked for the use of capping of renewable energies to be minimal and covered by a specific regulatory framework.

To successfully implement this grid adaptation strategy, transmission system investments in the next 10 years are estimated as an average of €2 billion per year, of which €500 million is for the connection of the new offshore wind farms.

In its 10-year plan, RTE anticipates a need to create and upgrade about 560 km of infrastructures per year between 2021 and 2035, of which around 350 km would be structural adaptations to networks, essentially on the sub-transmission system and underground systems. This involves the upgrading of the old grid, interconnections and the connection of renewables. With major strengthening, the grid can accommodate up to 50 GW of additional renewable installed power (solar and wind farms), on condition that options to provide flexibility are implemented. This threshold will be reached in 2025: after that, more structural reinforcements will be necessary, through reinforcement of certain historical north-south axes. The grid should be able to accommodate 10 to 15 GW of offshore renewable generation capacity by 2035.

The grid transformation strategy presented by RTE in September 2019 is based on the use of flexible solutions that make it possible to limit infrastructure investments wherever possible, through the improvement of digital solutions to optimise electricity flows, participation in the implementation of contractual or market solutions such as the 'Flow-Based' mechanism for increasing exchange capacity at the borders, or incentives to change behaviours.

This results in an investment trajectory of around €2 billion per year between 2021 and 2025, which means a significant increase in costs linked to the connection of offshore wind projects, an increase in grid upgrade costs (€500 million per year) and more contained adaptation costs (€200 million per year) because of grid digitisation investments (€250 million per year) and increased maintenance costs (+€25 million per year). This makes it possible to extend the life of the infrastructures and push back certain grid adaptation investments beyond 2025 and particularly 2030, without degrading the operation of the electrical system.

The increased grid costs support the implementation of energy transition over the 2021–2035 period. The share of costs in the electricity transmission system remains around 10% of the total annualised costs of the electrical system. Seen in terms of generation (+92 GW of renewable energy), the cost associated with the adaptation of the grid to accommodate renewable energies remains limited up to 2035. Orders of magnitude can be specified for land-based renewable energy, with the costs of adapting the grid representing €3 to €4/MWh (for a cost per MWh between €58 and €64, which should continue to fall until 2035) and of €10 to €20/MWh for offshore wind, depending on the proximity of the existing grid (for a cost of €44/MWh for the most recent tender).

The purpose of digitising the grids is to replace the monitoring and control systems in electrical substations, which have historically been electromechanical, with digital systems to enable better collection of information in real time and improve the coordination of the system. The work of the system operators obviously involves essential research efforts in cybersecurity. This work is carried out under the supervision of the Network and Information Security Agency (ANSSI). System operators also have access to specific telecommunications infrastructures, which are intended to be expanded for this reason.

Public power distribution systems

Major investment guidelines

The development of renewable energies and new electricity uses, including electric vehicles, require that the structure and management of low- and medium-voltage distribution systems be rethought.

Distribution grids were initially designed exclusively as top-down structures, i.e. to route electricity to consumption areas. Nowadays, they accommodate the bulk of new renewable energy installations, creating a need for modernisation procedures to facilitate the two-way operation of the grids.

Moreover, the development of decentralised generation, especially in low consumption areas, may require the creation or reinforcement of grid structures. In this respect, the location of decentralised generation facilities and the size of the installations in relation to the grid's reception capacities are decisive in terms of connection costs.

Regarding the integration of electric vehicles, the deployment of recharging infrastructures open to the public should see an exponential acceleration. Investments depend in particular on the nature of the terminals installed (fast or slow recharging), which create more or fewer constraints on the grid.

For these two goals – the connection of renewable energies and the connection of recharging infrastructures for electric vehicles – the attainment of the objectives set in this MEP could involve an increase in annual dedicated investments by Enedis from nearly €350 million in 2019 to more than €900 million in 2028.

These amounts should be viewed in the light of the total investment by Enedis in the distribution system (€3.335 billion planned in 2019, in addition to the deployment of the Linky meter, which falls under a separate investment framework). Generally speaking, after a period of lower investment in grid upgrade works, resulting in particular in an overall ageing of the infrastructures and worsening of the average interruption time, Enedis commenced a new investment cycle several years ago. Projected investment amounts under the Enedis TURPE 5 (excluding Linky) for 2020 are €3.461 billion, up 5.8% compared to 2018 (€3.269 billion).

Local authorities, concessionary authorities and grid owners also invest around €800 to €900 million each year in the distribution grids, in particular using the resources provided by the TCCFE (final electricity consumption tax) and indirectly by TURPE through the local authority rural electrification support fund (CAS Facé) or fees linked to concessions.

Over the 2020–2023 period, investment requirements in electricity distribution systems will continue to grow, to continue the upgrading of existing grids and to adapt to the new sources of generation and consumption described above.

The priority programmes include ensuring the security and reliability of substations in dense urban areas, extending the service life of overhead medium-voltage lines in rural areas and upgrading dilapidated underground cables in metropolitan areas. Investments have historically focused on medium voltage (MV), which constitutes the 'backbone' of the distribution system, but must also be developed on the electrical equipment of distribution stations and the low-voltage (LV) system located downstream of these stations, which serves the bulk of consumers, in order to limit ageing and eradicate technologies that could cause incidents, especially bare wires. Improving the grid's resilience in relation to climatic uncertainties (especially heatwaves and floods) is another significant objective, specifically targeted by the National Climate Change Adaptation Plan (PNACC).

Investment planning and governance at national level

In view of this growth in investments in the distribution system and the strategic nature of that grid for the integration of renewable energies and the development of new electrical uses, effective coordination and clear governance are essential in the coming years to ensure good investment management.

While investments in distribution systems are still driven by the specific aspects of local situations (the emergence of grid constraints due to the development of consumption or generation, cable ageing, etc.), governance at national level must make it possible to ensure that investments are consistent and must guarantee a geographical balance.

The NOME law in 2010 established the Départemental Conferences, annual meetings under the aegis of the prefects to present the investment programmes of the various public power distribution system stakeholders, distribution system operators and organising authorities in each department.

The Public Electricity Distribution System Committee (CSDPE), created by the Law on Energy Transition for Green Growth , started operating in 2017. It is responsible for reviewing Enedis' investment policy and those of the authorities organising electricity distribution and local electricity distribution undertakings, relying in particular on the summaries of work provided by the Départemental Conferences to ensure coordination between national and local investment policies and to assess their relevance. Improving the visibility of the full range of investments and of the detailed report on the distribution grids at local level is a key issue for this coordination role and for the formulation of proposals for guidelines on investment policies[83].

European cooperation

European cooperation on supply security is implemented in France primarily through participation in the Pentalateral Energy Forum (or Pentaforum) – a regional initiative launched in 2005 to streamline electricity exchanges through the better operation of electricity interconnections and, generally, more efficient coordination of electricity supply security. This initiative has proved to be a priority framework for cooperation among its seven member countries (Austria, Belgium, France, Germany, Luxembourg, the Netherlands and Switzerland) through effective dialogue and good coordination between governments, system operators and regulators in the participating countries.

Since 2015, the Forum has contributed to:

- the production of two studies evaluating the supply-demand balance of the electrical system for the Pentaforum network, based on shared hypotheses and a common methodology (probabilistic and hour-by-hour model, similar to the RTE forecast report);
- performance of an electricity crisis coordination drill with all stakeholders in each Pentaforum country; this exercise is part of the sharing of best practices for the implementation of the European regulations in force and in the process of development;
- implementation of flow-based market coupling in the Centre-West region of Europe, marking a new stage in the integration of European electricity systems. By using a more detailed description of the grid to optimise exchanges, the flow-based method significantly improves the convergence of day-ahead prices while maintaining a high level of grid security. This not only reduces generation costs in the countries concerned, but also helps to improve supply security.

83. The local aspects of management of these investments is covered in Chapter 7 on Local Involvement.

In the future, the Pentaforum's work will focus on issues of flexibility, integration of intraday markets, and the explicit inclusion of foreign capacities in capacity mechanisms.

Discussions are also taking place with the Iberian Peninsula administrations on these subjects in the context of the High-Level Group created following the Madrid Declaration in 2015. Cooperation within this group has made it possible, in particular, to make significant progress on the 'Bay of Biscay' interconnection project between France and Spain.

Finally, Regulation (EC) No 714/2009 provides for the development of grid codes, which has led to the drafting of a European regulation on emergency situations and the restoration of the electrical system. This text has entered into force and shall apply from December 2018. In particular, it will enable the harmonised technical management of electricity crises at European level. A second grid code, established based on a guideline for the operation of the electrical system, enables a harmonised approach to the running of the transmission systems under normal operation and in stress situations (cold snaps, for example).

4.5.1.1. Smart grids

The term 'smart grids' encompasses all technical solutions, often based on new information and communication technologies, that enable grids to adapt and promote the major ongoing developments in the electrical system: insertion of variable renewable energies and development of new uses of electricity, including electric mobility and self-consumption.

Expected benefits

Smart grid technologies benefit all stakeholders in the electrical system.

They promote a reinforcement of the role of consumers by enabling them to participate in the optimal operation of the system, particularly through the development of self-consumption, curtailment of consumption and smart recharging.

They enable system operators to optimise their operations: in particular through a better understanding of the constraints and the possibility of remote operation of numerous grid elements, they can run the grid close to its limits, make it more resilient to uncertainties (for example through auto-backup) and avoid expensive investments. Flow optimisation also makes it possible to mitigate grid losses, which currently account for 8% of power consumption.

Smart grid solutions also foster the optimisation of generation installations in order to avoid the need to invest in new fossil-based power generation capacity, enabling management of renewable energy generation where this is possible, and promoting new sources of flexibility through storage.

Economic significance

In-depth studies on the longer-term socioeconomic significance of the various smart grid solutions have been conducted by the system operators with ADEME. These studies concluded that all smart grid solutions identified by system operators by 2030 are economically significant[84], with net benefits expected to be around €400 million per year for the community and a particularly positive impact resulting from the development of storage and from curtailment of industrial and 'major tertiary' actors.

84 See in particular 'Socioeconomic benefit of smart grids', ADEef, ADEME, Enedis and RTE, July 2017, which can be downloaded from http://www.enedis.fr/la-valorisation-economique-des-smart-grids.

It should be noted that the economic benefits of many smart grid technologies are closely linked to the regulatory framework and its ability to provide an economic manifestation of the services actually rendered to the electricity system.

Considerable technical challenges

The main technical issues in the field of smart grids are:

- **'System services' associated with frequency and voltage adjustment, which are essential to the stability of the electricity system, are currently provided to a large extent by the major thermal-based generation installations (nuclear, fossil-fired).**
- The storage of electricity can meet very varied needs in contributing to the efficient operation of the system: storage of power to meet almost instantaneous balancing needs, intraday storage intended to smooth a consumption or generation load curve, or longer-term storage of up to a few months to adapt to seasonal differences in generation and consumption patterns. Multiple technologies are available (batteries, hydrogen, flywheels, pump stations, etc.) and developments must continue to find the optimal technical/economic options.
- The management of electric vehicle recharging represents a major challenge in reducing the impact on grids and management of the supply-demand balance. Vehicle-to-Grid (VtG) solutions will make it possible to inject electricity stored in vehicle batteries into the grid.
- Many smart grid components rely on the development of software and telecommunications solutions that make it possible to obtain real-time information on the status of the grid and its constraints, to process the data produced effectively and to act remotely on the various parts of the grid, in a manner that is economically efficient, to make data available to the market actors. Because electricity grids are a vital infrastructure, particular attention must be paid to cybersecurity, because the increased number of grid entry points and information exchanges could increase their vulnerability.

Smart grid solutions require the involvement of many types of actors: electricity suppliers, balancing managers, aggregators, suppliers of technical equipment for the grid or for metering, energy solution integrators, software solution providers, telecom operators, car manufacturers, etc. Raising the awareness of each category to the operations and constraints of others is a major challenge in enabling the optimal development of these solutions.

Encouraging the development of smart grids

The development of smart grids in recent years has been structured around the implementation of the 'smart grids' plan, published in 2014 as part of the New Industrial France campaign. This plan aims to consolidate the French electricity and IT sectors in new high-growth and job-creating markets. Public support has played a critical role in enabling innovation in the development of smart grid solutions. Many trials have been launched in France over the last several years. As part of the future investment programme operated by ADEME, more than €120 million in funds invested since 2011 have resulted in about 20 demonstrators being implemented. These demonstrators promote the grouping of actors with complementary expertise (system operators, manufacturers, SMEs/SMIs, start-ups, laboratories, local authorities, etc.), which accelerates the development of new technologies and new business models. Smart grid solutions tested under real-life conditions have involved, in particular, the insertion of renewable energies into the grids, the development of technological components for modernisation of grid operation, and energy demand management[85].

Research is also encouraged, for example with the SuperGrid Institute for Energy Transition (ITE), a collaborative research platform that brings together the skills of industry and public research in a public-private joint investment arrangement. The programme aims to develop new technologies for electricity transmission systems, in particular high-voltage direct current (HVDC). SuperGrid receives public financial support (Government and local authorities) of more than €80 million.

All of these mechanisms aim to promote the development of the sector in order to enable it to benefit as quickly as possible from smart grid technologies, in France but also internationally.

The economic significance of smart grid solutions depends largely on the local context: regulatory framework, intermittent energy penetration rate, electricity price, level of grid interconnection with foreign countries, etc.

At institutional level, France is also very active in European and international bodies addressing smart grid themes, for example within the working groups of the International Energy Agency or the Mission Innovation initiative, set up during COP21 in Paris. The discussions in these forums make it possible to leverage the expertise developed in France and to benefit from the expertise of other countries.

Data: the key issue

The deployment of smart grid technologies is made possible by, and is accompanied by, the production of more and more data on the status of the grid and on consumption and generation, for increasingly detailed (granular) geographical levels and time intervals. These data open up new prospects for energy transition in terms of local governance of grids, especially in relation to multi-fluid planning (electricity, gas, district heating systems):

- For consumers, understanding and interpreting smart meter data, which is more accurate and easily available, can support action to control energy consumption.
- In terms of grid operation, the data make it possible to use the infrastructures at their maximum capacity and optimise investments.

Internet tools are being rolled out to enable project developers to measure the grid impact of the connection of renewable electricity generation facilities or electric vehicle recharging infrastructures, notably by Enedis; they constitute a real breakthrough.

Moreover, more and more data on annual consumption on a more detailed geographical level – making it possible to maintain data confidentiality where necessary – or on local consumption profiles are made available to everybody on open data portals. They facilitate the development of local public energy transition policies and will enable the effectiveness of these policies to be monitored and evaluated.

Given the proliferation of data that will be provided by smart grids, discussions between stakeholders, suppliers and data users must continue, to achieve a data governance approach that is satisfactory for everyone and serves energy transition. Ensuring the greatest possible clarity on the rules for sharing, use and protection of data is a major issue.

85. The regional programmes Flexgrid, SMILE and You&Grid are discussed in Chapter 7 on Local Involvement.

In particular, the tasks of managers of public electricity grids will evolve with the proliferation of the data for which they are responsible. There is a need to ensure that all actors within the electricity system can have access to relevant data in a simple, transparent and secure manner.

The smart meter: a major asset

The deployment of Linky smart meters began on 1 December 2015 and will continue until 2021. More than 23 million meters have already been installed.

The investment of around €5 billion is supported by distribution system operators through the TURPE. The roll-out involves a first capital-intensive phase at the start of the project (from 2014 to 2021), followed by a second phase of ROI. The business model for the meter is balanced over its 20-year service life, i.e. the gains offset the costs of deployment, thus entailing a neutral long-term effect on tariffs.

Smart meters offer two key innovations over existing meters:

- a much finer (more detailed) measurement of consumption and information on the quality of the electricity supplied;
- two-way communication: the meters can send information and receive instructions using power line communication technology.

Smart meters play a fundamental role in grid modernisation by making it possible for system operators to significantly increase the observability of the low-voltage grid, in particular through more detailed (granular) monitoring of the level of voltage on the low-voltage network, and faster detection of consumption faults and anomalies.

The meters promote the emergence of consumer control services, which they will support. They also support the deployment of new pricing mechanisms, which enable greater transparency on the costs of the electricity system and encourage the right incentives, in terms of transmission tariffs (TURPE) or deals offered by electricity suppliers. Because consumers are able to exercise greater control over their consumption, they will be participating in the optimisation of the power grid and the means of production.

4.5.1.2. The development of flexibility of electricity demand: curtailment

New uses of electricity and their impact on the consumption profile

The uses of electricity are constantly changing, especially for individuals, with the continuous development of new electrical and electronic equipment for comfort and leisure and changing HVAC needs. Furthermore, the target of achieving carbon neutrality by 2050 is encouraging the transfer of certain uses to electricity in transport and in industry. In particular, the development of electric mobility could have a major impact on the electrical system depending on the recharging management strategy adopted. It is therefore essential to develop solutions for optimising the charging of electric vehicles (regulatory, economic, tariffs, etc.) in order to smooth consumption and limit impacts on the grid and the electrical system.

Curtailment of consumption: a useful lever of flexibility for the electric system

The Energy Code defines electricity consumption curtailment as the action intended to obtain, from a particular consumer and upon request, a temporary reduction of the level of electricity taken off electricity transmission or distribution systems, compared to a forecast schedule of consumption or estimated consumption.

Curtailments help to balance the entire electrical system in real-time, by using short mobilisation delays. Curtailments are intended to replace peak production resources such as thermal power plants during peak winter consumption periods. They can also help limit the need for grid reinforcement and related costs. Consumption curtailments can be achieved in two ways:

- *Consumers are encouraged by their suppliers to reduce consumption* during peak periods by a higher price as part of their supply contract: in this case, the Energy Code refers to curtailment that is inseparable from supply.

Historically, this type of offer has played an important role, because of the existence of certain pricing options in regulated sales tariffs built on this principle, such as 'peak day curtailment' rates (EJP) or TEMPO rates. The phasing-out of certain tariffs (*EJP bleu* tariff since 1998 and *Tempo bleu professionnel* from 2004), as well as the end of the yellow and green regulated sales tariffs on 1 January 2016, has led to a marked reduction in the volume of these curtailments, which is now below one gigawatt, despite efforts made to promote the development of this type of demand management and, in particular, opening the TEMPO signal up to competition in 2014. This downward trend should change direction and will be reversed in the coming years through the gradual deployment of Linky meters by 2021, which will enable energy suppliers to offer deals based on the features offered by this meter differentiated according to time, day and season, including the incorporation of mobile peaks. This possibility of offering differentiated deals is further reinforced by the integration into TURPE 5 of hourly/seasonal slots and even, for certain voltage levels, a mobile peak signal, as provided for business customers with medium-voltage connections.

- *Alternatively, the consumer's supply is curtailed through the action of a curtailment operator*, which offers a service that is separable from a supply offer.

Recent years have also been marked by a growth in curtailment volumes activated by curtailment operators, economic actors whose added value is to aggregate curtailment capacities at end customers (industrial, tertiary or diffuse) and to use these curtailment capacities over the different time periods of the electricity markets. The aggregation allows for a bulking of capacities and economic optimisation by the operators, which can thus develop innovative solutions to meet the energy and capacity needs of the electrical system.

Different types of consumers and electrical uses among these consumers can, in practice, be curtailed. In private homes ('diffuse' curtailment), curtailment of electricity consumption mainly affects electric heating, domestic hot water, or the charging of an electric vehicle. For commercial, industrial or tertiary consumers, curtailment is achieved in particular by interrupting a manufacturing process, shutting down refrigeration systems in tertiary warehouses, or using a local method of electricity generation (generator) in place of extraction from the public power grid.

The consumption curtailments estimation framework

In order to encourage the development of curtailment capacity, France has undertaken an in-depth reform of its electricity market with the aim of opening up all market mechanisms to curtailment, so that they can participate in the same way as power generation facilities.

Industrial curtailments (since 2003) and diffuse curtailments (since 2007) can participate in the adjustment mechanism operated by RTE, which is intended to ensure real-time supply-demand balancing and secure grid operation. In 2018, about 22.3 GWh of curtailment was activated using the adjustment mechanism, for an average capacity of 727 MW deposited on that mechanism.

Curtailments can also participate in the various reserves contracted by RTE for balancing the system[86]:

- Participation in system services ('primary' and 'secondary' reserves) for sites connected to the transmission system since the launch of a trial on 1 July 2014. In 2018, the primary reserve had about 140 MW of curtailment (almost 10%, with a 12% average level and 20% peaks in late 2018).
- Participation in rapid and complementary reserves since 2011, with a gradual increase in opening, which has made it possible to reach a curtailment capacity participation of 530 MW on average in rapid reserves (about 50% of the contracted rapid reserve) and 45 MW in complementary reserves in 2018.

Since 1 January 2014, curtailments can also be exchanged between market players in the energy market via the 'NEBEF' mechanism. Thus, for an electricity supplier, the purchase of 1 MWh of electricity generated and 1 MWh of curtailed electricity is strictly equivalent. In 2018, nearly 27 GWh of curtailment was exchanged via this mechanism.

Finally, curtailments can participate in the capacity mechanism, which has been operational since 1 January 2017.

In addition to these market mechanisms, the Law on Energy Transition for Green Growth has also introduced the possibility of calls for tenders to develop France's current curtailment capacity, in order to meet the objectives set in the MEP for the development of flexibilities. The implementation of this system required prior validation of the scheme by the European Commission, under the State aid regime; this involved an approval procedure during which the Commission asked for competitive criteria to be put in place to ensure the competitiveness of the calls for tenders and the proportionality of the support provided to the sector. The system was formally approved on 7 February 2018 for a period of six years, until 31 December 2023. This approval has made it possible to secure the completion of annual calls for tender, with the volume targets for each year detailed below.

Target trajectory (in MW)	**Annual volume of curtailment tenders**	**Including category > 1 MW**	**Including category < 1 MW**
2018	2200	1900	300
2019	2500	2000	500
2020	2900	2100	800
2021	2000	1000	1000
2022	1800	500	1300

86 To ensure the success of its system balancing tasks and guarantee its security, RTE ensures that it provides sufficient flexibility reserves at all times, to balance grid injections and extractions. Some of these reserves (rapid and complementary reserves) are mobilised through the adjustment mechanism. Each of these reserves is subject to contracts entered into by RTE and agents that are then paid to make the capacities in question available (irrespective of potential demand).

Target trajectory (in MW)	Annual volume of curtailment tenders	Including category > 1 MW	Including category < 1 MW
2023	2000	500	1500

Target volumes for each call for tenders

In total, for the year 2019, the volume of curtailment capacity available to ensure supply security during peak periods can be estimated as 2,900 MW. This corresponds to about 2,300 MW of certified curtailment capacity on the capacity mechanism, plus about 600 MW of curtailment performed by suppliers.

Current curtailment pool and outlook for development of the sector

The figure of 2,900 MW of curtailment capacity existing in France should be viewed in terms of the resources that it is technically possible to develop and economically important to establish. This achievable pool depends on several factors, in particular future changes in the electricity mix, the costs of deploying the new curtailment capacity, and the value that the community is willing to devote to support the development of this activity.

Since the previous MEP exercise, several studies – published in 2017 – have been conducted to assess curtailment development prospects in France:

- the study by ADEME,[87] which specifically addressed industrial and tertiary curtailments;
- the study by RTE[88] which, continuing the initial works on smart grids from 2015, proposed to establish appropriate development targets for the various curtailment sectors (diffuse, tertiary and industrial) up to 2030.

These works lead to the following observations:

- the value of curtailments is largely capacity-related (according to ADEME, 95% of the revenues for the sector are capacity-related);
- the continued diversification of the electricity mix should reinforce development opportunities for the sector.

In view of the results of the ADEME and RTE studies, the figure of 5 GW of industrial and tertiary curtailment capacity (including interruptible capacity) represents a high threshold: according to ADEME, this amount represents the upper range of the economically achievable pool with a remuneration of €60 K/MW[89], and is confirmed by RTE's estimates to 2030[90]. Still based on the analyses from the transmission system operator, at present, the economically relevant pool would be close to 3 GW. For diffuse curtailment, by 2030, the RTE study envisages a potential:

- of 300,000 households, large consumers, equipped with real-time consumption management devices;

87. Electrical curtailment in France – Evaluation of curtailment potential by process modulation in industry and tertiary in Metropolitan France, ADEME, 2017.

88. Smart grids: Economic, environmental and overall deployment value, RTE, June 2017.

89. Pool for the 'high' scenario, with remuneration of €60 K/MW.

90. See the conclusions of the above-mentioned RTE study on the development outlook for industrial and tertiary curtailment capacities to 2030.

- coordination of different uses – including heating – using smart meters: with 7 million households for management of hot water, 5 million for the management of electric vehicles and 700,000 for heating.

In view of these elements, a diffuse curtailment potential of around 1.5 GW by 2030 seems consistent. In total, there is therefore a target of 6.5 GW of curtailment capacity – unchanged from the previous MEP – by 2028. Reaching this target will nevertheless depend on changing costs in the sector during the time frame and the level of demand that the system will face for new capacity.

However, it is proposed that a more gradual approach be applied for the interim milestone target for 2023, with this being lowered to 4.5 GW in order to set a smooth growth trajectory for the sector towards this target by 2028.

This rephasing in achieving the target set for 2028 – which does not jeopardise the role that the sector will need to play in the long-term – can be explained by the following:

- an initially optimistic view of the need for new capacities, which, because it has not materialised, has not made it possible to support the economic development of curtailment at the pace anticipated in the first MEP;

- an issue of technical consolidation and enhancement of the reliability of the sector, which has led to the elimination of a certain volume of capacity formerly offered by curtailment operators, on the basis that they did not meet legitimately expected reliability standards[91];

- an issue of changing the support framework for curtailment, in order to best meet the expectations of the industry.

The framework through which the curtailment call for tenders is undertaken is the result of negotiations with the EC competition authorities; they required the implementation of measures to ensure the competitiveness of the call for tenders and the proportionality of the public support provided to the sector.

Adjustments to this framework could be envisaged to take account of the results of the first calls for tenders. To that end, several complementary initiatives have been launched and are now under way in the realm of curtailment, including the following in particular:

- A project led by Philippe Van de Maele on the development of consumption curtailment and energy-saving measures in the residential sector.
- A discussion led by DGEC, ADEME, CRE, RTE and Enedis, informed in large part by a summer 2019 dialogue regarding curtailment, which seeks to analyse the relevance of the regulatory framework and existing support mechanisms in relation to the development objectives laid down in the MEP. Where applicable, it also aims to make proposals for additional measures to promote the achievement of these objectives.

The year 2020 will be an opportunity to implement the complementary recommendations from these various initiatives. Proposed adjustments should be compatible with EU law on State aid, which may, in some cases, involve discussions with European Commission departments.
These adjustments should be compatible with EU law on State aid, which may, in some cases, involve discussions with European Commission departments.

91. Presentation on consumption curtailments for the CURTE market access commission, organised on 27 January.

4.5.1.3. Electricity storage

Electricity storage provides a response to the issues associated with the variability of generation and consumption. Storage makes it possible to flatten production peaks and transfer energy to consumption peaks at different timescales (ranging from a few seconds or minutes to several months or even years depending on the technologies). The storage of energy is therefore a complementary solution to curtailments and to the deployment of smart grids to increase the share of renewable energies.

The services rendered by storage for the electrical system are of different types:

- Electricity generation: optimisation of generation (e.g. smoothing, load monitoring, shifting of generation, market arbitrage).
- Electricity transmission and distribution: participation in system services according to grid codes, arbitrage with the construction of new lines, optimisation of grid management, voltage control and distribution security.
- Consumption: decrease in peak consumption, continuity of supply, self-consumption or even energy autonomy at isolated sites.

At present, the law does not set any target for electricity storage.

State of play for technologies

There are currently a large number of electricity storage technologies, each with various costs, maturity levels and technical characteristics in terms of power, energy, response time and charge-discharge interval times and different energy densities targeting centralised, distributed or diffuse storage markets. By providing responses for different services, technologies offer a certain degree of complementarity. Energy storage solutions fall into three main categories:

'Mechanical' storage:

- facilities using potential mechanical energy such as pumped-energy transfer stations (STEPs), hydroelectric dams, and compressed air energy storage (CAES), which are more centralised storage technologies capable of returning electricity for periods ranging from days to weeks;
- facilities using kinetic mechanical energy such as flywheels, which are very short-term storage solutions.

'Electrochemical' storage:

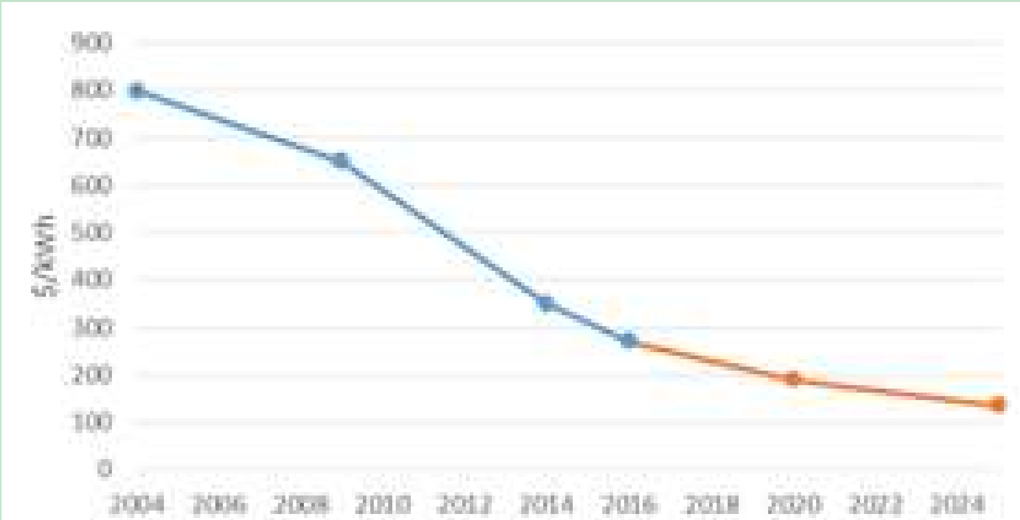
- batteries, cells and capacitors are decentralised or diffuse storage technologies that are more suited to very short-term storage (a few seconds or minutes) or short-term storage (a day, for example);
- the hydrogen produced by electrolysis is considered a means of inter-seasonal storage through power-to-gas, although electrolysers are also able to operate quickly on demand.

'Thermal' storage:

Through latent or sensitive heat (e.g. hot water tanks) for one day or several days' storage.

Currently, no electricity storage technology is able to cover all of these services at the same time, and the services provided may also depend on the position of the facility on the power grids.

Box 10: Changes in the price of Li-ion batteries between 2004 and 2016 and perspective towards 2025



Source: BNEF, DGEC

State of play of storage in France

Pumped-energy transfer stations (STEPs) and hydroelectric dams are currently the major large-scale storage solutions in France (4.3 GW STEPs and 13 GW hydro with reservoir). It is estimated that there is still potential of around 2 GW in Metropolitan France for this technology. STEPs today are still the only 'economically competitive' means of storage, although it is not possible under current market conditions to achieve a return on a new investment without short-term grants. There is a further 13 to 20 TWh of thermal storage in hot water tanks.

Development prospects

In electricity mixes with a large share of variable renewable energies, different types of storage are necessary to ensure the supply-demand balance, for example:

- In the very short-term, means capable of reacting very quickly, such as batteries, flywheels or super-capacitors, are useful to compensate for a possible drop in frequency, and even faster where the system has less inertia through increased development of photovoltaic or wind power.
- Short-term (day-to-day) means such as batteries or STEPs make it possible to manage the evening peak, for example by using any surplus solar production from midday during peaks.
- Longer-term (weekly to inter-seasonal) means will make it possible to mitigate, for example, several days without wind or without sun. This is therefore a need for 'long-term' storage systems that can be met by STEPs and by other storage technologies such as hydrogen, compressed air energy storage and certain forms of thermal storage.

The needs of each of these types of storage are intrinsically linked to the electricity mix planned for Metropolitan France, but also to those of our European neighbours.

By 2028, over the time frame of the MEP, with the expected penetration of renewable energies and the changes to the electricity mix determined by this MEP, there will be no additional storage needs to ensure the supply-demand balance. The electrical system in Metropolitan France, which is integrated into the European electricity system, already has enough resilience.

This will remain the case until 2035 in the Volt and Ampere scenarios presented by RTE in its 2017 forecast report:

- In the Volt scenario (40% renewable energy and 56% nuclear in 2035, i.e. 55 GW), the flexibilities on consumption are sufficient to meet the flexibility needs of the electricity system. The characteristics of the system as laid down by RTE do not make it possible to make a return on investments in additional storage assets.

- In the Ampere scenario (50% renewables and 46% nuclear power in 2035, i.e. 48.5 GW), the need for new flexibilities is also low to 2035 and can likewise be provided by curtailment. Storage remains a less competitive solution over this time frame.

RTE's analyses indicate, however, that this lack of a need for new flexibility depends on the controllable capabilities installed in France, particularly nuclear.

In a variant of the Ampere scenario ('Ampere +'), in which nuclear installations are replaced more rapidly by renewable energies beneath the 50% threshold and reach 38.5 GW in 2035, additional flexibility will be needed. RTE therefore considers the following flexibilities: +3.5 GW of curtailment, +2 GW of new STEPs and +2 GW of battery storage, based on a process of cumulative flexibilities rather than competition between them.

The development of renewable energies coupled with the eventual decommissioning of the existing nuclear installations may therefore require new flexibility requirements beyond the MEP time frame to ensure the supply-demand balance of the electricity system. Given the time needed to launch certain investments or to develop certain sectors, steps must be taken during the MEP time frame.

With regard to STEPs, the decisions on implementing these projects need to be brought forward, in view of the duration of the procedures and the work to be undertaken (nearly 10 years) and insofar as these decisions must be incorporated into the concession award procedures. Development potential of 1.5 GW of STEPs has already been identified and could be developed as part of the reopening of hydroelectric concessions to be awarded before 2025. It would seem useful to develop this in view of the expected daily and weekly needs of the electricity system from 2030 to 2035.

Moreover, in addition to hydrogen, several uses already involve the development of battery storage by 2028, linked to the rapid drop observed in the cost of this technology (see graph below):

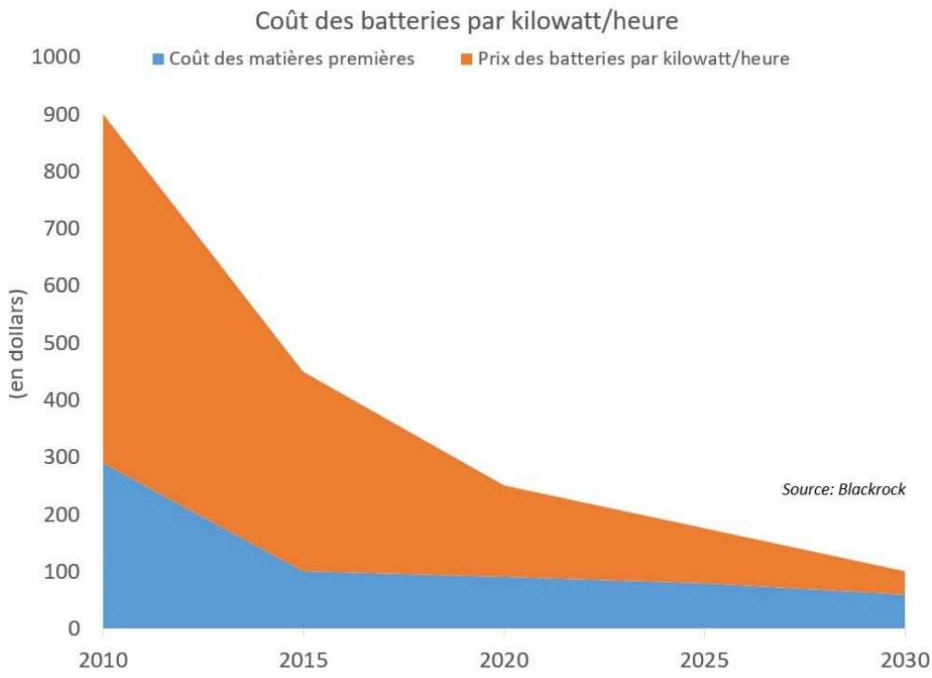
- battery usage could be considered to provide system services (e.g. primary and secondary frequency adjustment, as batteries have very fast response times). However, the accessible market potential remains limited (competition with generation and curtailment, total reserves of less than 2 GW);

- development of batteries can also be expected by private consumers, in connection with the development of self-consumption, in order to maximise self-consumption rates;

- the development of electric vehicles will also spread batteries throughout the country, so new associated flexibility services can be tested: this is the idea of 'vehicle-to-grid', in which the vehicle's battery is used as a means of flexibility (charging or discharging) when the vehicle is connected to the recharging point;

- finally, storage could also make it possible to avoid or defer investments for grid reinforcement in order to avoid local congestion when renewable energies are generating at the same time in grid-constrained areas, thus avoiding the need to cap them.

Figure 76: Cost of batteries per kilowatt/hour – Source: Blackrock



Coût des batteries par kilowatt/heure	Cost of batteries per kilowatt/hour
Coût des matières premières	Cost of raw materials
Prix des batteries par kilowatt/heure	Price of batteries per kilowatt/hour
(en dollars)	(in dollars)

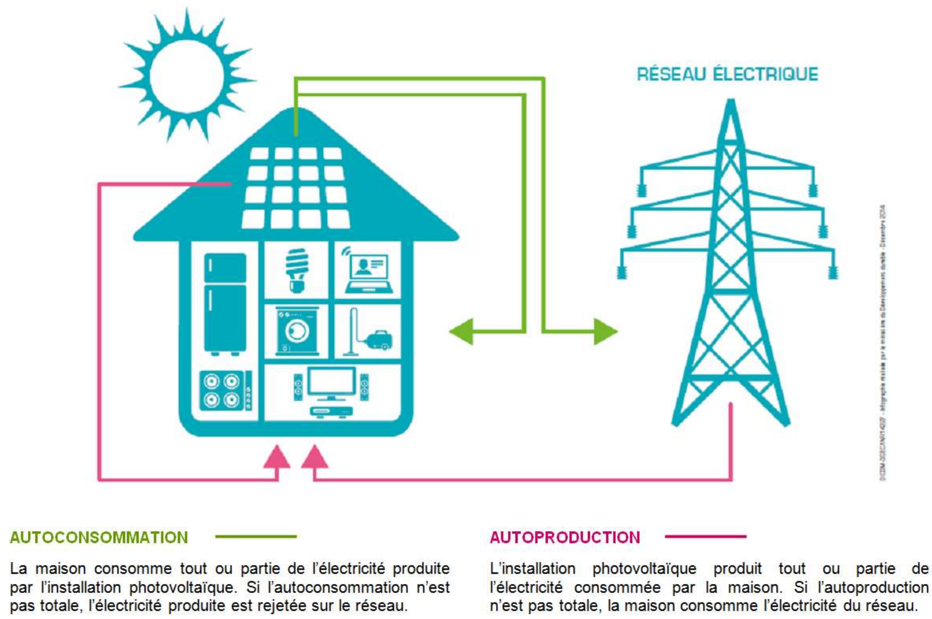
Box 11: Virtual line trial

The 'Ringo' virtual line, designed by RTE, consists of a simultaneous battery storage-retrieval system at three points on the grid, where lines are congested and absorb a large proportion of variable renewable energies. The batteries tested have a capacity of 12 MW and thus 24 MWh at each site. The trial will take place over three years (from 2020 to 2023). From 2023, the batteries will be operated by third parties and will be able to provide several services: frequency adjustment, generation/consumption adjustment, congestion resolution, etc. The use of batteries instead of grid reinforcement might therefore find an economically viable role during the period covered by the MEP.

4.5.1.4. Self-consumption and local energy generation

Individual self-consumption is the act of consuming one's own electricity generation. It is associated with the notion of self-generation, which is the generation of one's own consumption.

Figure 77: Illustration of the concepts of self-consumption and self-generation



Réseau électrique	Electricity grid
Autoconsommation	Self-consumption
Autoproduction	Self-generation
La maison consomme tout ou partie de l'électricité produite par l'installation photovoltaïque. Si l'autoconsommation n'est pas totale, l'électricité produite est rejetée sur le réseau.	The house consumes all or some of the electricity generated by the photovoltaic installation. If self-consumption is not total, the electricity generated is discharged onto the grid.
L'installation photovoltaïque produit tout ou partie de l'électricité consommé par la maison. Si l'autoproduction n'est pas totale, la maison consomme l'électricité du réseau.	The photovoltaic installation generates all or some of the electricity consumed by the house. If self-generation is not total, the house consumes electricity from the grid.

In practice, in the majority of cases, consumption sites will need to use the traditional electricity grid for certain periods, either to obtain electricity or to inject excess electricity generated by their local generation installation. Thus, operating on a self-consumption or self-generation basis does not mean being energy self-sufficient.

The development of individual self-consumption is now a reality and has accelerated in recent years:

- at the end of the second quarter of 2019, nearly 200 MW of capacity was connected for self-consumption by almost 52,000 installations, i.e. double the amount recorded in the second quarter of 2018;
- in 2019, 90% of connection requests or declarations made to distribution system operators for photovoltaic projects concerned self-consumption projects.

Collective self-consumption projects have also been proliferating. There are currently 16 active collective self-consumption operations, representing nearly 200 participants. About 100 operations are in the process of being set up throughout 2019.

This development should continue thanks in particular to the deployment of the Linky smart meter, which will accelerate the development of self-consumption by simplifying all metering devices (a single meter, remote reading, etc.).

Regulatory and support framework

The law defines the concepts of individual and collective self-consumption, which can be either 'basic' or 'extended'. 'Basic' collective self-consumption consists of combining several consumers and producers, which are related to each other within the same legal entity and located in the same building. Since the Law on Energy and Climate was passed on 8 November 2019, social housing owners can be the legal entity behind a collective self-consumption project. 'Extended' collective self-consumption brings together several consumers and producers that are linked together by a single legal entity and located on the low-voltage grid. They must meet criteria, primarily geographical proximity, established by Ministerial Order. The fact that these criteria are established by a Ministerial Order simplifies the procedure for any potential adjustments.

Self-consumption and local power generation represent an opportunity for energy transition and enable consumers to participate in that transition. The aim is that they will continue to develop and grow into a larger share of the energy mix, within a context where:

- **the generation costs of renewable and particularly photovoltaic electricity installations are decreasing and electricity prices are rising;**
- **citizens and communities increasingly aspire to a local economic development model involving 'green' electricity generation that makes it possible to meet their own needs.**

In particular, if the projects are well dimensioned with regard to consumption needs, self-consumption can bring significant benefits to the community by promoting local loops of consumption and generation, which makes it possible to limit the construction of new lines or the reinforcement of distribution systems.

The development of self-consumption should not be at the expense of other electricity consumers and, more broadly, should not undermine the principle of national solidarity that governs the pricing of the use of public networks. The pricing applicable to self-consumers should reflect the benefits as well as the costs that they can create for the electricity system.

The legislative and regulatory framework specific to self-consumption (both individual and collective) came into effect in 2017. It includes provisions enabling system operators to facilitate self-consumption operations (in particular by equipping collective self-consumption operations with Linky meters), specifies the responsibilities of the participants; and also tasks the Energy Regulatory Commission with developing a tariff for the use of public electricity systems (TURPE) specific to self-consumption.

A specific support framework for developing self-consumption has been put in place:

- **small solar installations on buildings (< 100 kWp) for self-consumption are covered by a purchase contract for 20 years, in which an investment premium is paid for five years coupled with a purchase price for the surplus energy injected into the grid;**
- **power installations between 100 kW and 1,000 kW, regardless of the renewable electricity generation technology used, have access to calls for tenders in the form of a bonus for electricity generated, regardless of whether it is self-consumed or injected into the public grid. This call for tenders is aimed in particular at consumers in the industrial, tertiary and agricultural sectors, economic actors for which self-consumption can bring the most significant benefits thanks to the combination of consumption and generation. The support is currently built in such a way that it encourages maximisation of the rate of self-consumption.**

These support mechanisms will evolve to ensure that self-consumption projects up to 300 kWp are covered by the pricing decree and to make the calls for tenders more attractive.

Work will also be done to establish energy communities, as part of the implementation of Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources and Directive (EU) 2019/944 on common rules for the internal market for electricity.

4.5.2. Energy transmission infrastructures

4.5.2.1. District heating and cooling systems

District heating systems play a key role in the development of renewable energies and the use of recovered energies, because they enable the mass mobilisation of biomass, geothermal energy and solar power, or the recovery of waste heat from industry, waste recovery units, etc. The Law on Energy Transition for Green Growth has set the objective of a five-fold increase in the amount of renewable and recovered heat and cold delivered by district heating systems by 2030 (baseline 2012), which represents a target of 39.5 TWh.

Baseline situation 2012	Situation in 2016	Target in MEP_{2016} for 2018	Low target in MEP_{2016} for 2023	High target in MEP_{2016} for 2023
7.9 TWh	13 TWh	15.7 TWh	22 TWh	26.7 TWh

Targets set by the MEP adopted in 2016 for renewable or recovered heat consumption by district heating systems

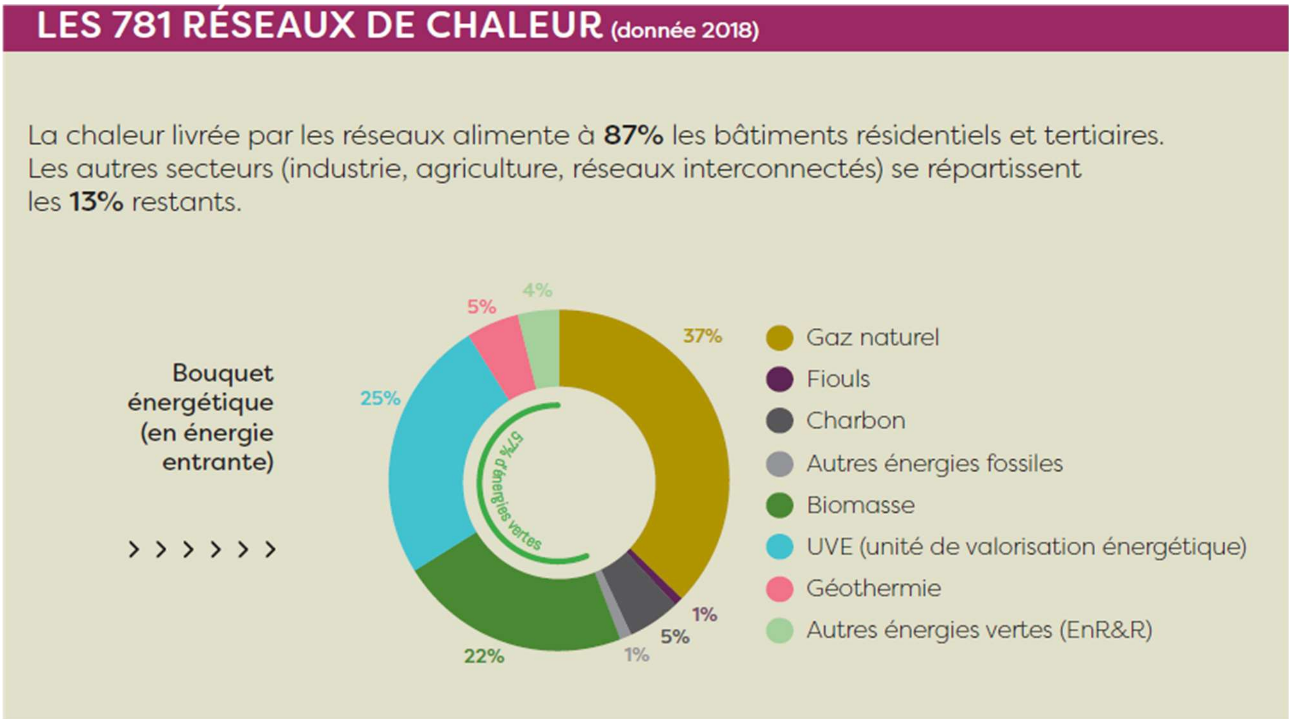
To reach the 2023 upper range, the pace of projects must be increased by a factor of 2.8.

State of play in the sector

In 2018[92], there are approximately 781 district heating systems in France covering more than 5,781 km and generating 25.4 TWh of heat. 23 district cooling systems cover 202 km of networks and deliver 1.05 TWh of cold. District heating systems supply 2.42 million household equivalents[93]. While fossil fuels continue to play an important role in supply (of which 37% is gas), the share of renewable and recovered energies (R&R energy) is continuing to increase, reaching 57.1% in 2017 compared to 27% in 2005 and 40% in 2013. The share for biomass has increased most significantly. The market share, or connection rate for buildings to an R&R energy district heating system in France, remains low (around 6% compared to a European average of 13% in the residential and tertiary sector) compared to other countries (Germany 13%, Austria 18% and Denmark and Finland close to 50%).

92. The data are taken from the annual survey on district heating systems conducted on behalf of the statistics department of the Ministry of Ecological and Inclusive Transition. A total of 669 system operators took part.
93. A household consumes about 12 MWh.

Figure 78: Energy mix of district heating systems in 2018 – source: SNCU; annual national survey of district heating and cooling systems 2019 (data 2018)



Les 781 réseaux de chaleur (donnée 2018)	The 781 district heating systems (2018 data)
La chaleur livrée par les réseaux alimente à 87% les bâtiments résidentiels et tertiaires. Les autres secteurs (industrie, agriculture, réseaux interconnectés) se répartissent les 13% restants.	The heat delivered by the systems supplies 87% of residential and tertiary buildings. The other sectors (industry, agriculture, interconnected networks) share the remaining 13%.
Bouquet énergétique (en énergie entrante)	Energy mix (in incoming energy)
Gaz naturel	Natural gas
Fiouls	Fuel oils
Charbon	Coal
Autres énergies fossiles	Other fossil fuels
Biomasse	Biomass
UVE (unité de valorisation énergétique)	ERU (energy recovery unit)
Géothermie	Geothermal
Autres énergies vertes (EnR&R)	Other green energies (R&RE)

Resources

District heating systems are effective in dense areas. Considering a minimum density of 4.5 MWh delivered per linear meter for the system to be profitable, the SNCU assesses the potential of district heating systems as delivery of 11 times more than the figures for 2012. By combining these data with renewable and recovered energy resources, ADEME estimates that the maximum potential would be around 67 TWh (i.e. 8.5 times more than in 2012).

An analysis of regional energy and climate plans (PCAET) (now integrated into regional plans for SRADDET) for the previous financial year shows that only three regions have stated a quantitative objective for district heating systems. It would be valuable for the SRADDETs, which will be approved in the coming months, to define objectives in each region (or at PCAET level). This can be achieved by using the national mapping of the development potential of district heating systems[94] or the SNCU study, which has published maps indicating regional potential[95].

Socioeconomic, industrial and environmental issues

Yields

District heating systems make it possible to use renewable and recovered energies with satisfactory energy efficiency. The average yield of all the systems participating in the annual district heating system survey is about 85%. When plans permit, new systems are built with a low water-flow temperature (< 90 °C), which allows a two-fold reduction in losses compared to a high-temperature system (150 °C). The drop in temperatures also makes it possible to maximise integrations of possible low-temperature sources (solar, geothermal, recovery, etc.).

Current and foreseeable costs

The costs of a district heating system originate largely from the engineering works related to the length of buried pipes. The energy density (or linear thermal density) indicator, which is expressed in MWh of energy delivered per meter of pipe section (MWh/ml) per year, is one of the characteristics determining the viability of an R&R energy district heating system. The costs are highly variable and depend on the type of system being financed. Based on the data from the Heat Fund, which supports the creation, densification and extension of these systems, it is estimated that the investment cost is around €1,000/linear metre[96].

R&R energy district heating systems enable competitive energy supply for users in the long term. The higher the share of renewable energies in the grid and the more the varied the energy mix, the more stable the sale prices of the heat delivered will be.

The characteristics of the sector in terms of employment

District heating systems generate an annual investment of around €305 million (primary distribution and heat generation) and employ around 6,800 direct FTEs (jobs in the activities in the value chain). Local employment is promoted during the construction, supply and day-to-day management of systems (engineering, maintenance operation, mobilisation of engineers, technicians, workers and salespeople). French engineering skills are widely recognised and sought after for export.

Densification, creation, extension and greening issues

To achieve the factor of 5 set by law, France will need to continue the densification, extension and greening of existing systems, but will also need to create new ones. District heating and cooling systems are often effective. If they are not, this is also the fault of the inertia of the systems in place. The performance of a feasibility study should enable cities to learn about the importance of district heating systems and to take action on this mechanism. Cities are the regional units responsible for creating and operating district heating systems.

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94. http://reseaux-chaleur.cerema.fr/carte-nationale-de-chaleur-france
95. Mapping of the development potential of district heating systems in France (SNCU/FEDENE/SETEC ENVIRONNEMENT): http://www.observatoire-des-reseaux.fr/le-potentiel-de-developpement/
96 Markets and jobs related to energy efficacy and renewables – ADEME – April 2016.

In addition to the creation, densification and extension of systems, the mobilisation of renewable and recovered energies must be accelerated. The average R&R energy rate on all the district heating systems is currently 56% (variable from one year to the next according to weather conditions). Biomass must continue to increase, along with the recovery of waste energies, and in particular heat recovery from waste heat treatment units must continue (a specific initiative will be carried out on the 10 or so units still not connected to a district heating system, when compatible with the regional waste plan). Solar thermal mobilisation could also supplement the energy mix of virtuous district heating systems.

The regulatory tool in force since 1 January 2015 aims to impose a requirement to submit a cost/benefit analysis in order to study the possible recovery of waste heat in a district heating system[97]. This analysis is mandatory for any new installation of more than of 20 MW or for any substantial change[98]. This concerns two cases: an industrial installation that must study the possibility of recovering its waste heat in an existing system or in a system being created, but also an energy generation installation in a system that must first study the possibility of recovering the waste heat from existing industrial facilities nearby, before scaling its power. France should capitalise on the benefits provided by this regulation.

Furthermore, it is necessary to maximise the R&R energy ratio of planned and existing district heating systems without jeopardising competitiveness for the end user. The Renewable Energy Directive adopted in December 2018 provides for the option of increasing the average system R&R energy rate by at least 1 point per year from 2020 for all Member States where the rate is yet to reach 60%. Over the last 10 years, the average system R&R energy rate in France has increased by 25 points (i.e. an average of 2.5 points per year), but the challenge is to continue growth between 2020 and 2030. It is therefore proposed that an indicative target rate of 60% of R&R energy in systems be set for 2023 (national average), and then 65% by 2030, combined with the objective in terms of housing equivalent connections.

Ensuring the integration of R&R energy in local policies and plans

The integration of R&R energy should also take place as close as possible to the projects and could be included in Local Development Plans. In addition, specific local actions could be implemented to promote system ranking[99], based for example on those holding 'eco-network' labels. This label is based on three criteria: a minimum R&R energy of 50%, competitiveness, and the performance of a consultation process. The production of 'all energies' master plans should also be developed and applied in all cases.

To encourage local acceptance of projects and inform users, the creation of consultation committees between local authorities, operators, subscribers and users must be encouraged. Social housing owners should also be encouraged to develop R&R energy and anti-fuel poverty targets.

Renewable and recovered district cooling systems

There are several system-based cold production technologies:

- cold compression units with removal of heat using aerothermal systems (this technology can be considered to be the benchmark solution and is not counted in the system's R&R energy target);
- surface aquifer or surface water heat pumps;

97. https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000029920606&categorieLien=id
98. Modification resulting in a cost of at least 50% of the cost of a new unit.
99. The ranking of a district heating or cooling system is a procedure that enables a community to make it mandatory to connect to the existing or planned system in certain areas for new building installations.

- free cooling and geocooling (technologies that use the natural temperature of water or of the subsoil without the use of a heat pump); SWAC (sea water air-conditioning) technology;
- and waste heat recovery technologies such as the absorption machine or the heat pump in a thermo-frigo-pump assembly that allows the simultaneous production of heat and cold.

In 2017, cold energy delivered by district cooling systems amounted to 1 TWh[100]. Cold generation in district cooling systems is 94% based on cold compression units. Some systems operate by 'free cooling' and some water loop projects funded by the Heat Fund's call for projects on New Emerging Technologies are being put into operation. Certain technologies are already classified as renewable energy under Directive 2009/28/EC: this relates to free cooling. The current review of this Directive plans to define the criteria for identifying other renewable technologies for the generation of cold.

In France, the Law on Energy Transition for Green Growth Law sets the goal of a five-fold increase in the number of renewable and recovered heat and cold energies in systems by 2030. This is why the Heat Fund is supporting technologies considered to be renewable and recovered technologies nationally from 2018, without waiting for these to be defined by the EU. It is for this reason that this MEP sets an indicative target for the delivery of renewable and recovered cold (see below). Aquifer thermal energy storage (ATES) technology could also be developed (see the chapter on low and medium geothermal energy) and could be supported in research programmes and through the Heat Fund's call for projects on New Emerging Technologies. The challenge for district cooling systems is to develop cogeneration of heat in winter and cold in summer using aquifer thermal energy storage.

Environmental challenges

District heating systems have fewer impacts on the environment (apart from the issues specific to supply chains depending on the energy mix). They make it possible to centralise the production of energy and to obtain better energy and environmental performance. This is especially true for the use of solid biomass. In environmental terms, district heating systems supplied mainly by renewable and recovered energies allow very low levels of CO_2 emissions (50 to 100 gCO_2/kWh for a biomass system) compared to individual fossil-based solutions or systems powered by fossil fuels (above 200 gCO_2/kWh).

District cooling systems have a positive impact on the environment as a means of replacing individual refrigeration units[101]. They enable a reduction in the quantity of coolants, and water vector technologies (aquifers, surface water, free cooling) and also offer an alternative to the challenge of heat islands in urban areas. District cooling systems have a very low environmental impact (around 16 gCO_2/kWh).

4.5.2.2. The liquid fuels network

The logistics network consists of import depots for petroleum products, located as close as possible to refineries or ports, crude oil or finished product transport pipelines, and intermediate depots before final delivery to consumers through the service station network. Each level of infrastructure is an essential link in ensuring that the country is well supplied. A decrease in consumption will make it unprofitable to maintain the entire network and, in particular, the intermediate depots.

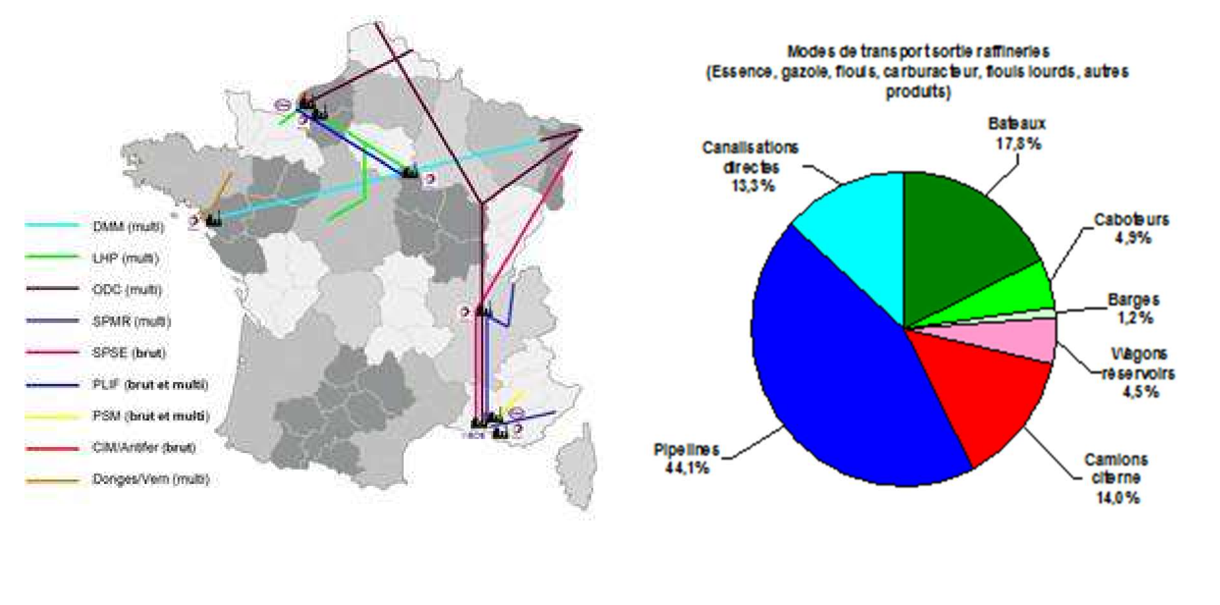
Pipelines are the only infrastructures dedicated to mass transportation of petroleum products. They are used to convey products from import and production areas to consumption sites. In 2018, the quantities

100. Source: survey on district heating systems, 2016.
101 Energy and environmental efficiency is five to ten times more efficient than conventional electric air conditioning – Source: RAEE and IEE Work Package, 2006.

of crude oil transported in the two main pipelines are increasing (2.4%). The transportation of finished products remains stable at 34.2 Mt.

Pipeline systems are the predominant means of transportation used to move products out of refineries and import depots as they allow for safe, mass transportation.

Figure 79: Pipeline systems and transport modes from refineries



DMM (multi)	DMM (multi)
LHP (multi)	LHP (multi)
ODC (multi)	ODC (multi)
SMPR (multi)	SMPR (multi)
SPSE (brut)	SPSE (crude)
PLIF (brut et multi)	PLIF (crude and multi)
PSM (brut et multi)	PSM (crude and multi)
CIM/Antifer (brut)	CIM/Antifer (crude)
Donges/Vern (multi)	Donges/Vern (multi)

Modes de transport sortie raffineries (Essence, gazole, fiouls, carburéacteur, fiouls lourds, autres produits)	Ex-refinery transport modes (petrol, diesel, fuel oils, jet fuel, heavy fuel oil, other products)
Canalisations directes 13,3%	Direct pipelines 13.3%
Bateaux 17,8%	Boats 17.8%
Caboteurs 4,9%	Coasters 4.9%
Barges 1,2%	Barges 1.2%
Wagons réservoirs 4,5%	Rail tank-cars 4.5%
Camions citerne 14,0%	Tanker trucks 14.0%
Pipelines 44,1%	Pipelines 44.1%

The main installations for conveying crude oil are the following:

- The Southern European pipeline (PSE) – 760 km: supplies the refineries of Feyzin and Cressier (Switzerland) from the major seaport of Marseilles.

- The Île-de-France pipeline (PLIF) – 260 km: supplies the Grandpuits refinery (south-east of Paris) from the port of Le Havre and can be used as a backup for the supply of the Normandy refinery.
- The Antifer-Le Havre pipeline – 26.5 km: transports crude oil from the port of Antifer to the CIM (Compagnie Industrielle Maritime) depot, in Le Havre. The product is then transported to refineries in the Basse-Seine area.

Transportation of finished products:

- The Le Havre-Paris pipeline (LHP) – 1,380 km: supplies the Île-de-France region and the Parisian airports. It also serves the areas of Caen and Orleans-Tours.
- The Mediterranean Rhône pipeline (PMR) – 765 km: supplies the Lyons region, the Côte-d'Azur and Switzerland (Geneva) from Fos-sur-Mer.
- The Common Defence Pipeline (ODC) – 2,260 km in France: represents the French part of the Central Europe Pipeline System (CEPS) of the North Atlantic Treaty Organisation (NATO).
- The Donges-Melun-Metz (DMM) pipeline – 627 km: crosses France from west to east, from the port of Saint-Nazaire to Saint-Baussant. It supplies the region of Le Mans and the east of France. It is interconnected with the LHP and the ODC.

The operation of the pipelines is closely linked to the presence of depots, to enable the shipment and receipt of products. The balance between transport mode and storage capacity contributes to ensuring the security of oil product supplies for the country.

4.5.2.3. The gas system

The natural gas system transports natural gas from import points, LNG terminals and biomethane production facilities to consumers and export points. It includes transmission pipelines, compressors and distribution systems, all operating in synergy with underground natural gas storage infrastructures.

The natural gas transmission system

The French natural gas transmission system is used to move gas from import points at the borders (land-based interconnections with other European countries, gas pipeline from the Norwegian Sea and LNG terminals) to delivery points distributed throughout the country (distribution systems and large industrial customers) or underground storage sites.

It is operated by two operators:

- GRTgaz: 75% subsidiary of Engie and 25% of Société d'Infrastructures Gazières (public consortium made up of CNP Assurances, CDC Infrastructures and the Caisse des Dépôts et Consignations) operating 7,498 km of primary network and 24,916 km of regional network.
- Teréga: owned by the Italian operator Snam (40.5%), the Singaporean state investment fund GIC (31.5%), EDF (18%) and Predica (10%), it operates 1,155 km of primary network and 3,985 km of regional network.

The gas transmission systems are regulated by the Energy Regulatory Commission (CRE). The most recent tariff for the use of transmission systems, 'ATRT6', came into effect on 1 April 2017. It was designed to be applied over four years and is updated on 1 April of each year.

In recent years, the French natural gas transmission system has been upgraded to facilitate the movement of natural gas within it, to limit the risks of congestion and to streamline trade between southern and northern France, which made it possible to merge the marketplaces on 1 November 2018. The upgrades involve:

- The creation of the Arc de Dierrey by GRTgaz (DN 1200, 308 km), which was classified as a project of common interest (PCI), with an investment of €1.185 billion, between Cuvilly and Voisines (Yonne). This project was commissioned in late 2015. It transports gas from Norway, the Netherlands, Great Britain and LNG terminals on the Atlantic and North Sea to the east and south.
- The Val-de-Saône infrastructure project sponsored by GRTgaz (DN 1200, 190 km) is classified as a PCI, with investment of €744 million. It consists of a doubling of the Burgundy Artery between Etrez (Ain) and Voisines (Haute-Marne) and was commissioned in 2018.
- The Gascogne-Midi project sponsored by Teréga (DN 900, 60 km): this project is classified as a PCI and involves a partial doubling of the Gascony artery between Lussagnet (Landes) and Barran (Gers), which was commissioned in 2018. Teréga is also upgrading the Barbaira compressor station (Aude), with an estimated budget of €152 million.

Investments have also been made to facilitate exchanges of natural gas between France and neighbouring countries, in order to promote the internal market for natural gas. Since the publication in 1998 of Directive 98/30/EC on common rules for the internal market for natural gas, capacity for gas exchange via gas interconnections between France and neighbouring countries has increased by almost 50% in input and multiplied by five in output:

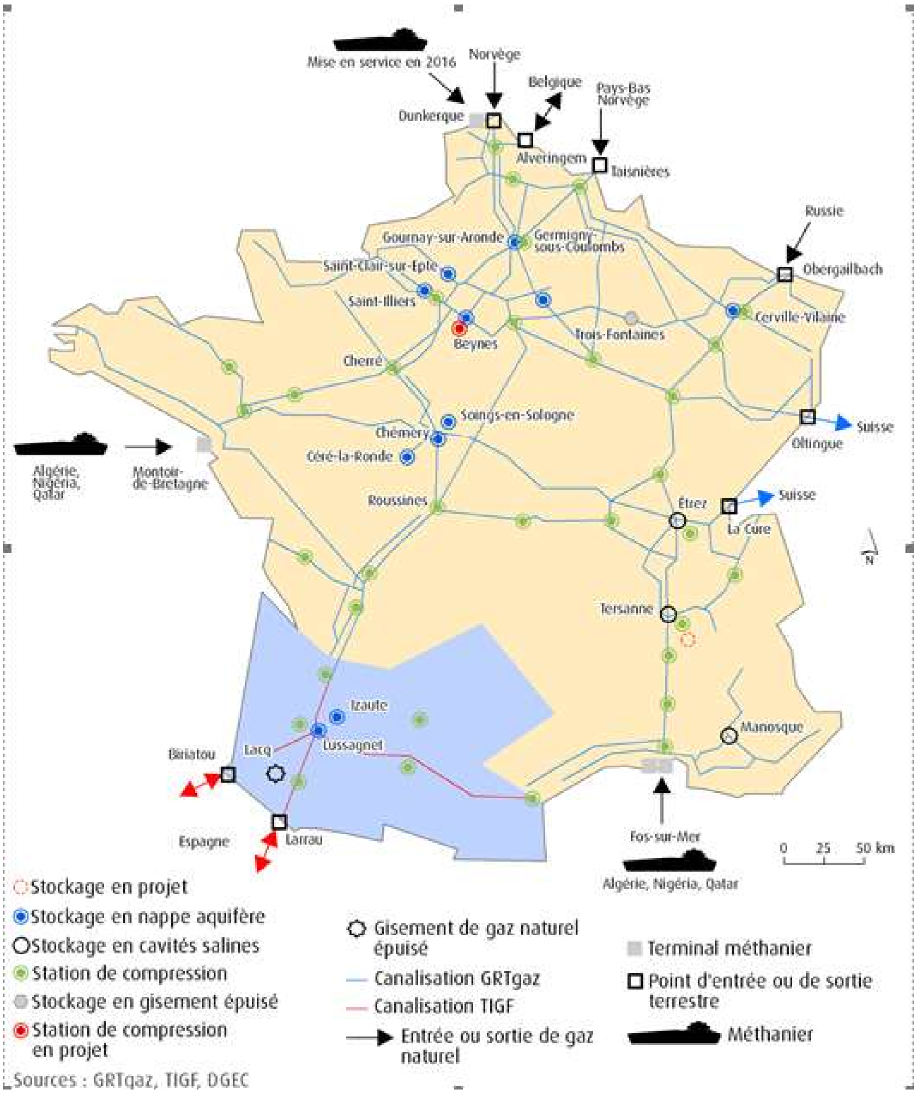
- the capacities of the Larrau and Biriatou interconnection points have been gradually upgraded, enabling an increase in the firm capacities from France to Spain from 70 to 165 GWh/day; at the same time, 225 GWh/day in firm capacity has been created in a south-north direction;
- the 2001 commissioning of the Oltingue interconnection point has resulted in the supply of 220 GWh/day of firm capacity from France to Switzerland and Italy;
- upgrades to the Obergailbach interconnection have led to an increase in 2009 in the firm capacity between Germany and France from 400 to 570 GWh/day;
- the new Alveringem interconnection point enabled the creation of 270 GWh/day of firm capacity from France to Belgium in 2015.

France is part of the North-South Gas Interconnection Corridor in Western Europe, one of four trans-European energy infrastructure corridors identified as posing particular challenges for the further diversification of supply routes and improvements in the short-term capacity of gas delivery. France is continuing with the technical, economic and administrative analysis of projects under this framework, in particular:

- the MidCat and South Transit East Pyrenees (STEP) projects, involving the construction of a new gas pipeline between France and Spain in the eastern Pyrenees, as well as various levels of enhancements in the French network. These projects are included in the list of projects of common interest adopted by the European Commission on 23 November 2017, as they contribute to the achievement of Europe’s energy and climate objectives and are one of the determining factors for the Energy Union;
- the project to create output capacity to Germany on the Obergailbach interconnection.

These analyses seek to evaluate the significance of projects in respect of their costs and therefore to clarify the decision to go ahead with or abandon these projects. Given the expectation of a decline in natural gas consumption, new gas infrastructures should be avoided, as there will be insufficient time to allow a return on investments. Special care is taken to ensure that the share of financing borne by natural gas consumers does not exceed the benefits they would derive from new infrastructures. In addition, the possible completion of new gas infrastructure projects is envisaged only in the context of meeting optimal environmental conditions, in accordance with the provisions of the Environment Code and under the procedures defined by the law, particularly as regards public consultation.

Figure 80: Gas infrastructures



Mise en service en 2016	Commissioned in 2016
Norvège	Norway
Belgique	Belgium
Pays-Bas	Netherlands
Dunkerque	Dunkirk
Russie	Russia
Suisse	Switzerland
Algérie, Nigeria, Qatar	Algeria, Nigeria, Qatar
Espagne	Spain

Stockage en projet	Planned storage
Stockage en nappe aquifère	Aquifer storage
Stockage en cavités saline	Salt cavern storage
Station de compression	Compressor station
Stockage en gisement épuisé	Storage in field depleted
Station de compression en projet	Planned compressor station
Gisement de gaz naturel épuisé	Natural gas field depleted
Canalisation GRTgaz	GRTgaz pipeline
Canalisation TIGF	TIGF pipeline
Entrée ou sortie de gaz naturel	Natural gas entry or exit
Terminal méthanier	LNG terminal
Point d'entrée ou de sortie terrestre	Land-based entry or exit point
Méthanier	LNG terminal

Natural gas distribution systems

The natural gas service to domestic, tertiary or small industrial consumers, downstream of the transmission system, is provided via distribution systems.

Natural gas distribution systems are owned by local authorities. They are operated through concession contracts between operators and local authorities, by GRDF (100% subsidiary of Engie), which distributes around 96% of the market, 23 local distribution companies (mostly located in the south-west and in the east), and a few other licensed companies.

They serve more than 9,500 French municipalities and 11 million customers (including almost all municipalities with more than 10,000 inhabitants). This represents just over a quarter of the 36,000 French municipalities, but means that 77% of the French population has access to natural gas.

The 27,000 municipalities not currently supplied with gas have several options for accessing this type of energy:

- the extension of the existing natural gas network through the development of a distribution system by the operator of their choice, following selection through a call for applications, subject to approval by the Minister of Energy;
- the development of propane networks;
- the development of isolated natural gas networks, served by LNG delivered by trucks (transported LNG), subject to the establishment of a suitable regulatory framework.

The issues involved in ensuring good management of distribution systems require progress on:

- satisfactory knowledge of the networks: their capacity, their operation, the development of remote monitoring applications, remote operation and the roll-out of smart meters;
- the incorporation of renewable gas in increasing quantities, by removing the barriers on the capacity limits of the networks.

The development of biomethane-injection projects may need to increase the flexibility of the distribution systems. Indeed, the amount of biomethane that can be injected into a distribution network is limited by the gas consumption on that network. Upgrades to gas networks, particularly to allow the implementation of backward flows from the distribution system to the transmission system, may be necessary to prevent biomethane production projects located near an existing network from being blocked due to lack of capacity.

Natural gas smart meters

Article L. 453-7 of the Energy Code sets a target of rolling out smart meters for natural gas consumers. Historically, this type of meter was deployed only on sites with high consumption, especially industrial sites.

Through a decision of 23 September 2014, the Minister of Ecology, Sustainable Development and Energy and the Minister of Economy, Industry and Digital Affairs approved the deployment of the Gazpar smart meter by GRDF, which operates 95% of the natural gas distribution system. A technical and economic study showed that the present net value of the project was positive for local authorities, after considering the earnings outlook for natural gas consumers associated with managing the energy demand induced by the smart meter. After a test phase, GRDF initiated the widespread deployment of Gazpar meters on 1 May 2017. The roll-out of this operation, which involves 11 million meters, is scheduled to continue into 2022. As at the end of October 2019, 4.5 million Gazpar meters were installed, in line with targets.

The Gazpar meter means that the natural gas consumer can be billed based on actual consumption, thanks to a technique for remote transmission of the indexes. The procedures for changing supplier are simplified as a result. Consumers can use information made available to them about their consumption to take steps to manage the energy they consume.

Smart meters will also be deployed by Greenalp and Régaz-Bordeaux. Programmes are being studied by other public natural gas distribution system operators.

LNG terminals

Four LNG terminals are currently in service in France:

- Fos-Tonkin (3 Gm^3/year) and Montoir-de-Bretagne (10 Gm^3/year), owned by Elengy, a 100% subsidiary of GRTgaz.
- Fos-Cavaou (8.2 Gm^3/year), owned by Fosmax LNG, a subsidiary of Elengy (> 70%) and Total, managed by Elengy.
- Dunkerque LNG (13 Gm^3/year), owned by consortia made up of the Belgian transmission system operator Fluxys, Axa Investment Manager, Crédit Agricole Assurances and Korean companies IPM and Samsung Asset Management.

In 2018, liquefied natural gas (LNG) arrived in France primarily from Algeria (28%), Nigeria (27%), Russia (13%), Norway (11%) and Qatar (8%).

Since 2011, the utilisation rate of French and European LNG terminals has fallen sharply due to natural gas prices, which are significantly higher in Asian markets than in European markets, leading to an increase in LNG deliveries in Asia, at the expense of Europe. French LNG terminals were used on average at one third of their capacity between 2011 and 2017. The utilisation rate of LNG terminals rebounded sharply in 2018, in a context marked by the activation of new LNG production units.

The Dunkirk, Fos-Cavaou and Montoir-de-Bretagne LNG terminals are covered by capacity subscription agreements extending beyond the period covered by the MEP, which secures their operation for this period.

However, there is uncertainty about the future use of the Fos-Tonkin terminal. In the absence of any new capacity subscription by natural gas suppliers, its operation is currently guaranteed only until 2020. Elengy, the terminal operator, is studying a range of options. If operations are closed down at the Fos-Tonkin terminal, all LNG import capacities on the Mediterranean seaboard will be managed by the Fos-Cavaou terminal alone. Emission capacities would remain unchanged, but at the price of a more restricted operation.

Hydrogen and gas networks

Issues relating to the direct injection of hydrogen into gas networks are being studied. Beyond a certain concentration, hydrogen is likely to raise questions of technical compatibility and safety for the networks (material compatibility, gas burner settings, measurement of quantities delivered, etc.).

4.5.2.4. Recharging infrastructures for alternative fuels

The development of alternative fuels, namely Natural Gas for Vehicles (NGV), LPG-C, electricity, hydrogen, etc., represents a significant lever for the transition of the transport sector, in particular for road and river transport. These fuels can be used to limit the sector's dependence on petrol while diversifying energy sources. They also make it possible to reduce the environmental impact of travel and provide a significant opportunity for reducing greenhouse gas emissions, air pollution and noise emissions. Their development requires the involvement of the Government and local authorities. Undertakings must be guaranteed visibility to facilitate investments in cleaner-fuel vehicle technology.

Directive 2014/94/EU of 22 October 2014 on the deployment of alternative fuels asked Member States to reflect on the development of these energy sources in the transport sector by drafting a framework for national action. France published its action framework in 2017, laying the foundation for the development of these fuels.

The establishment and maintenance of a recharging and refuelling infrastructure network is a major challenge for the development of alternative fuels. The design of the distribution network is adapted to each fuel: electric recharging is divided between recharging at home by private individuals and public recharging; hydrogen recharging stations are developed primarily through identified captive fleets; maritime LNG requires specific development linked to use as a marine fuel; and the NGV distribution system is developing as part of general progress on European mobility. The LPG distribution network is already developed and in use.

Box 15: Alternative fuels

Alternative fuels are defined by Directive 2014/94/EU on the deployment of alternative fuels as:

'fuels or power sources which serve, at least partly, as a substitute for fossil oil sources in the energy supply to transport and which have the potential to contribute to its decarbonisation and enhance the environmental performance of the transport sector. They include, inter alia:

- electricity;
- hydrogen;
- biofuels as defined in point (i) of Article 2 of Directive 2009/28/EC,
- synthetic and paraffinic fuels,
- natural gas, including biomethane, in gaseous form (compressed natural gas (CNG)) and liquefied form (liquefied natural gas (LNG)), and
- liquefied petroleum gas (LPG). '

Electric recharging networks

Recharging infrastructures for electric road vehicles

To date, this primarily concerns private vehicles and light commercial vehicles. The bulk of recharging of electric vehicles currently takes place at home or at the workplace, and not at recharging points open to the public. In particular, one important issue is facilitating as far as possible the installation of recharging points in residential buildings, especially jointly owned properties, because individuals who are able to charge their vehicles at home will be in a position to load enough power for several days in one night.

Nonetheless, to allow the development of roaming, the deployment of terminals open to the public is necessary, both on the major road routes and more locally, for users who do not have a parking option and thus cannot charge at home, or those who want to recharge their vehicles for 'insurance' purposes or who are temporarily living away from their home (holidays). To scope the associated requirements, Directive 2014/94/EU sets an indicative ratio of one recharging point per 10 cars, i.e. a target of 100,000 recharging points in 2022 if the sector achieves its target set in the strategic sector contract signed with the Government in May 2018 of putting one million electric vehicles in circulation.

The distribution of the terminals should not be uniform across the entire country. Public recharging needs are more significant in dense urban zones, where the number of private parking places is limited. These urban zones also constitute one of the areas of specific relevance for electric vehicles. It is therefore necessary to provide for a dense public recharging network. In rural areas, the dispersed pattern of dwellings facilitates the installation of terminals at home and public recharging needs essentially relate to ensuring geographical coverage. Finally, high-power recharging points should be positioned along major road routes to allow travel by electric vehicles for long journeys.

Efforts must also be made to guarantee a satisfactory level of service of recharging terminals and to streamline their use. The use of battery-powered electric vehicles for long journeys will only develop if access to high-power recharging facilities is accessible to all. It is therefore necessary to develop an interoperable network that allows users to recharge their vehicles at all terminals without it being necessary for them to have a subscription or to complete any other time-consuming process.

Generally speaking, a massive increase in the number of electric vehicles should not weaken the French electricity system. Total energy consumption by electric vehicles over the next 10 or 15 years (up to 15 million electric vehicles in circulation) can be absorbed without difficulty in view of the developments in generation capacity and other consumption types anticipated over this time frame. The issue here is more power demands. It will be necessary to develop solutions to manage recharging in order to avoid an excessive impact on peak consumption in winter. Conversely, in certain cases, the return of energy by the vehicle battery known as 'vehicle to X' could provide network-balancing services.

Electric supply at the quayside

The availability of electrical supplies in ports allows inland waterway vessels and ships to avoid the use of onboard generators powered by heavy fuel oil when they are moored at the quayside. Connection at the quayside makes it possible to avoid significant greenhouse gas emissions and pollutants harmful to health in port conurbations. Not all ships have the same power needs: bulk carriers, tankers and container ships require less power than ferries. Cruise ships require significant power given the size of the electricity networks serving the urban areas adjacent to port installations.

Gas-distribution networks

Natural gas for vehicles

France has the largest network of NGV stations for heavy goods vehicles in Europe. The development of NGV stations is linked to biomethane development to ensure European mobility. To ensure that this fuel is adopted by road hauliers, the number of stations should be determined to provide coverage of major road routes along with geographical coverage, which can be defined as a maximum distance or travel time to the nearest station. The National Action Framework for Alternative Fuels has provided some initial development guidelines, so as to ensure the availability of NGV in compressed form in conurbations and in liquefied from along major roads. Calls for projects carried out in 2018–2019 in the context of the Investments for the Future Programme have made it possible cover the major structural axes designated by the European Commission for the Trans-European Transport Network and areas with more limited services. This series of projects should enable the creation of 119 supplementary stations between 2018 and 2022, compared to 38 stations accessible to heavy goods vehicles when the tender was launched.

The minimum number of stations required in 2023 and 2028 has been estimated as 138 and 326, respectively. Furthermore, the maximum number of profitable stations is estimated as 367 and 845 in 2023 and 2028, respectively.

Liquefied petroleum gas

LPG consumption in the world and in Europe is growing strongly. Consumption in France is very stable. There is a dense European network. France is one of the only European countries where the network has decreased slightly in the last 10 years. The network is in place and does not need any public investment. However, it is only used at 25% of its economic profitability. There is real potential for development of this market and the network is able to accommodate bio-LPG.

Hydrogen

The development of hydrogen recharging stations will continue based on the 'captive fleet' method, which involves helping to deploy stations near to those actors that have chosen to use hydrogen. Thus, the plan for the deployment of hydrogen is based on the roll-out of regional hydrogen mobility ecosystems, in particular through fleets of commercial vehicles:

- 5,000 light commercial vehicles and 200 heavy vehicles (buses, lorries, regional trains, boats), as well as the construction of 100 stations, supplied with locally produced hydrogen by 2023;
- 20,000 to 50,000 light commercial vehicles, 800 to 2,000 heavy vehicles and from 400 to 1,000 stations by 2028.

4.5.3. Electricity and gas markets, energy prices

4.5.3.1. Economic elements common to both electricity and gas

The end of 2018 was marked by record oil prices. In a continuing context of rising prices as seen in the second quarter, prices reached their highest level for four years at the end of September, hitting more than €70/bbl of Brent crude. Over the third quarter of 2018, oil prices averaged €64.5/bbl of Brent crude, and thus an increase of +2% compared to the previous quarter. Markets were busy because of fears of restricted supply, in particular with the sanctions in place against Iran and the consequent fall in production, which might not be sufficiently offset. For its part, anticipation of demand was made problematic by fears of a trade war between the United States and China. Coal prices increased over the end of 2018 and reached an average price in the third quarter of €78.3/t, thus an increase of close to 10% over the previous quarter. The growth of Asian demand is still one of the primary factors behind the dynamics of the markets. Coal prices also followed the upward trend in other raw materials and thus reached their highest level since 2013, at nearly €85/t in late September.

The rise in the price of the CO_2 allowance begun in the third quarter of 2017 continued during the second half of 2018. While the quarter closed in 2017 at a price of €7.1/tCO_2, it closed in 2018 at a price of €21.2/tCO_2, indicating that the price has almost tripled in the space of a year. The maximum achieved in this period, which is also the highest value for 10 years, was seen in early September and was €25.2/tCO_2, before a nonetheless sharp correction took place in the following days. This overall increase reflects a general context of increasing raw material prices but has also been driven by anticipation of the activation of the market stability reserve in early 2019. In the third quarter of 2017, 2,375 MtCO_2 was traded on stock markets and through brokers in the form of EUAs compared to 2,421 MtCO_2 in 2018, thus a steady traded volume, after a significant increase in the previous year. However, the market experienced a situation of overbuying, which, among other things, explains the price peak in early September and its subsequent correction.

The rise in fossil fuels has a direct effect on prices on wholesale gas markets (largely correlated with the Brent price per barrel).

The increase in the prices of fossil fuels and CO_2 allowances also has an effect on prices on wholesale electricity markets: in fact, because the interconnections are often marginal on the French market, the predominant fossil technologies of our neighbours are often the last used, and contribute significantly to the formation of French wholesale prices.

4.5.3.2. Current situation in the electricity market

Consumption

Compared to the third quarter of 2017, French consumption during the same period in 2018 remained stable at around 93 TWh.

Production and trade

Nuclear availability increased slightly, with an average availability rate of 66.6% (+1.5 points compared to the third quarter of 2017). However, given the severe heat waves affecting the nuclear sector, causing the shut-down of certain reactors, this rate is 8.9 points lower than the second quarter of 2018 (75.5%). Thus, nuclear power generation was 87.3 TWh, an increase of +1.4% compared to the same period of 2017. Compared to 2017, a year that was generally marked by a low level of hydroelectric activity, generation as at the third quarter of 2018 grew by 16.7% to 12.2 TWh (Figure 18). However, this fell by -44.9% compared to the previous quarter (22.2 TWh). The quarter was also marked by a 20% fall in wind generation (4.1 TWh) compared to the previous quarter. This reduced demand for hydroelectric generation and the significant drop in wind generation explain the +135.5% rise in generation based on fossil fuels, which increased from 3.1 TWh to 7.3 TWh. The utilisation rate of coal and gas (Figures 16 and 17) was an average of 20% during the third quarter of 2018, compared to 12% and 11% respectively during the previous quarter, when hydroelectricity generation was very substantial. Compared to the third quarter of 2017, this fossil-based generation fell by 11.9%. France's export balance grew to 16.5 TWh compared to 13.0 TWh in the third quarter of 2017 (Figure 20), thus an increase of +27.0%.

Exports grew by +6.0%, in particular with an increase of +3.6% in exports during peak hours and +7.3% in exports in non-peak periods. Imports fell by -30.3%, with a drop of -19.3% in imports during peak hours and a -37.2% drop in imports in non-peak periods.

State of play in the wholesale market

On futures markets, the 2019 France Baseline Calendar product price increased by 18% on average compared to the previous quarter, and its German equivalent grew by +20.5%. The prices reached €53.3/MWh and €48.6/MWh respectively in the third quarter of 2018. Viewed in terms of the same period in 2017, these prices show average increases of +36% for the France Baseline Calendar. M+1 product prices have seen average increases of +48% compared to the second quarter of 2018, and are at €58.1/MWh, which corresponds to a rise of approximately +54% compared to the third quarter of 2017 (Table 2). In terms of trading on futures markets, the annual product volumes traded (Y+1) fell by -50% compared to the third quarter of 2017 and by -14% compared to the second quarter of 2018. For monthly products (M+1), the volumes traded are up +60% against the third quarter of 2017 and by +39% compared to the second quarter of 2018. Lastly, volumes traded on the Spot market are stable compared to the same period in 2017 but are recording a drop of -12% compared to the previous quarter (Table 3).

State of play in the retail market

As at 30 September 2018, 37.6 million sites are eligible, representing approximately 437 TWh of annual electricity consumption. Customers can use two different types of contracts:

- **contracts with regulated sales tariffs (RST), offered only by historical suppliers;**
- **contracts at market prices, offered by both historical and alternative suppliers.**

Table 1: Summary of number of sites				
	Residential		Non-residential	
Situation (number of sites)	**As at 30 September 2018**	As at 30 June 2018	**As at 30 September 2018**	As at 30 June 2018
Total number of sites	**32,508,000**	32,460,000	**5,051,000**	5,052,000
Sites supplied at market rates, of which:	6,974,000	6,573,000	1,887,000	1,867,000
► Historical suppliers	**216,000**	145,000	**733,000**	730,000
► Alternative suppliers	**6,758,000**	6,428,000	**1,154,000**	1,137,000
Sites subject to regulated tariffs	25,611,000	25,887,000	3,164,000	3,185,000
Market share for alternative suppliers	**20.7%**	19.8%	**22.8%**	22%

Table 2: Summary of annualised consumption				
	Residential		Non-residential	
Situation (annualised consumption)	**As at 30 September 2018**	As at 30 June 2018	**As at 30 September 2018**	As at 30 June 2018
Total consumption of sites	***153.53 TWh***	152.61 TWh	***283.95 TWh***	289.37 TWh
Consumption supplied at market rates, of which:	*29.11 TWh*	*27.17 TWh*	*256.26 TWh*	*254.63 TWh*
► Historical suppliers	***1.1 TWh***	0.75 TWh	***135.78 TWh***	135.64 TWh
► Alternative suppliers	***28.01 TWh***	26.42 TWh	***120.48 TWh***	118.99 TWh
Consumption supplied at regulated tariffs	*124.42 TWh*	*125.44 TWh*	*27.69 TWh*	*34.74 TWh*
Market share for alternative suppliers	*18.2%*	17.3%	*42.4%*	41.1%

State of play in retail electricity markets as at 30 September 2018 (source: CRE)

As at 30 September 2018, approximately 160 non-national electricity suppliers are active in France, including historical suppliers (local distribution undertakings). These suppliers with a local or regional presence in the country offer services to one or more customer segments.

During the third quarter of 2018, 2.6% of residential customers:

- **changed supplier**
- **started supply from an alternative supplier**
- **started supply from an historical supplier outside their service area.**

This rate has been growing steadily since 2012.

4.5.3.3. Current situation in the gas market

Consumption

Gas consumption in France during the third quarter of 2018 fell slightly by 3.4% compared to the same period in 2017. Consumption related to demand from gas-fired power plants to cover unavailability of electrical plants during the summer did not offset the fall in demand. Following on from the second quarter, amounts injected into storage were significant, reaching 68 TWh, and thus an increase of around 50% compared to the same period in 2017. LNG imports fell by 21% (-6 TWh), offset by land-based imports, which grew by 7% (7 TWh) compared to the third quarter of 2017.

State of play in the wholesale market

Day-ahead prices reached an average value of €24.4/MWh on the PEG Nord, representing a 16% increase compared to the previous quarter but a 52% rise over the same period in 2017. The small quantities of LNG and the high demand for injection have been particular factors in driving this increase. Fluctuations in the price of gas on neighbouring markets have been similar, with an average differential between the PEG Nord and the TTF of €0.2/MWh. In the TRS zone, day-ahead prices have been €27.0/MWh on average. This shows a relatively high average difference against the PEG Nord area (€2.6/MWh), but this fell significantly over the end of the quarter. This difference is linked to the tight natural gas supply in the south and the low availability rate for the north-south link (73%), which was thus used at maximum level. In line with the upward trends observed for day-ahead prices, calendar prices rose by 16% compared to the previous quarter, with an average value of €22.9/MWh. Driven by the increase in raw material prices, the 2019 calendar price hit its highest level since 2014 in late September, recording a value of €26.6/MWh.

State of play in the retail market

As at 30 September 2018, the entire market represents 11.4 million sites and annual consumption of approximately 488 TWh. Customers can use two different types of contracts:

- **contracts with regulated sales tariffs (RST), offered only by historical suppliers;**
- **contracts at market prices, offered by both historical and alternative suppliers.**

Tableau 6 : Synthèse en nombre de sites

	Résidentiels		Non résidentiels	
Situation (en nombre de sites)	***Au 30 septembre 2018***	Au 30 juin 2018	***Au 30 septembre 2018***	Au 30 juin 2018
Nombre total de sites	***10 663 000***	10 672 000	***657 000***	660 000
Sites fournis en offre de marché, dont :	*6 229 000*	6 126 000	*591 000*	592 000
► Fournisseurs historiques	***3 194 000***	3 169 000	***308 000***	316 000
► Fournisseurs alternatifs	***3 035 000***	2 956 000	***283 000***	277 000
Sites au tarif réglementé	*4 434 000*	4 546 000	*65 000*	67 000
Parts de marché des fournisseurs alternatifs	***28,5 %***	27,7 %	***43,2 %***	41,9 %

Sources : GRT, GRD, Fournisseurs historiques – Analyse : CRE

Tableau 7 : Synthèse en consommation annualisée

	Résidentiels		Non résidentiels	
Situation (en consommation annualisée)	***Au 30 septembre 2018***	Au 30 juin 2018	***Au 30 septembre 2018***	Au 30 juin 2018
Consommation totale des sites	***118,6 TWh***	118,7 TWh	***366,2 TWh***	366,3 TWh
Consommation fournie en offre de marché, dont :	*70 TWh*	69 TWh	*365,2 TWh*	365,3 TWh
► Fournisseurs historiques	***37,4 TWh***	37,1 TWh	***122,6 TWh***	122,6 TWh
► Fournisseurs alternatifs	***32,6 TWh***	31,9 TWh	***242,7 TWh***	242,7 TWh
Consommation fournie au tarif réglementé	*48,6 TWh*	49,7 TWh	*1 TWh*	1 TWh
Parts de marché des fournisseurs alternatifs	***27,5 %***	26,9 %	***66 %***	66,3 %

State of play in retail gas markets as at 30 September 2018 (source: CRE)

Tableau 6 : Synthèse en nombre de sites	Table 6: Summary of number of sites
Résidentiels	Residential
Non résidentiels	Non-residential
Situation (en nombre de sites)	Situation (number of sites)
Au 30 septembre 2018	As at 30 September 2018
Au 30 juin 2018	As at 30 June 2018
Nombre total de sites	Total number of sites
Sites fournis en offre de marché, dont :	Sites supplied at market rates, of which:
Fournisseurs historiques	Historical suppliers
Fournisseurs alternatifs	Alternative suppliers
Sites au tarif réglementé	Sites subject to regulated tariffs
Parts de marché des fournisseurs alternatifs	Market share for alternative suppliers

Tableau 7 : Synthèse en consommation annualisée	Table 7: Summary of annualised consumption
Situation (en consommation annualisée)	Situation (annualised consumption)
Consommation totale des sites	Total consumption of sites
Consommation fournie en offre de marché, dont :	Consumption supplied at market rates, of which:
Consommation fournie au tarif réglementé	Consumption supplied at regulated tariffs
Parts de marché des fournisseurs alternatifs	Market share for alternative suppliers

As at 30 September 2018, close to 40 non-national suppliers were active in France: 22 historical suppliers (local distribution undertakings) and around 20 alternative suppliers. These suppliers with a local or regional presence in the country offer services to one or more customer segments.

The supplier switchover rate has been growing steadily since 2008: during the third quarter of 2018, 2.8% of residential customers:

- **changed supplier,**
- **started supply from an alternative supplier,**
- **started supply from an historical supplier outside their service area.**

For business customers, this rate is over 4%.

Projected changes on the basis of policies and measures up to 2040

The decisions of the Council of State of 19 July 2017 (for natural gas: Decision No 370321) and 18 May 2018 (for electricity: Decisions Nos 413688 and 414656):

- **held that RST for natural gas are incompatible with EU law, in terms of the general economic interest objectives pursued;**
- **accepted the existence of regulated sales tariffs for electricity in that they make it possible to guarantee a stable electricity price, while excluding from their scope non-domestic sites belonging to major undertakings and implying a need for a regular review of their relevance.**

On the basis of these decisions, dialogue has been under way for several months with the main stakeholders to define terms for phasing out gas RST for all consumers and electricity RST for the major undertakings concerned, and to determine the necessary support measures for consumers and to enable unrestricted competition. These conditions have been included in the Law on Energy and Climate of 8 November 2019 to ensure compatibility as quickly as possible for regulated gas tariffs, while guaranteeing the phasing-out of those tariffs and ensuring that switchover for customers concerned to market price-driven contracts is open and competitive.

For electricity, corresponding provisions have also been included in the Law on Energy and Climate to ensure compatibility of the legislative provisions in the Energy Code on regulated tariffs with the associated decisions and with the Electricity Directive, which recognises the possibility of regulated electricity tariffs, and limits the scope of those tariffs from 31 December 2020 to residential customers and very small businesses.

4.5.3.4. Energy poverty

Assistance for the payment of energy bills: energy allowance

The energy allowance is a payment voucher issued to the lowest income households to combat fuel poverty. This scheme, created by Article 201 of the Law on Energy Transition for Green Growth of

17 August 2015, replaced the social electricity and natural gas tariffs on 1 January 2018. It has a twofold objective:

- to provide a more equitable system than the social energy tariffs, which benefits all households experiencing fuel poverty equally, regardless of their heating energy;
- to significantly improve target attainment, hampered in the previous system by the complex data checking inherent in the social tariff system.

The energy allowance is assigned on the basis of a single tax criterion, taking into account income level and household composition. It enables the eligible households to pay their energy bills, regardless of the heating method they may use (electricity, gas, fuel oil, wood, etc.). If they wish, beneficiaries may use the allowance to fund some of the energy-saving building work that they undertake in their homes.

The energy allowance was trialled in 2016 and in 2017 in four departments (Ardèche, Aveyron, Côtes-d'Armor and Pas-de-Calais). The average amount of aid was close to €150, adjusted according to family composition and the level of reference income (RFR). The eligibility criteria were:

- the reference income level per consumption unit (this must be less than €7,700/CU/yr);
- the number of consumption units (CU) in the home;
- the fact of having a home that is subject to housing tax (although exemptions are permitted in certain cases).

The results of the trial have been very encouraging: more than 82% of energy allowances were used by the beneficiaries for the 2017 campaign, exceeding the number of households using social tariffs in these regions. The energy allowance has been rolled out nationwide in 2018 to 3.6 million beneficiaries. The Government has decided to increase the value of the energy allowance and modify its scope in 2019. The energy allowance amounts paid in 2018 will therefore be increased by an average of €50 after 2019. Moreover, the income ceiling for eligibility for the energy allowance will be raised so as to include 2.2 million additional households in the 2019 campaign.

	RFR/CU < €5,600	**€5,600 ≤ RFR/CU < €6,700**	**€6,700 ≤ RFR/CU < €7,700**	**€7,700 ≤ RFR/CU < €10,700**
1 CU (1 person)	€194	€ 146	€ 98	€ 48
1 < CU < 2 (2 or 3 persons)	€ 240	€ 176	€ 113	€ 63
2 CU or more (4 persons or more)	€ 277	€ 202	€ 126	€ 76

2019 amount of the energy allowance, based on reference income (RFR) and household composition (Consumption Unit[102])

To improve beneficiary cover, specific assistance for social housing has been introduced, in order to include the approximately 100,000 residents in the energy allowance scheme.

102 . CU: consumption unit (the first person in the household counts for 1 CU, the second for 0.5 CU and the others for 0.3 CU).

The winter respite scheme

A winter respite scheme for all households has been put in place in relation to energy: under this scheme, suppliers are required to maintain supply of natural gas and electricity between the 1 November and 31 March. Energy allowance beneficiaries are also protected from power limitations on electricity supply, and are eligible for a reduction in certain fees (in the case of moving house or non-payment).

In the event that a supply interruption is planned outside the winter respite period, its implementation must be strictly managed for all households (reminder notices, deadlines, social services information by the supplier when the power has not been restored within five days of being cut off).

White Certificate (WC) provisions relating to the component intended to prevent fuel poverty

The LTECV has created a specific obligation to achieve energy savings to benefit households suffering from fuel poverty (eligibility determined based on household income). The first accounting period covered the two years from 2016 to 2017, with a target of 150 TWh_{cumac} (compared to the 'traditional' WC obligation of 700 TWh_{cumac} over the three years from 2015 to 2017). This target has been achieved.

To extend the impetus provided by the introduction in the LTECV of a specific obligation to achieve energy savings to benefit households suffering from fuel poverty, the fuel poverty requirement for the new period of the 2018–2020 WCs has been brought to 400 TWh_{cumac}, in addition to the original requirement of 1,200 TWh_{cumac}, and thus a total of 1,600 TWh_{cumac}. Thus, more than €2 billion should be invested by the energy companies in the prevention of fuel poverty. A decree currently being issued should extend the period by one year (2021) for this annual obligation, thus bringing the total to 2,133 TWh_{cumac} for the 2018–2021 period (1,600 between 2018 and 2020).

The National Housing Agency (ANAH) 'Habiter Mieux' programme

The ANAH is implementing a programme to combat fuel poverty called 'Habiter Mieux'. This programme provides financial assistance and social, technical and financial support to households suffering from fuel poverty in order to carry out energy renovations. The programme is funded from the Agency's own budget (mainly supplied through the sale of carbon allowances), through a contribution from energy companies (EDF, GDF-Suez and Total) and through the income from the tax on vacant dwellings, which increased from €21 million to €61 million from 2019. The Major Investment Plan (GPI) also contributes to ANAH funding, to the tune of €110 million/year in 2018 and 2019, and then €170 million from 2020, for funding of energy renovations.

The beneficiaries of this assistance are the owner-occupiers and co-owners with the lowest incomes, and joint-ownership associations that are in difficulty or disadvantaged (since 2017), as well as landlords, and the assistance is not subject to means testing. The programme covers payments to occupier households of subsidies covering 25% to 50% of the cost of energy renovation works, subject to means testing. The energy gain obtained on completion of the work must be at least 25% for owner-occupiers and 35% for landlords and joint-ownership associations.

In 2019, the total number of heat renovations amounted to more than 106,000 homes. The 2019 programme has been marked by a very strong dynamic on one assistance mechanism (Habiter Mieux Agilité), supported by a possibility of aggregation with the WCs.

The buildings energy renovation plan thus commits €1.2 billion of public funds to combating fuel poverty. In social housing, the objective is to renovate heat sieves at a rate of 100,000 per year, with the support of the Caisse des Dépôts et Consignations, using a range of innovative solutions with a budget of €4 billion under the Major Investment Plan.

Finally, the Energy Renovation Guarantee Fund (FGRE) is scaled to support more than 35,000 households on low income (eco-loans) and 6,500 joint-ownership situations (loans).

4.6. Current French data on R&D in the energy sphere and outlook

4.6.1. Current public funding of R&D in the energy sphere

According to an annual study by the Ministry of Ecological and Inclusive Transition (MTES), energy R&D expenditures funded by the Government in 2018 in the form of subsidies amounted to €1,169 million, of which:

- €515 million on new energy technologies (44%);
- €635 million on nuclear energy, covering both fusion and fission (54%);
- €18 million on fossil fuels excluding carbon capture, usage and storage (CCUS) (< 2%).

New energy technologies include: energy efficiency (in industry, tertiary, housing and transport), renewable energies (solar, wind, marine, bioenergies, geothermal and hydroelectricity), CO_2 capture, storage and utilisation, energy storage, electricity grids and hydrogen and fuel cells, and fundamental science.

The trend over recent years has been to increase the funding of public research in the area of new energy technologies. However, the amounts allocated for innovation for fossil fuels have been drastically reduced, in line with the national carbon neutrality targets for 2050.

4.6.2. Outlook for R&D support in the energy sphere

France is committed to a major process of ensuring the long-term transformation of the economy, which must be more circular, carbon-free and sustainable. Research and innovation are essential components of this process, and are necessary for the development of solutions that are virtuous, competitive and socially acceptable. Thus, research and innovation will remain the cornerstones of national policies on energy transition in the coming years in order to achieve the targets set for 2030.

As stated in Chapter 3.5.3., the three first components of the Investments for the Future Programme (PIA) have enabled very substantial support for innovation for the development of new carbon-free technologies for energy. In particular, the PIA 3, with its allocation of €1 billion specifically for ecological transition, in addition to horizontal tools, driven in particular by the CDC and BPI France, has made it possible to develop projects that are crucial for achieving our targets.

For the future, dialogue has been initiated on the configuration of support tools to follow on from the current PIA instruments. This support, which is expected to be increased, will need to enable the development of technologies that permit large-scale industrial application of carbon-free solutions so that the environmental and climate targets set can be achieved quickly, while providing a competitive advantage for French industry in emerging markets.

At the same time, the law on multiannual research planning is currently being readied for debate in Parliament, which is planned for 2020.

This law addresses three major challenges:

- increasing the funding capacity for research projects, programmes and laboratories;
- consolidating and reinforcing the attractiveness of scientific jobs and careers;
- consolidating partner-oriented research and the French model for innovation.

To achieve this, the multiannual legislative framework will make it possible to:

- consider the **intrinsically lengthy research period** and restore time and visibility for laboratories;
- provide **a consistent, sustainable framework** for the reforms undertaken to leverage the effects of public investment in research;
- prepare a framework that is perfectly aligned with the **Horizon Europe** programme scheduled to commence in 2021;

identify the **major research programmes** to be conducted to meet the nation's needs, while giving appropriate prominence to 'basic' research, which pushes back the boundaries of knowledge.

5. IMPACT ANALYSIS OF PLANNED POLICIES AND MEASURES

5.1. Impacts of planned policies and measures described in Section 3 on the energy system and GHG emissions and removals, including comparison to projections with existing policies and measures (as described in Section 4).

5.1.1. Projections of the development of the energy system and GHG emissions and removals as well as, where relevant, of emissions of air pollutants in accordance with Directive (EU) 2016/2284 under the planned policies and measures at least until 10 years after the period covered by the plan (including for the last year of the period covered by the plan), and relevant Union policies and measures

The 'with additional measures' (WAM) scenario aims to meet the targets set by France in terms of energy and climate, in the short, medium and long term. It develops a possible trajectory for reducing greenhouse gas emissions to achieve carbon neutrality in 2050, the essential target of the scenario. This scenario was used as reference for the 2018 review of the National Low-Carbon Strategy and the MEP. The carbon budget calculation and the guidelines of the SNBC 2 project (described in Section 3) are based on the WAM scenario and projections.

The construction of this scenario was based firstly on an analysis focused on a carbon-neutral France. This served as the basis for an exploration of various potential avenues and the identification of certain essential steps in achieving the country's climatic and energy targets in each of the relevant sectors.

This is a long-term scenario because it covers energy and climate issues up to 2050. In the short term, it explains the possible transformations in the various sectors in view of the public policy measures driven by the Government and the constraints associated with the development of low-carbon technologies and the international macroeconomic context.

5.1.1.1. Summary of the scenario and WAM projections by sector

Transport

The target of neutrality by 2050 means that the transport sector needs to be almost completely carbon-free, either by switching to electric vehicles or by switching to biofuels and biogas. However, a quantity of non-bio-based fuels is still permitted up to 2050 for air transport and international marine bunkers.

It is assumed that demand for mobility is increased but gradually uncoupled from economic growth, and strong assumptions have been made in terms of efficiency and engine type. The scenario utilises all of the following five levers: carbon-free energy consumed by vehicles; energy performance of vehicles to limit energy consumption; control of growth in demand; modal shift; and optimisation of the use of vehicles for transportation of passengers and goods.

Electrification, which is approximately two to three times more effective than internal combustion solutions in terms of vehicle energy yields, is given priority in the long term, in particular for private vehicles (100% of sales of new private vehicles to be electric from 2040). This involves ambitious development, because it assumes a five-fold increase in the number of sales of electric vehicles by 2022 (corresponding to the commitment made in the Strategic Contract for the Automobile Sector for 2018–

2022). In 2030, the number of new vehicle sales in the scenario is 35% electric private vehicles and 10% rechargeable hybrid private vehicles. Major efforts are also made in relation to vehicle efficiency, in particular for internal combustion vehicles. The scenario aims in particular to achieve a level of 4 l/100 km for sales in 2030. New electric vehicles reach a level of 12.5 kWh/100 km by 2050 (approximately 40% less consumption than current figures).

A more balanced mix (renewable gas, electricity, biofuels) is sought for goods transport because of the more significant constraints on engine systems associated with this form of transport. Electrification is slower than for private vehicles. Significant energy efficiency efforts are also undertaken for heavy goods vehicles: depending on engine type, efficiency gains of between 35% and 40% are obtained by 2050.

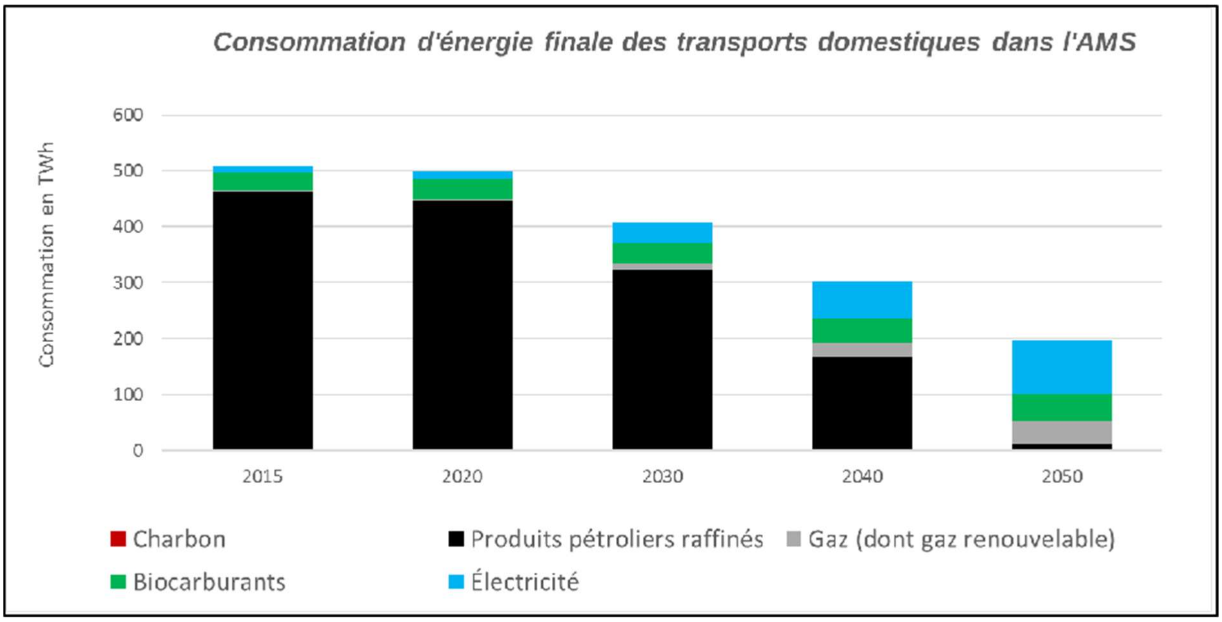
The energy efficiency gains and carbon-free operation apply to all transport modes. In particular, the scenario provides for a gradual development of biofuels in aviation up to a rate of 50% by 2050. Maritime and river transport is fully carbon-free for domestic emissions by 2050 and 50% carbon-free for international bunkers.

The scenario assumes that traffic increases will be controlled for both passenger and goods transport, with a modal shift towards active mobilities, public transport and mass transport along with optimisation of vehicle use.

Passenger traffic in passenger-km for all modes combined increases by 26% between 2015 and 2050 but on a more moderate basis than in a trend-based scenario, in particular because of the development of teleworking and the limiting of urban sprawl. Modal shifts are encouraged. Bicycle’s modal share increases four-fold from 2030. Public transport develops significantly, with growth in corresponding modal share of 7 points, along with shared mobilities and carpooling. In all, this makes it possible to contain private automobile traffic, which falls by approximately 2% between 2015 and 2050.

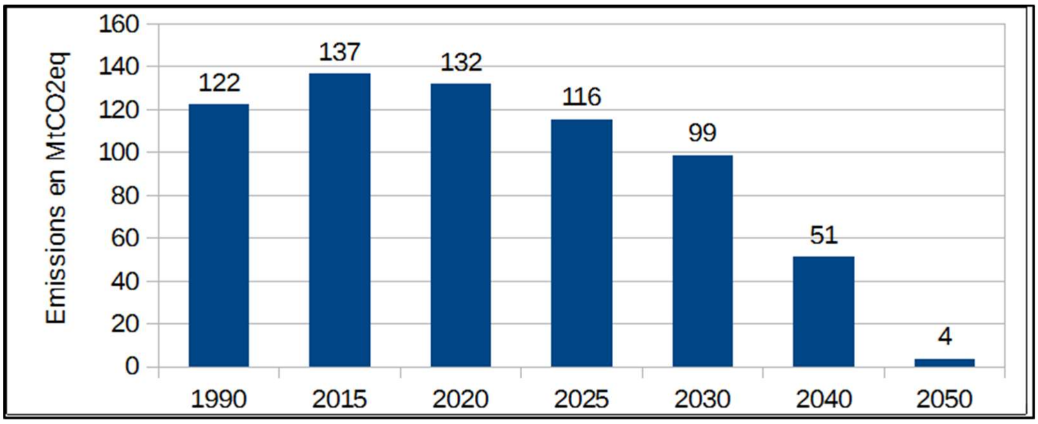
Goods traffic in tonnes-km grows by 40%, but to a more limited degree than in a trend-based scenario, because of the development of the circular economy and short circuits. Rail and river freight develops. The load rate for heavy goods vehicles increases, and the growth in heavy goods traffic is limited to 12% by 2050.

Figure 81: Final energy consumption for domestic transport in the WAM



Consommation d'énergie finale des transports domestiques dans l'AMS	Final energy consumption for domestic transport in the WAM
Consommation en TWh	Consumption in TWh
Charbon	Coal
Biocarburants	Biofuels
Produits pétroliers raffinés	Refined petroleum products
Électricité	Electricity
Gaz (dont gaz renouvelables)	Gas (including renewable gas)

Figure 82: Transport sector emissions in the WAM



Emissions en MtCO2eq	Emissions in MtCO2eq

Buildings

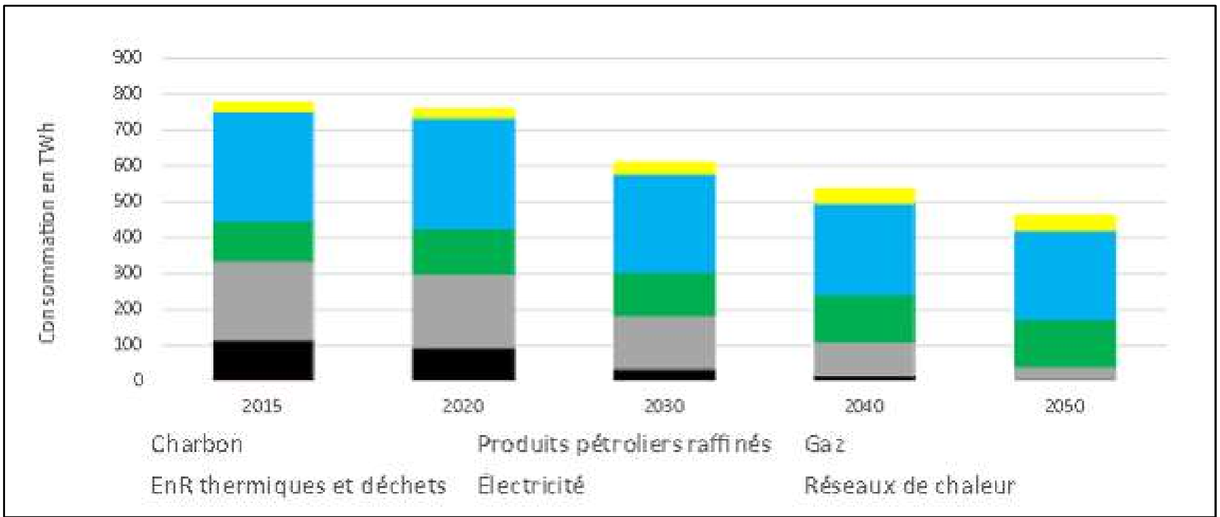
For this sector, the scenario assumes a gradual tightening up of the environmental regulations that apply to new builds, in particular through the introduction of a criterion for GHG emissions over the building's entire lifetime. Demographic assumptions suggest that the volume of new builds continues to fall until 2050.

The scenario also assumes that a large majority of the stock of buildings, starting with the dwellings that consume the most energy, are renovated in order to achieve the target of 100% 'low-energy buildings' on average by 2050. In the residential sector, the pace of renovation reaches around 370,000 full renovation equivalents[103] on average over the 2015–2030 period and then increases to achieve 700,000 full renovation equivalents on average over the 2030–2050 period. The tertiary sector experiences a similar pace of renovation.

The energy mix is fully carbon-free. This is based on the electrification of non-heating uses and a more varied energy mix for heating, in particular with substantial use of heat pumps and district heating systems. Gains in efficiency are assumed for all equipment used in buildings.

The scenario also provides for a fall in the energy requirement for certain items as a result of the dissemination of technologies enabling a reduction (smart management system, effective mixer taps, etc.), a different organisation of buildings (bioclimatic design) and virtuous individual behaviours (heating temperature lowered by 1 °C by 2050).

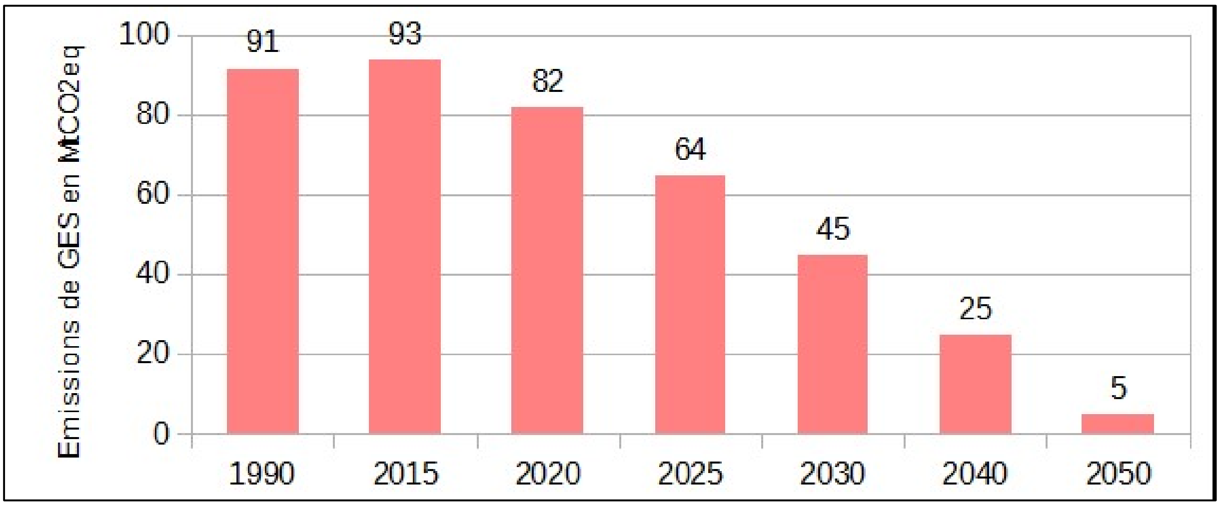
Figure 83: Final energy consumption for buildings in the WAM



Consommation d'énergie finale des bâtiments dans l'AMS	Final energy consumption for buildings in the WAM
Consommation en TWh	Consumption in TWh
Charbon	Coal
Produits pétroliers raffinés	Refined petroleum products
Gaz	Gas
EnR thermiques et déchets	Thermal RE and waste
Électricité	Electricity
Réseaux de chaleur	District heating systems

103 The energy gain achieved during a full renovation equivalent corresponds to the gain achieved during renovation of an entire building to a very high-performance level. The scenario does not provide for any distribution between renovation in stages or all-in.

Figure 84: Building sector emissions in the WAM



Emissions de GES en MtCO2eq	GHG emissions in MtCO2eq

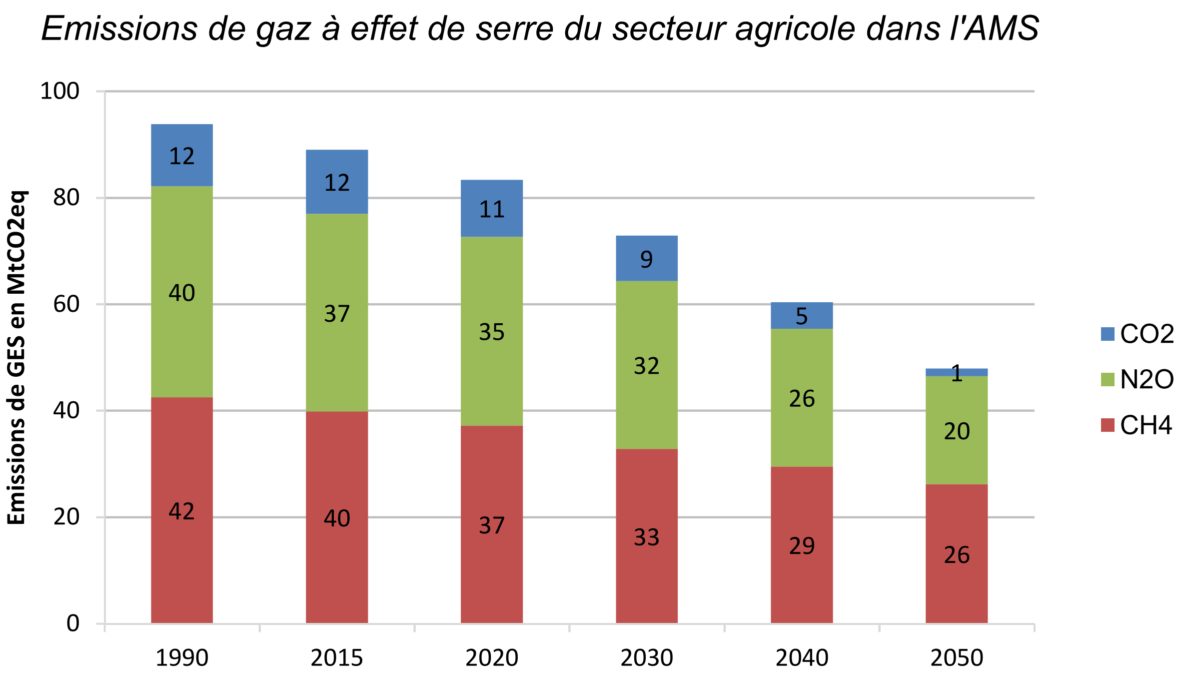
Agriculture

The scenario is based on the implementation of all technical levers to reduce greenhouse gas emissions to their full potential (legume crops, optimisation of the nitrogen cycle, reduction in surplus proteins in animal feed, ploughing practices, etc.), on the development of agricultural systems (agroforestry, bioagriculture, grass-based production, limits on anthropogenic development), the modification of domestic demand (alignment on nutritional guidelines by 2035, fall in food waste) and on the growing production of biosources energy and materials by the agricultural system.

In terms of energy consumption, energy efficiency and the control of requirements make it possible to halve consumption by 2050. Significant electrification takes place through the use of heat pumps or electric tractors where this is possible.

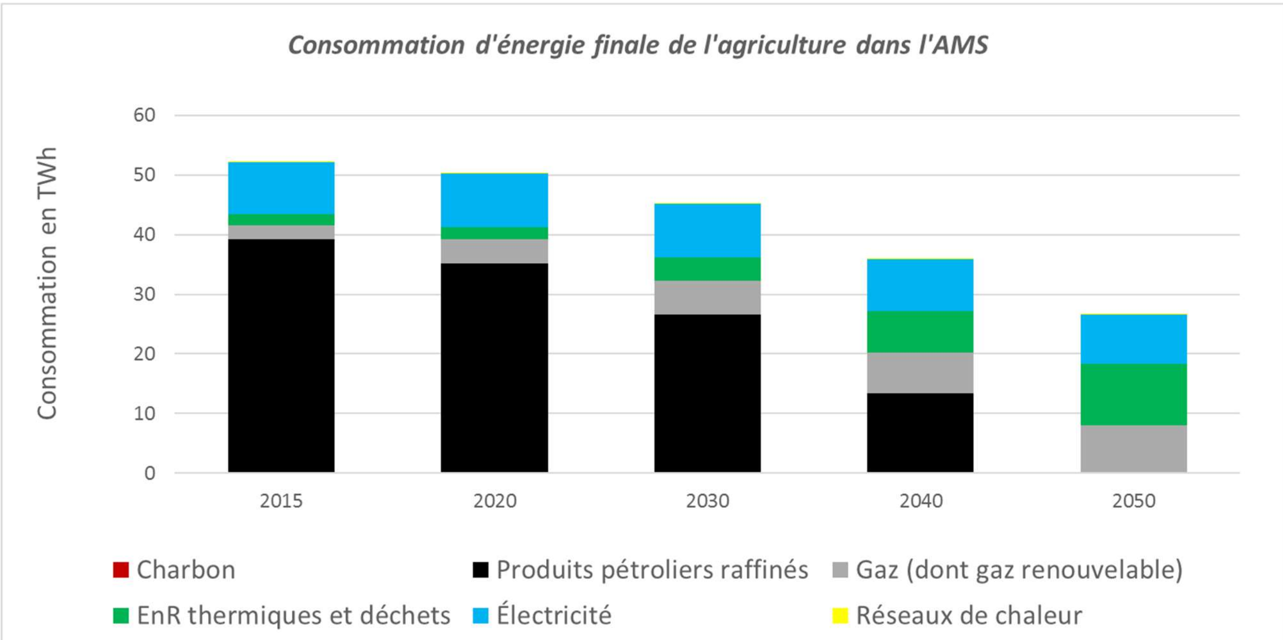
The agriculture sector plays an important role in the production of bio-based energy resources, in particular through waste recovery. Close to two thirds of the biomass mobilised by 2050 comes directly or indirectly from the agricultural sector.

Figure 85: Agricultural greenhouse gas emissions in the WAM



Émissions de gaz à effet de serre dans l'agriculture dans l'AMS	Agricultural greenhouse gas emissions in the WAM
Emissions de GES en MtCO2eq	GHG emissions in MtCO2eq

Figure 86: Agricultural final energy consumption in the WAM



Consommation d'énergie finale de l'agriculture dans l'AMS	Agricultural final consumption in the WAM
Consommation en TWh	Consumption in TWh
Charbon	Coal
Produits pétroliers raffinés	Refined petroleum products

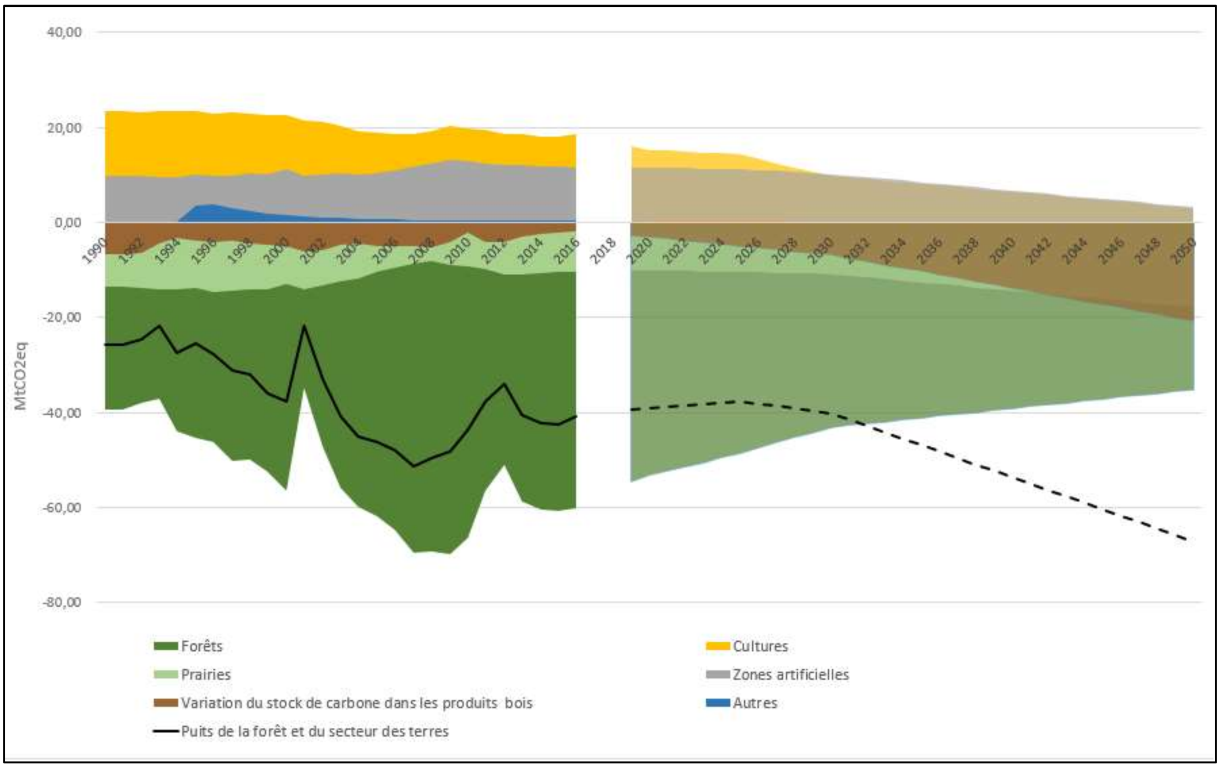
Gaz (dont gaz renouvelable)	Gas (including renewable gas)
EnR thermiques et déchets	Thermal RE and waste
Électricité	Electricity
Réseaux de chaleur	District heating systems

Forests/Land sector

Forests contribute to the scenario as carbon sinks, through the production of bio-based materials that can be substituted for high-emission materials, and through the production of biomass (wood energy, products related to wood processing industries, and wood waste). Smart and sustainable forest management make it possible to gradually increase the carbon pump while improving its resilience to climatic risks and better preserving biodiversity. The forest area increases, encouraged by afforestation. Harvesting increases gradually from 44 Mm³ in 2015 to 59 Mm³ in 2030 and 75 Mm³ in 2050, which requires substantial mobilisation efforts, and goes against the current trend, especially in private forests. The use of wood as a material is very strongly encouraged rather than for energy uses for wood leaving forests. The production of wood products with long lifetimes (especially those used in construction) triples between 2015 and 2050, which increases carbon sinks of wood products. Downstream, better collection of end-of-life wood products makes it possible to increase production of this type of biomass. Ultimately, the carbon sink in the forest and wood sector is maintained despite a drop in the sink in current forests caused by increased harvesting, thanks to the carbon sink for wood products and new forests.

The following graphic shows the changes in the carbon sink in the land sector as a whole, encompassing forest and other land (crops, meadows, anthropogenically developed land, etc.). Through forest management, achievement of the target of zero net anthropogenic development in 2050 and consideration of the carbon stored in agricultural land, this net carbon sink increases between 2030 and 2050, after little change between 2015 and 2030.

Figure 87: Historical (solid line) and projected (dotted line) changes in the forest and land sector carbon sink between 1990 and 2050



MtCO2eq	MtCO2eq
Forêts	Forests
Cultures	Crops
Prairies	Meadows
Zones artificielles	Anthropogenic areas
Variation du stock de carbone dans les produits bois	Variation in carbon stock in wood products
Autres	Other
Puits de la forêt et du secteur des terres	Carbon sinks in forests and the land sector

Industry/waste

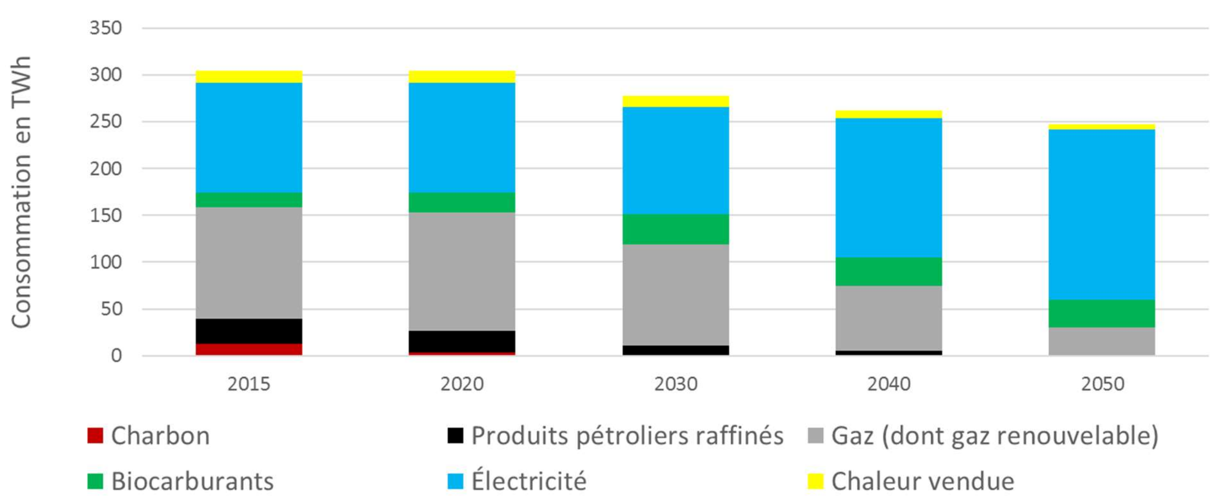
In the industrial sector, the scenario is based on the process efficiency and electrification. Energy efficiency gains vary across sectors. In 2030, the scenario assumes gains of between 10% and 30%. In 2050 gains increase between 20% and 40%. The electrification rate increases slightly between 2015 and 2030 (from 38% to 43%) and then more quickly until 2050, covering more than 70% of final consumption by that date.

A circular economy is introduced, with recycling rates that increase drastically and increased use of ecodesign. Waste is almost entirely recovered.

The industrial sector also sees its non-energy emissions fall thanks to greater use of materials with low carbon impacts (low-carbon cement, bio-based chemistry, carbon-free hydrogen, etc.). More systematic use of wood in materials should also enable a reduction in the use of materials with a higher carbon footprint.

The competitiveness of industry is preserved vis-à-vis competing industries in regions of the world with less stringent climatic requirements, in order to retain a level of production similar to 2015 and therefore limit imports with excessively high carbon content.

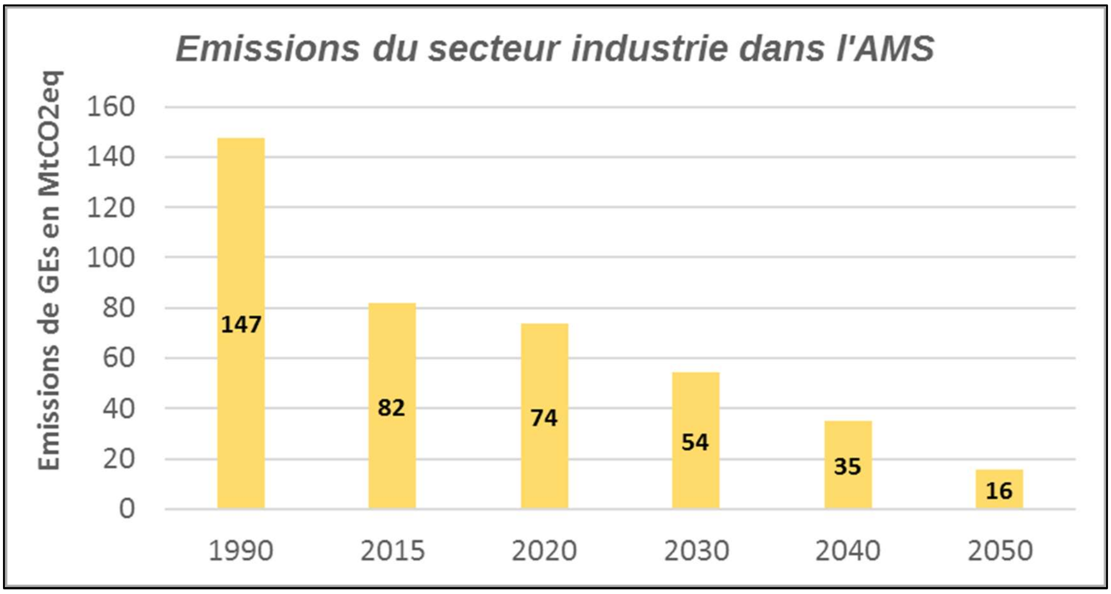
Figure 88: Final energy consumption in industry



Consommation d'énergie finale de l'industrie dans l'AMS	Final energy consumption in industry in the WAM
Consommation en TWh	Consumption in TWh

Charbon	Coal
Produits pétroliers raffinés	Refined petroleum products
Gaz (dont gaz renouvelable)	Gas (including renewable gas)
Biocarburants	Biofuels
Électricité	Electricity
Chaleur vendue	Heat sold

Figure 89: Emissions in the industrial sector in the WAM



Emissions du secteur de l'industrie dans l'AMS	Emissions in the industrial sector in the WAM
Emissions de GEs en MtCO2eq	GHG emissions in MtCO2eq

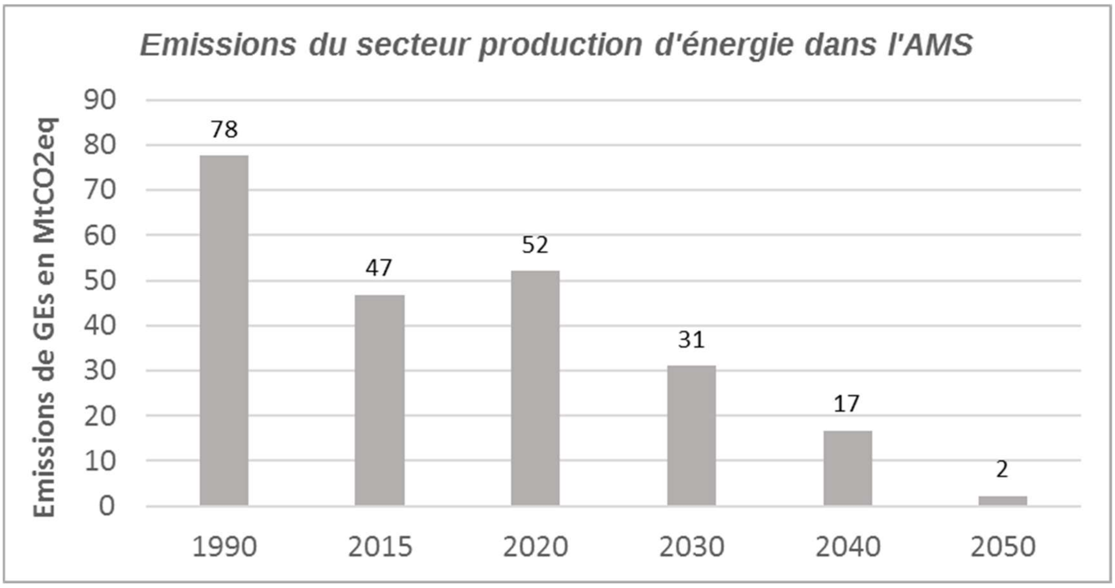
Energy production and CCS

The energy sector is almost completely carbon-free[104]. The energy mix in 2050 is made up of renewable and recovered heat (90 to 100 TWh), biomass (400 to 450 TWh) and carbon-free electricity (balance remaining of 600 to 650 TWh, some of which is used for conversion to other final energy vectors: hydrogen, gas, etc.). In 2050, the production of renewable gas is within a range from 195 to 295 TWh[105]. The share of gas used in the residential and tertiary sectors is decreasing significantly.

Carbon capture and storage (CCS) technologies are also mobilised, on a prudent basis. In 2050, these technologies would make it possible to avoid around 6 $MtCO_2$/year in industry and to achieve a dozen or so $MtCO_2$ each year in negative emissions for biomass energy generation installations (BECCS).

104 The sector is only 'almost completely' carbon-free, given 'unavoidable' residual leakages of renewable gases.
105 The top end of the range corresponds to gas conversion of all non-electrified heavy goods vehicles, all non-electrified consumption of heat in buildings and the production of more electricity from gas. The only remaining would be solid biomass consumption in industry and biofuel consumption in air transport. Hydrogen is included in these estimates.

Figure 90: Emissions in the energy generation sector in the WAM

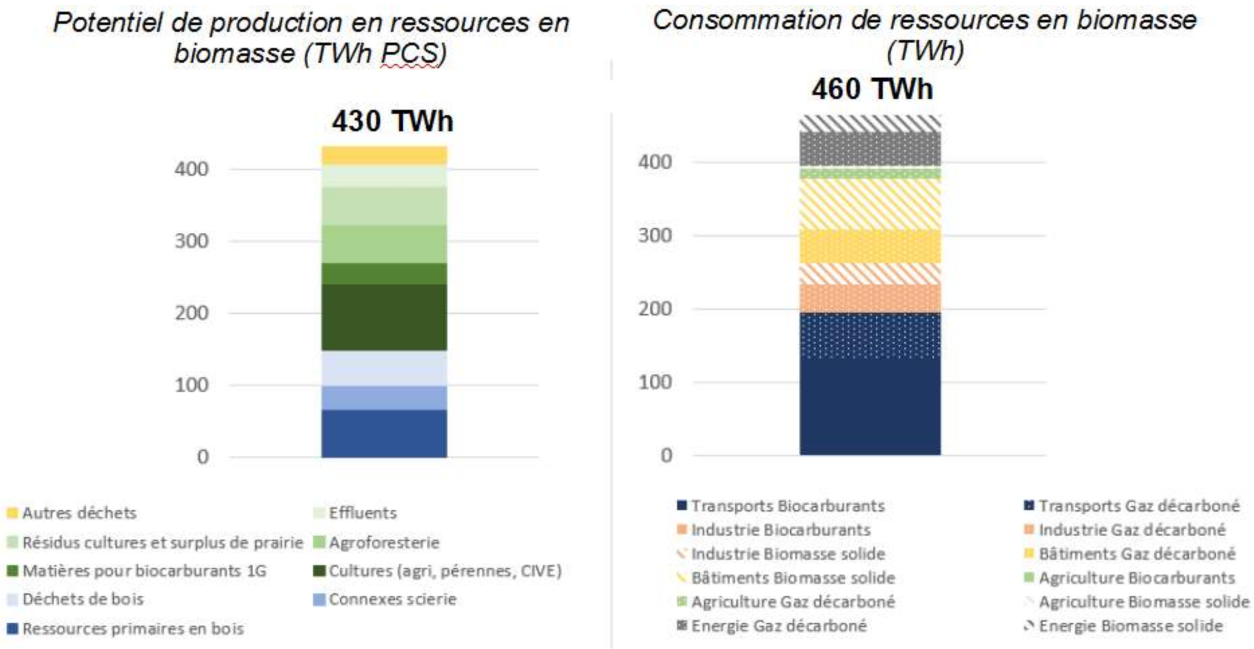


Emissions du secteur production d'énergie dans l'AMS	Emissions in the energy generation sector in the WAM
Emissions de GEs en MtCO2eq	GHG emissions in MtCO2eq

Some lessons drawn from the scenario

Near-total decarbonisation of energy generation needs to be based solely on the following energy sources: biomass resources (waste from agriculture and wood products, wood energy, etc.), heat from the environment (geothermal, heat pumps, etc.) and carbon-free electricity. Given the current structure of the economy and its substantial focus on liquid and gaseous fuels, a certain tension results in relation to biomass resources. These resources have therefore been allocated as a priority for uses with high added value and few possibilities for substitution. The following graphic indicates the indicative distribution applied in the scenario. We can see a slight overrun in terms of consumption of biomass resources compared to potential for production of biomass resources. Works subsequent to the SNBC will make it possible to adjust the scenario on this specific point. This slight overrun does not significantly change the results of the modelling and thus does not undermine the suggested trajectory.

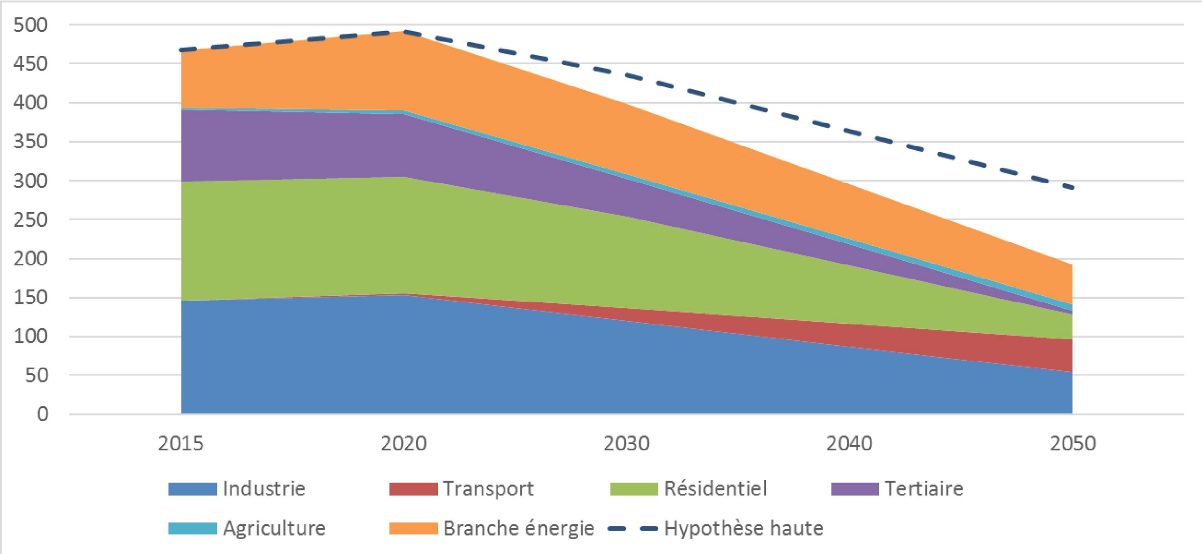
Figure 91: Distribution of potential biomass production and consumption sectors in the WAM



Potentiel de production en ressources en biomasse (TWh PCS)	Production potential in biomass resources (TWh HHV)
Autres déchets	Other waste
Effluents	Effluents
Résidus cultures et surplus de prairie	Crop residues and meadow surplus
Agroforesterie	Agroforestry
Matières pour biocarburants 1G	Materials for 1G biofuels
Cultures (agri, pérennes, CIVE)	Crops (perennial and Intermediate Crops for Energy Purposes)
Déchets de bois	Wood waste
Connexes scierie	Sawmill products
Ressources primaires en bois	Primary wood resources
Consommation de ressources en biomasse (TWh)	Consumption of biomass resources (TWh)
Transports Biocarburants	Transport Biofuels
Transports Gaz décarboné	Transport Decarbonised gas
Industrie Biocarburants	Industry Biofuels
Industrie Gaz décarboné	Industry Decarbonised gas
Industrie Biomasse solide	Industry Solid biomass
Bâtiments Gaz décarboné	Buildings Decarbonised gas
Bâtiments Biomasse solide	Buildings Solid biomass
Agriculture Biocarburants	Agriculture Biofuels
Agriculture Gaz décarboné	Agriculture Decarbonised gas
Agriculture Biomasse solide	Agriculture Solid biomass
Energie Gaz décarboné	Energy Decarbonised gas
Energie Biomasse solide	Energy Solid biomass

The constraint in terms of biomass thus means that gas consumption until 2050 should fall and that, over the same period, electricity consumption should increase, as indicated in the two graphics below, despite the substantial fall in energy consumption within that period. The first indicates the sector-based trajectory of national gas consumption in the case of the low hypothesis of the scenario. Total gas consumption in the high hypothesis is also shown.

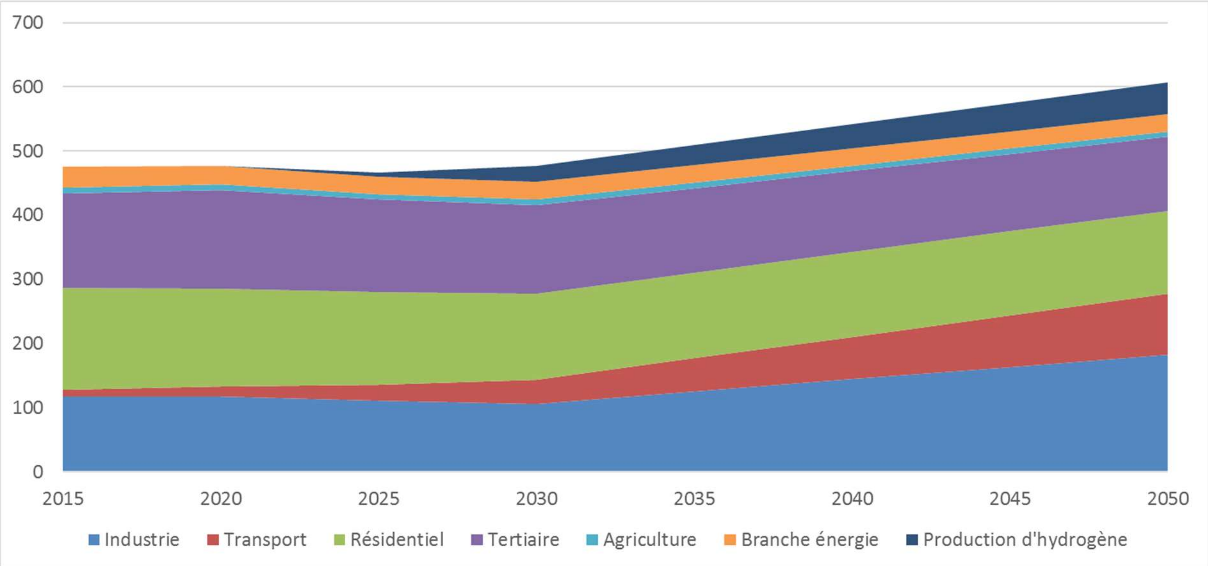
Figure 92: Total gas consumption in the WAM scenario



Industrie	Industry
Transport	Transport
Résidentiel	Residential
Tertiaire	Tertiary
Agriculture	Agriculture
Branch énergie	Energy sector
Hypothèse haute	High hypothesis

The second shows national electricity consumption excluding network losses.

Figure 93: Total electricity consumption in the WAM scenario



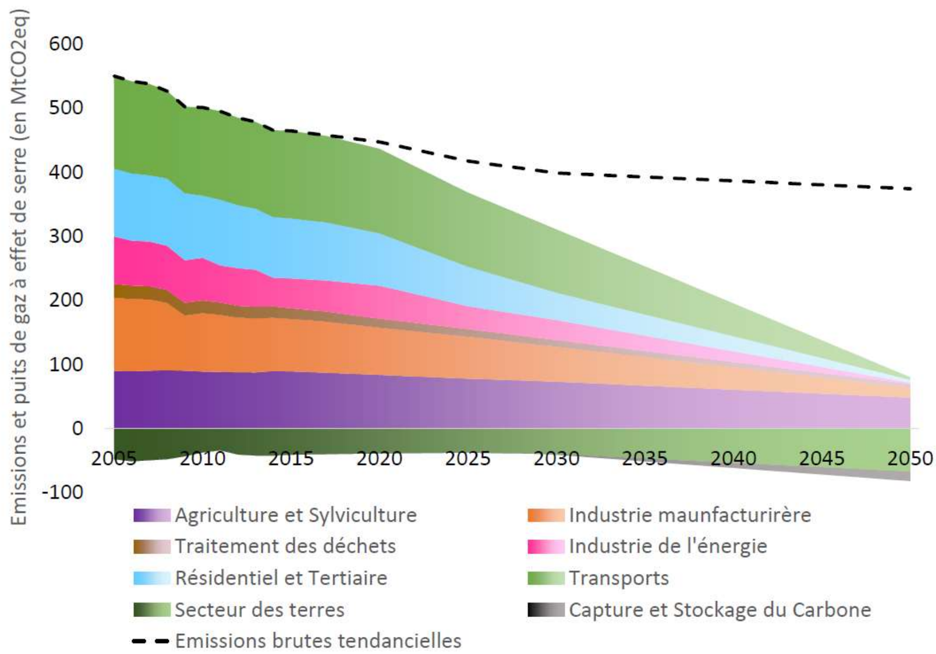
Industrie	Industry
Transport	Transport
Résidentiel	Residential
Tertiaire	Tertiary
Agriculture	Agriculture
Branch énergie	Energy sector
Production d'hydrogène	Hydrogen production

5.1.1.2. Trajectory for reducing emissions in the WAM scenario by sector and compliance with 2030 and 2050 targets

Trajectory for reducing emissions

The trajectory for reducing greenhouse gas emissions resulting from the WAM scenario, broken down by sectors, is described in the following graphic.

Figure 94: Trajectory for GHG emissions and sinks in France between 2005 and 2050 in the WAM scenario



Emissions et puits de gaz à effet de serre (en MtCO2eq)	GHG emissions and sinks (in MtCO2eq)
Budgets carbone	Carbon budgets
Agriculture et Sylviculture	Agriculture and silviculture
Traitement des déchets	Waste treatment
Résidentiel et Tertiaire	Residential and tertiary buildings
Secteur des terres	Land sector
Emissions brutes tendancielles	Gross emissions under the trend-based scenario
Industrie manufacturière	Manufacturing sector
Industrie de l'énergie	Energy industry
Transports	Transport
Capture et Stockage du Carbone	Carbon capture and storage

Reductions in greenhouse gas emissions by sector

The emission reductions by sector to 2050 are shown in the following table:

Sectors	Emission reduction by sector in the WAM scenario **compared to 2015**
Transport	-97%
Buildings	-95%
Agriculture/silviculture (excluding LULUCF)	-46%
Industry	-81%
Energy production	-95%

Waste	-66%
Total (excluding LULUCF)	-83%
LULUCF	64%

Thus, the sectors that are essentially carbon-free in 2050 in the WAM scenario (transport, buildings and energy generation) show the highest emission reductions (more than -95% compared to 2015). Conversely and schematically, the sectors for which unavoidable residual emissions have been considered in 2050 according to current knowledge (agriculture/silviculture, industry and waste) show lower emission reductions.

Although the agriculture and silviculture sector has the lowest emission reductions, the efforts set out in the WAM scenario for this sector are just as ambitious as for other sectors. The assumptions applied to 2050 in fact represent a very substantial change to French agricultural practices compared to 2015, in particular:

- 25% fall in dairy cattle;
- 33% fall in non-dairy cattle;
- 82% fall in surplus nitrogen;
- maximised soil cover, with the following in particular:
  - 84% increase in intermediate catch crops;
  - 60% in intermediate energy crops.

Lastly, the emission reductions in the LULUCF sector clearly demonstrate the assumptions made for this sector, namely maximisation of the carbon pump compared to 2015 (+64%) while mobilising biomass to channel more wood into the economy.

Compliance with greenhouse gas emission targets

This trajectory makes it possible to comply with France's greenhouse gas emission targets for 2030 and 2050:

Deadline	Objective	Reference	Results for the WAM scenario
2030	-40% GHG emissions compared to 1990 (excluding LULUCF and CCS)	The Law on Energy Transition for Green Growth	-43%
2030	-37% compared to 2005 excluding LULUCF and excluding sectors covered by the European carbon market (EU ETS)	2030 Climate and Energy Framework	-42%
2050	Carbon neutrality	2017 Climate Plan	Achieving carbon neutrality (with a margin of 2 $MtCO_2eq$)

Projections for emissions of air pollutants in the WAM scenario

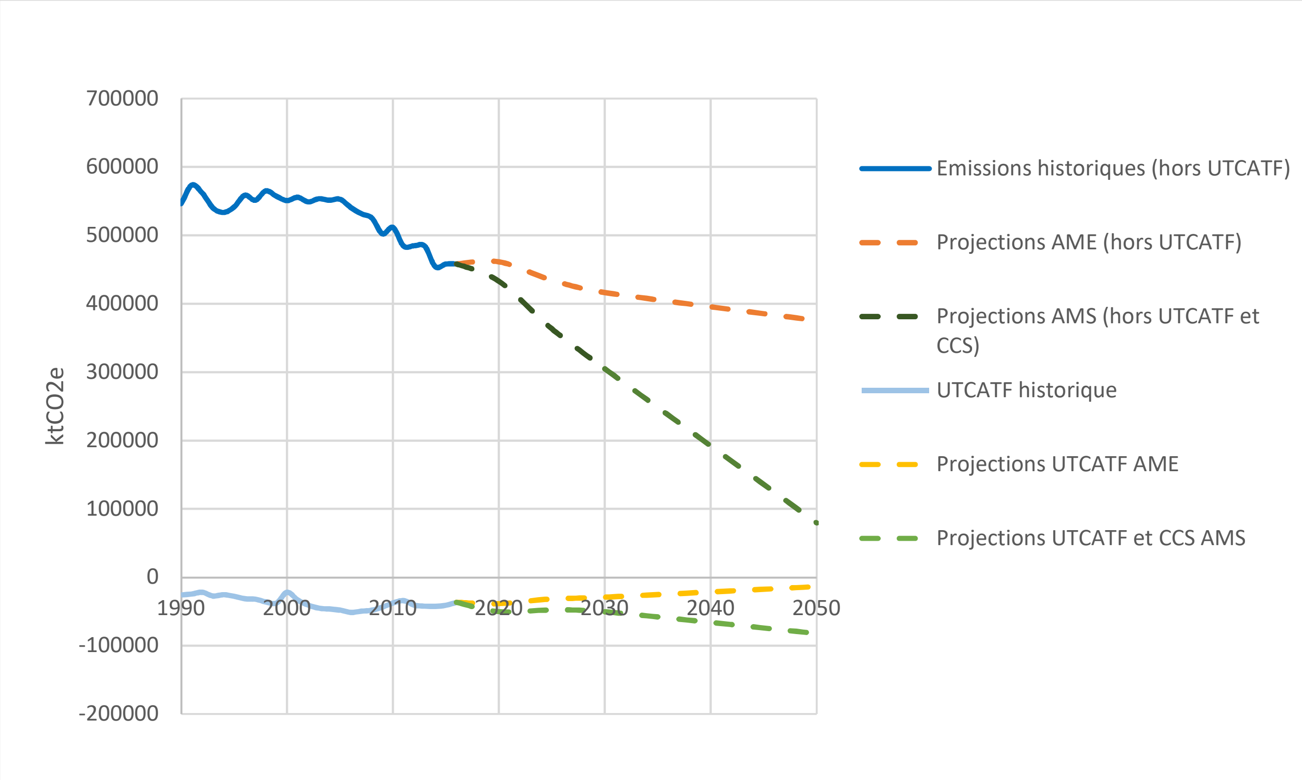
Emissions of air pollutants in the WAM scenario have been quantified.

	2005	2020	2030
SO2 (kt)	457.9	94.8	81.8
NOx (kt)	1416.9	656.5	376.8
NMVOC (kt)	1163.5	590.9	521.1
NH3 (kt)	624.7	596.9	517.1
PM2.5 (kt)	259.7	151.9	118.4

5.1.2. Assessment of interactions between existing policies and measures and planned policies and measures, and between those policies and measures and Union climate and energy policy measures

The following figure makes it possible to compare projections for WEM and WAM scenarios.

Figure 95: Comparison of WEM and WAM projections



ktCO2e	ktCO2e
Emissions historiques (hors UTCATF)	Historical emissions (excluding LULUCF)
Projections AME (hors UTCATF)	WEM projections (excluding LULUCF)
Projections AMS (UTCATF et CCS)	WAM projections (LULUCF and CCS)
UTCATF historique	Historical LULUCF
Projections UTCATF AME	WEM LULUCF projections
Projections UTCATF et CCS AMS	WAM LULUCF and CCS projections

The emissions reductions in the WAM scenario compared to the WEM scenario to 2030 and 2050 are shown in the following table:

Sectors	Emission reductions by sector in the WAM scenario compared to the WEM scenario	
	2030	**2050**
Transport	-21%	-97%
Buildings	-32%	-88%
Agriculture/silviculture (excluding LULUCF)	-11%	-38%
Industry	-26%	-78%
Energy production	-47%	-96%
Waste	-27%	-37%
Total (excluding LULUCF and CCS)	**-25%**	**-79%**
LULUCF	**38%**	**393%**
Total (including LULUCF and CCS)	**-30%**	**-101%**

The WAM scenario drives the efforts to improve energy efficiency and develop renewable energies much further compared to the trend-based WEM scenario, enabling a near total decarbonisation of the transport, buildings and energy generation sectors in 2050.

The sectors for which unavoidable residual emissions have been considered in 2050 according to current knowledge (agriculture/silviculture, industry and waste) show emission reductions that are lower, but nonetheless significant compared to the WEM.

Lastly, the WAM scenario enables a moderate mobilisation of carbon capture and storage (CCS) technology to increase carbon sinks. In 2050, these technologies would make it possible to avoid around 6 MtCO2/year in industry and to achieve a dozen or so MtCO2 each year in negative emissions for biomass energy generation installations.

5.2. Macroeconomic and, to the extent feasible, the health, environmental, employment and education, skills and social impacts, including just transition aspects (in terms of costs and benefits as well as cost-effectiveness) of the planned policies and measures described in Section 3 at least until the last year of the period covered by the plan, including comparison to projections with existing policies and measures

The SNBC-MEP scenario has been subject to a macroeconomic assessment performed by two modelling teams[106] and a social impact analysis on household billing and energy poverty[107]. The main results are available in the report accompanying the SNBC, which is published on the Ministry's website.

5.2.1. Macroeconomic impact

The results of the assessment suggest a double dividend, both economic and environmental, from the long-term SNBC. The energy transition does little to modify the trend-based trajectory of GDP. The energy transition would provide additional GDP in the order of 1% to 2% in 2030 and 3% by 2050 compared to the trend-based scenario. It would also result in the creation of 300,000 to 500,000 extra jobs by 2030 and 700,000 to 800,000 jobs by 2050 compared to the trend-based scenario, in an international context of low-carbon transition and efficient recycling of carbon taxation.

Jobs increase across all sectors of the economy except in those associated with fossil fuels, fossil-fired and nuclear power plants, as well as road goods haulage.

The bulk of indirect and spin-off jobs created are in the tertiary sector, because that sector represents 80% of GDP.

In terms of skills, the Government will support the following, in particular through the Skills Investment Plan (PIC):

- **'skills development initiatives' by professional disciplines (for example, this support has enabled the launch in 2019 of the commitment to expand employment and skills (EDEC) within the electricity sector);**
- **training for job seekers in energy transition professions through a dedicated call for projects called '10k vert';**
- **training development:**
  - **initial training: accrediting ministries will organise a review each year of:**
    - **the development of their diplomas and the degree of integration of interdisciplinary approaches and systemic control, which are essential for energy transition;**
    - **the attractiveness of diplomas covering energy transition;**
    - **the appropriateness of reviewing the diplomas of each Professional Advisory Committee (PAC), subject to advice from professional disciplines; the MTES will continue to inform the work of the PAC from**

[106]CIRED using the Imaclim model and ADEME and CGDD using the ThreeME model.

[107]CGDD using the Prometheus model.

the accrediting ministries in order to ensure that ecological transition is taken into account properly in the associated reference information;

- **in-service training: as part of its future tasks, France Compétences will lead discussions on updating changes in the professional areas and the requirements for adapting professional training throughout life. The various disciplines will be responsible for ensuring the development of the reference systems for their areas and for specific in-service training for their sectors (CQP) when a need for this is identified. The question will be asked at least every two years.**

5.2.2. Social impacts

Energy transition has long-term benefits for household bills, with gains in energy performance winning out over energy price increases. Over the transition period, the impact on household budgets is variable: costs for investment in the renovation of dwellings; increase in energy bills for households with gas and fuel oil heating in poorly insulated dwellings that have not yet undergone renovation; gains on energy bills for households making the transition quickly. While investments in energy transition are profitable in the long term, the transition phase requires support, particularly for lower-income households.

The SNBC 2 and MEP 2 have both been subjected to strategic environmental evaluation.

While households may be impacted, where energy consumption is unchanged, by certain measures intended to promote energy transition, it is crucial to enable them to contribute fully to this transition by protecting their purchasing power. The actions intended to support households to reduce their consumption make it possible to reduce total household bills despite any price increases. The most vulnerable households must be given particular attention, so that energy transition can be an inclusive process.

To achieve this objective, incentives are provided to enable households to improve the energy efficiency of their dwellings and their travel, and to reduce their energy consumptions, and thus their bills. These provisions have three goals:

- **support and encourage households to continue moving towards energy transition;**
- **limit the impact on purchasing power of households;**
- **protect the most vulnerable households, with a view to social justice.**

In this context, several existing measures will be extended and others will be implemented for both housing and mobility. In particular, these measures include tax incentives intended to promote virtuous behaviours, by encouraging users of the most polluting energies to switch to cleaner options. To support households in their efforts to adapt their homes to energy transition, two kinds of measures are introduced:

- **Actions to raise awareness and provide information will be undertaken when the mechanisms are deployed and implemented. For example, this is the objective of the FAIRE campaign, sponsored by ADEME.**
- **Several mechanisms aim to support households in funding improvements in the energy quality of their homes: the primary tools include the CITE tax credit and the 'Habiter Mieux' programme from the ANAH, which has continued to ramp this programme up in 2019. These mechanisms make it possible to support households, prioritising those with the lowest incomes, to perform works to improve the energy performance of their homes, and thus reduce their energy consumption and therefore their bills. These two mechanisms will evolve in 2020 to become more incentive-focused (transformation of the CITE into a**

bonus; merger of this bonus with ANAH's Habiter Mieux Agilité scheme to improve financial incentives for low-income and very-low-income households).

Mobility is the other major pillar of energy transition for households, and is all the more important because the forms and methods of mobility are expected to develop over the coming years. Two far-reaching measures are implemented to accelerate the renewal of the automobile fleet, to promote new, more environmentally efficient vehicles by providing increased assistance to the most disadvantaged households:

- **the bonus for purchasing a new electric vehicle is kept at a high level (27% of the purchase price up to €6,000 for vehicles priced below €45,000 in 2020) while gradually incorporating technology and usage gains, with a maximum budget amount increased by 50% compared to 2019 (€395 million in 2020, maintained in 2021);**
- **in 2018, and then 2019, the bonus has been extended to continue the replacement of a large number of old vehicles with new or used ones with much lower emissions:**
    - **the emission ceiling for eligible vehicles has been reduced to 117 gCO_2/km (compared to 130 gCO_2/km in 2018);**
    - **the bonus is doubled for the households with the lowest incomes and for working people in the first five income deciles living at least 30 kilometres from their place of work or required to travel long distances for their professional activities: €3,000 for a thermal-based vehicle and €5,000 for a rechargeable hybrid or electric vehicle, new or used;**
    - **the bonus is increased to make it more attractive to convert to a rechargeable hybrid or electric vehicle: it is €2,500 for the purchase of a rechargeable hybrid or electric vehicle with sufficient range, new or used, irrespective of income level;**
    - **Crit'Air 1 vehicles are no longer eligible for purchase for the most affluent households.**

Another measure aims to introduce a 'sustainable mobility grant' that will enable private and public employers to contribute to the travel costs to and from work for their employees by carpooling or bicycle. This grant can be up to €400/year and is tax-free and not subject to social security contributions. Bicycle users can also be reimbursed for their travel costs when travelling for professional purposes.

The affirmation of everyone's right to mobility means ensuring that the country has coverage by suitable mobility infrastructures and services, in particular by strengthening the organisation of services by public transport systems or appropriate mobility solutions for certain low-density areas. This also implies constant, careful vigilance of the issues associated with accessibility of these services, in particular for individuals with disabilities or reduced mobility but also for individuals who are vulnerable in economic, social or energy terms, who may require specific support systems.

Alongside these two main measures, the Government is putting in place financial incentives that will make it possible for authorities responsible for organising mobility services to themselves organise or contribute to funding social mobility services, and to pay individual mobility grants, to facilitate personalised support for vulnerable people, especially in terms of access to employment and training.

The gradual development of offers of aggregated distributed curtailment, accompanied by curtailment tenders, will also make it possible to develop new levers for competitiveness of electricity prices for private customers, while using residential electricity consumption to help balance the network, providing increased purchasing power and better control of energy consumption.

To protect the most vulnerable households for the purposes of ensuring social justice, the Government widened the scope of the energy allowance in 2018, with the average amount being higher than the amount of the social energy tariffs it replaces. The amount of the energy allowance has been increased by €50 in 2019, and the number of households eligible has been extended to cover 20% of the households with the lowest incomes, thus an extension of the base by 2.2 million households.

Low-income households can also obtain grants from housing funds in the individual departments. Energy suppliers are also being encouraged to take steps to support disadvantaged groups through the white certificates (WC) for energy poverty, which were extended and increased in 2018. These WC will also make it possible to deploy support programmes for sustainability in isolated areas and for people in situations of economic or social vulnerability.

The fuel poverty obligation for the new period for WC in 2018–2020 has been increased to 400 TWh_{cumac}, in addition to the 1,200 TWh_{cumac} of the traditional obligation, namely 1,600 TWh_{cumac}. Thus, more than €2 billion should be invested by the energy companies in the prevention of fuel poverty, for all sectors combined. A decree currently being issued should extend the period by one year (2021) for this annual obligation, thus bringing the total to 2,133 TWh_{cumac} for the 2018–2021 period (1,600 between 2018 and 2020).

The Government is therefore putting in place tools for households to ensure that the MEP targets are achieved in a manner that is inclusive and socially just.

5.2.3. Environmental impacts of the SNBC

The strategic environmental evaluation of the draft SNBC 2 reveals some probable significant positive effects on the following environmental challenges:

- **The limiting of greenhouse gases**, the primary objective of the strategy, thanks to the guidelines provided for all sectors responsible for emissions or with storage potential.
- **The increased resilience of local areas to climate change and limited natural resources**, thanks to the guidelines relating to regional development and the building sector.
- **The limiting of resource depletion and the development of the circular economy**, thanks to the guidelines on prevention and management of waste, recovery of local resources and promotion of bio-based materials.
- **The preservation of the quality of the soils and water and management of spaces**, thanks to the guidelines in the agriculture and forest-wood sectors intended to reduce pollutions in the soils and increase associated carbon storage. The strategy also proposes guidelines intended specifically to limit the anthropogenic development of the soils. The development of low-carbon processes and technologies and the installation of new infrastructures must, however, be studied carefully to avoid effects in terms of soil and water pollution. The MEP contains environmental recommendations on this issue.

The strategic environmental evaluation also raises several other points for attention, in particular in relation to:

- **The preservation of biodiversity and the consumption of natural, agricultural and forest spaces**. The increased use of biomass may cause indirect impacts associated with an intensification and extension of agricultural and forest production systems. The environmental recommendations made by the National Biomass Mobilisation Strategy are specifically intended to limit impacts of this type.
- **The management of non-energy mineral resources** associated with the development of renewable resources and the electrification of transport (production of batteries, photovoltaic panels, networks, etc.), and the energy renovation of buildings. These issues are considered in

more operational terms in the MEPs, the National Energy Renovation Plan and the France Resources Plan.

- **Air quality**, potentially impacted by the use and burning of biomass, and by building energy renovation actions (maintenance of interior air quality using ventilation systems). This subject is integrated into the SNBC guidelines and addressed more operationally in the National Air Pollutant Reduction Plan and the Housing Energy Renovation Plan. The probable positive impacts of the SNBC on exterior air quality should also be noted, particularly linked to the guidelines on the decarbonisation of energy and the large-scale electrification of transport.

5.3. State of play of investment needs

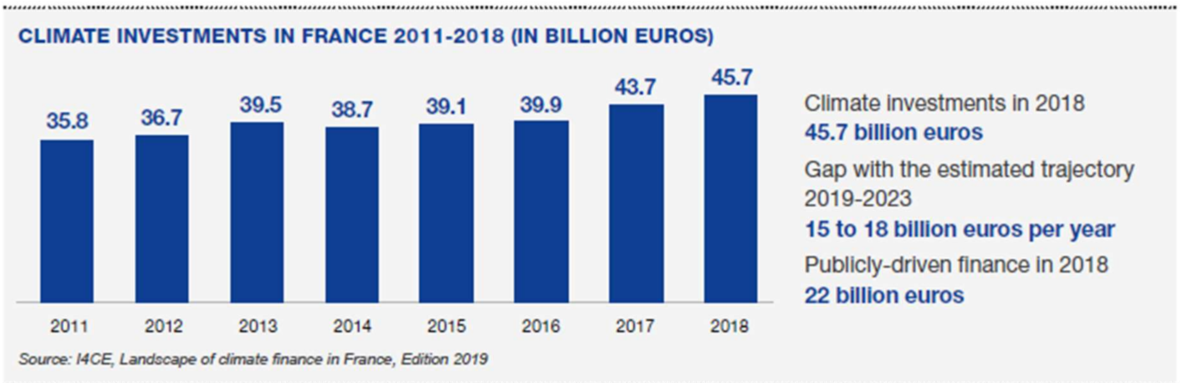
5.3.1. Existing investment flows

Climate investments in France in 2017

The Landscape of Climate Finance is a research programme sponsored by I4CE (Institute for Climate Economics) and supported by ADEME. Each year it gathers information about climate investment expenditures in France and analyses how these expenditures are funded. This analysis covers both private investments, made by households and undertakings, and investments by public bodies: Government, local authorities, social housing providers and infrastructure managers.

According to the Landscape of Climate Finance published in 2019[108], climate investments amounted to €45.7 billion in 2018, an increase of 17% over the last three years and of 4.6% between 2017 and 2018. These investments can be divided as follows: €19.5 billion was devoted to energy efficiency, €11.4 billion to the construction of sustainable infrastructures in the transport and networks sectors, €7.5 billion to the deployment of renewable energies, €4.9 billion to the development and extension of nuclear stocks and €2.3 billion to forests and non-energy industrial processes.

Climate investments in France (in € billion):



Households made 37% of investments, i.e. €17.0 billion in 2017. Their investments were focused in the building sector for the construction and renovation of housing and in the transport sector for the purchase

[108] https://www.i4ce.org/wp-core/wp-content/uploads/2018/11/I4CE-Panorama-des-financements-climat-r%C3%A9sum%C3%A9-2018-FR.pdf

of private vehicles. Undertakings invested €13.6 billion in 2017. They were involved in all sectors, and represented almost all amounts invested in energy generation, industry and agriculture. Investments in the public sector made by the Government, local authorities, social housing operators and infrastructure managers represented €15.1 billion, primarily in the transport sector, for the construction and maintenance of infrastructures.

5.3.2. Budgetary and tax expenditures to prevent climate change

Each year, the Government reports to Parliament on the public expenditures associated with its climate policy in the cross-functional policy document on 'Prevention of climate change'[109]. This document summarises all fiscal efforts made by all Government departments in terms of preventing climate change.

The approach used in the document to report on the Government's efforts is based on the application of a 'climate share' that is intended to capture the actual contribution of a climate change prevention programme. For comparison purposes, the Landscape on Climate Funding described above includes all these investments in its analysis. There is also a difference in scope in relation to research and development expenses, which the Government's policy document covers but are not currently covered by the I4CE study.

According to the 2019 policy document, the total amount of budgetary and fiscal expenditures contributing to preventing climate change was **€10,847 million for 2019** (€9,727 million in budgetary expenditures for commitment authorisation and €1,140 million for tax costs).

Budgetary expenditures contributing to preventing climate change increased by 24.8% between 2017 and 2019, while tax costs fell by 44.9%. The significant fall in tax costs can be explained primarily by the reduction in 2019 in the tax costs associated with the CITE tax credit (52% reduction in the total amount of the tax credit between 2019 and 2017). This tax credit was in fact refocused on the equipment presenting the greatest leverage effects, with doors, windows and insulating shutters being excluded from the scope of the tax credit in 2018 (environmental cost/benefit ratio deemed insufficient).

Certain measures for which financing is covered in the Government's policy document also generate tax revenues. This is the case, for example, for the taxation of the most polluting vehicles (penalty) as part of the automobile bonus/penalty mechanism intended to balance the expenditures generated by the bonus awarded to the most economical vehicles. In addition, since 2017, a portion of the revenues from the domestic consumption tax on energy products (TICPE) is channelled to the special allocation account for energy transition (CAS TE), which is used primarily to fund the support for electrical renewable energies, curtailment of electricity consumption and injection of biomethane.

The climate policy is also based on resource allocations, including a portion specifically funded by actions participating in the climate change mitigation policy without passing through the Government's general budget. For example, the ANAH has been mainly funded since 2013 by the revenues from the auctioning of EU ETS quotas. In 2017, the ANAH was therefore allocated resources generated by the sale of quotas in an amount of €313 million. The ANAH runs the Habiter Mieux programme, which offers support and financial assistance to owner-occupiers with limited resources wanting to undertake renovation works to enable energy gains.

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[109] https://www.performance-publique.budget.gouv.fr/sites/performance_publique/files/files/documents/dpt-2019/DPT2019_climat.pdf

5.3.3. Forward-looking assumptions on investments on the basis of the proposed policies and measures

The quantity of average annual investments required for energy and climate transition is estimated as between €45 billion and €85 billion/year for the next three carbon budgets (2019–2023, 2023–2028, 2028–2032), of which €15 billion to €25 billion is for buildings (primarily in renovation), €20 billion to €50 billion for transport (essentially associated with the development of low-carbon vehicles), and €10 billion is for energy and electricity grids.

The above estimates correspond to the investments necessary for energy transition in the broad sense and take into account, for example, the entire cost of low-emission vehicles or the entire cost of low-emission transmission infrastructures. Within these investments, it is possible to evaluate the portion corresponding to additional costs compared to investments that do not incorporate the energy transition target (consideration only of the additional cost for low-carbon vehicles compared to their internal combustion equivalent, consideration of the 'climate share' of infrastructures in terms of those that also meet other targets). By adopting this more restrictive accounting approach, the additional investment requirements necessary for energy transition are estimated as between €25 billion and €40 billion for the coming three carbon budgets.

The amounts corresponding to the two methods (considering 'total costs' and 'additional costs only') are detailed in the tables below for each of the periods of the carbon budgets (average annual amounts by period), and then for the period to 2050.

'Total costs' method (in € billion/year)

	2019-2023	2024-2028	2029-2033	2034-2050
Buildings	14	18	22	28
Transport	21	36	52	85
Energy and networks	11	10	11	13
Total	46	64	85	126

'Additional cost' method (in € billion/year)

	2019-2023	**2024-2028**	**2029-2033**	**2034-2050**
Buildings	**14**	**18**	**22**	**28**
Transport	**3.5**	**6.5**	**10**	**18**
Energy and networks	**7**	**5.5**	**6**	**8**
Total	**24.5**	**30**	**38**	**54**

It should be noted that some of these investments may generate significant cost savings (for example in terms of carbon-free vehicles or energy renovation). Substantial public and private investments will therefore be necessary to achieve carbon neutrality. This does not mean that new resources will need to be mobilised each time. Some of the investments to be made correspond to expenditures that would have been incurred in any case, for example to build housing and replace the vehicle fleet. The issue is that these investments contribute to the decarbonisation of the economy.