FRENCH STRATEGY FOR ENERGY AND CLIMATE

MULTI ANNUAL ENERGY PLAN

2019-2023

2024-2028

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RÉPUBLIQUE FRANÇAISE

MINISTÈRE
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Introduction

1. Introduction

1.1. Multi-Annual Energy Plan

1.1.1. Nature of Multi-Annual Energy Plan

Multi-Annual Energy Plan (MAEP) establishes the priorities for government action regarding energy policy for Metropolitan France in the next decade, shared in two 5-year periods. Every 5 years the Multi-Annual Energy Plan is updated: the second 5-year period is revised and a subsequent 5-year period is added.

The MAEP is governed by the provisions of Articles L.141-1 to L.141-6 of the Energy Code, amended by the law of 17 August 2015 on the energy transition for green growth. It must cover aspects relating to:

- Guarantee of the security of supply;
- Improvement of energy efficiency and reductions in primary energy consumption, especially fossil fuel consumption;
- Promotion of the use of renewable and recovered energies;
- The balanced development of energy networks, storage and transformation and the management of energy demand, in particular to promote local energy production, the development of smart grids and self-production;
- The preservation of consumer purchasing power and competitiveness of energy prices;
- Assessment of the professional skills needed in the field of energy and adaptation of training to meet these needs.

This Multi-Annual Energy Plan covers two successive five-year periods: 2019-2023 and 2024-2028.

This multi-annual energy plan consists of:

- a decree defining the main energy objectives and action priorities;
- an executive summary of the MAEP;
- this report;
- the strategic environmental evaluation.

This report is an annex of the decree and is of regulatory enforcement.

1.1.2. Legal scope of Multi-Annual Energy Plan

Strategies and planning documents that include energy guidance must be consistent with the guidelines set out in the Multi-Annual Energy Plan.

In particular, the following issues should be consistent:

- the setting of quantitative targets for the launch of tenders for electricity generation plants (renewable energy in particular), for load management capacities or for investments enabling the injection of biomethane into gas networks;
- the definition of the guidelines with which permits for the operation of new electricity generation plants, as well as EDF's strategic plan, must be compatible;
- the definition of the level of security of supply of the French energy system, by fixing the failure criterion used to assess the balance between electricity supply and demand or the criterion for the security of supply of gas and the stocks to be maintained.

1.1.3. Coordination of Multi-Annual Energy Plan with other planning documents

The Multi-Annual Energy Plan is coordinated with different plans, programmes and strategies that break down its action priorities from an operational perspective. The figure below illustrates this coordination.

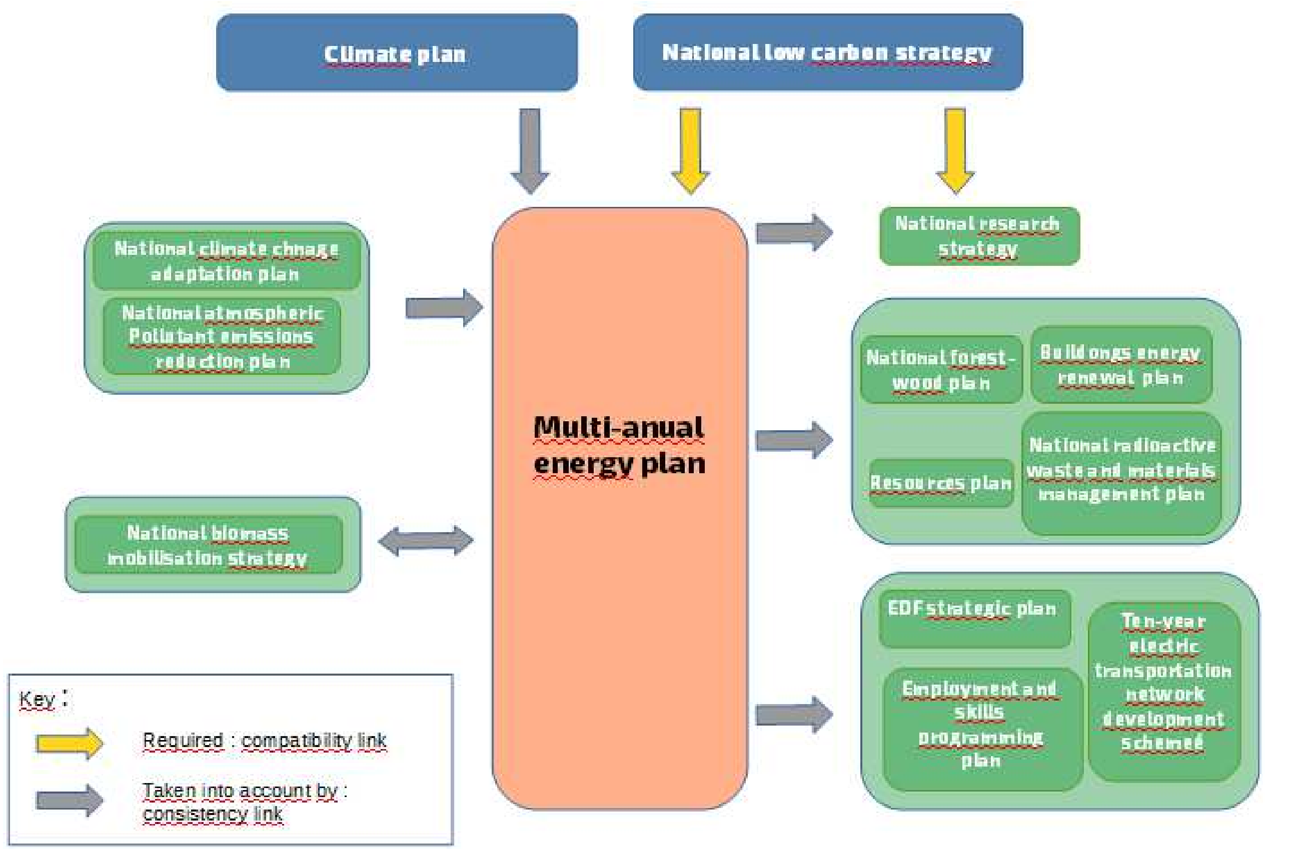


Figure 1. Coordination of the MAEP with other planning documents

National Low Carbon Strategy (SNBC) and Carbon Budgets

The Multi-Annual Energy Plan must be compatible with the greenhouse gas emission reduction targets set by the carbon budgets, in particular for the energy sector, and more broadly with the low carbon strategy (SNBC). This link implies that the MAEP does not include measures that are directly contrary to the guidelines and provisions of the SNBC.

The MAEP contributes significantly to the decrease of greenhouse gas emissions by all the measures dedicated to the decrease of energy consumption, with a priority to the decrease of energies with the highest carbon rate, and by the switch from fossil fuels to renewable energies.

National plan for reduction of emissions of atmospheric pollutants (PREPA)

Energy policy and the MAEP must contribute to meeting the air pollution reduction objectives defined by the PREPA.

The MAEP contributes to the decrease of atmospheric pollutants emissions in the same way it contributes to the decrease of greenhouse gas emissions: by the reduction of the energy consumption, prioritized on energy with the highest carbon rate, and by the switch from fossil fuels to renewable energies.

Plans and Strategies for operational development of the MAEP

Several planning documents provided for by law must be coordinated with the MAEP:

- *The clean mobility development strategy (SDMP)*, which is a component annexed to this plan.
- *The National Biomass Mobilization Strategy (SNMB)*, which aims in particular to develop the supply of energy production facilities, such as domestic wood-burning appliances, industrial and tertiary collective boilers, cogeneration and biofuel production units. The previous national biomass mobilization strategy was approved in March 2018. It will be revised no later than one year following the revision of the Multi-Annual Energy plan.
- *The Employment and Skills Programming Plan (PPEC)*, which will define skills and employment development needs in the territories and in the professional sectors, in respect of the ecological and energy transition. The law stipulates that the MAEP must include a component dedicated to the assessment of professional skills needs in the field of energy and the adaptation of training to these needs: the MAEP will address this matter in general terms and it will be further developed by the employment and skills programming plan.
- *The National Energy Research Strategy (SNRE)*, adopted by the Ministers for Research and Energy, was published on 27 December, 2016. It specifies the energy component of the national research strategy, taking account of the guidelines defined by SNBC and the MAEP. The SNRE highlights the key transformative themes for energy transition. The priority is to increase energy efficiency and reduce the consumption of resources. The development of renewable energies and therefore research into networks (flexibility, interaction between energy systems and storage means, multi-scale governance, etc.) must continue because the integration of renewable energies will transform them in depth. From this perspective, the ecosystem of innovation dedicated to new energy technologies will have a resolutely inter-disciplinary character, encompassing, in particular, the digital revolution and taking account of the socio-economic issues inherent to future changes (associating consumers and territories, developing and deploying training adapted to the professions of the future).

Regional Climate, Air quality and Energy Plans (SRCAE and SRADDET)

The regions are leaders of communities on energy issues. As such, they are responsible for coordinating the action of local authorities on energy. They define their energy policy in their regional development, sustainable development and territorial balance (SRADDET) plans, which follow up the regional climate-air-energy plans (SRCAE), and which must be approved from by mid-2019. The territorial component is developed in part 7.

The coordination between national plans and strategies and local plans and strategies is an important issue for the good steering of the energy transition. The completeness of the coordination would still have to be pursued to find out practical solutions respectful of the legal responsibilities of all concerned authorities.

1.2. MAEP development process

1.2.1. Association of stakeholders

The MAEP review was launched in June 2017 at the same time as the SNBC review, as part of a joint meeting of the MAEP monitoring committee and the SNBC steering committee. The MAEP monitoring committee consists of around 80 French stakeholders, mainly members of the National Council for Ecological Transition (CNTE) and the High Energy Council (CSE). This Committee was convened on 3 times during the year to provide it with an opportunity to comment on the progress of the work.

Workshops on demand side management were shared with the review work of the SNBC. These workshops were held for different sectors. They met 4 times each between June 2017 and June 2018:

- Industry;
- Construction;
- Transport;
- Economy;
- Agriculture and forestry;

In addition, 24 workshops were organized between October 2017 and January 2018, on all the topics specifically addressed by the MAEP. Each workshop brought together 20 to 50 people. The members of the monitoring committee were invited to each workshop, as were experts from structures specialized in the subject to be debated. More than one hundred presentations were discussed and 70 written contributions were shared during these sessions. With regard to the anticipation of energy supply, the workshops were organized by sector:

- Biofuels;
- Biogas;
- Solid biomass;
- Offshore wind / Renewable marine energies;
- Onshore wind;
- Geothermal energy;
- Hydropower;
- Nuclear;
- Solar power;
- Energy recovery from waste.

With regard to energy systems, the workshops were organized by theme:

- Petroleum products supply and demand;
- Gas supply and demand;
- Gas transmission networks, storage and natural gas import infrastructures;
- Distribution networks and new uses of natural gas;
- Housing / Services sector heating;
- Industry / agriculture sector heating;
- Heating and cooling networks;
- Electricity mix;
- Electrical networks;
- Demand management (cut-offs, etc.);
- Self-consumption;
- Storage ;
- Security of electricity and gas supply;
- Recharging infrastructure for alternative fuels.

1.2.2. Public association

A public debate was organized by the National Public Hearings Commission (CNDP) from 19 March 2018 to 29 June 2018. The debate included:

- a debate website, an online questionnaire, stakeholder data logs;
- thematic workshops (Europe-international, innovation, current opinion);
- dispute workshops (between experts) and expert hearings;
- a citizen forum (panel of 400 members drawn by lot);

- territorial initiatives;
- targeted initiatives with partners.

The government has made a project owner's file available to inform citizens about the challenges of the Multi-Annual Energy Plan and to ask them about specific issues: https://ppe.debatpublic.fr/dossier-du-maitre-douvrage-dmo

The issues on which citizen opinion was required were the following:

- the measures that citizens consider effective in terms of reducing energy consumption: what would be the best levers to convince them to take action at home and action in relation to their mobility choices?
- their opinion on the development of the various renewable energy production sectors: wind, solar, anaerobic digestion ...
- their opinions on guarantees in terms of security of supply? What do they think about the way the criteria are formulated? Would other definitions or other levels be more relevant? Would consumers be willing to run a greater risk of a power cut in return for lower energy costs?

At the end, 86 meetings were organized as part of the public debate which brought together nearly 8000 participants. The website has been viewed 47 572 times and has received 561 posts, 140 papers and 193 stakeholders data logs has been published. 2379 comments on the posts and information available and 666 questions were asked by Internet users. The special committee of the public debate drafted a report, available at: https://ppe.debatpublic.fr/

The government followed the contributions of citizens closely throughout the debate. The government decision was taken the 2018, November 30th ,following the recommendations of the CNDP, and published on Official Newspaper on 2018, December 4th. The government has taken into account the knowledge raised by the debate to write this Plan.

1.2.3. Formally collected opinions

Formal consultations will be hols on the MAEP project. The opinions:

- of the Environmental Authority for its Strategic Environmental Assessment;
- of the National Council for Ecological Transition;
- of the High Energy Council;
- the Expert Committee on Energy Transition;
- the CSPE Management Committee;
- the Public Electricity Distribution System Committee;
- bordering or non-bordering countries whose electricity system is interconnected with the French system: Belgium, Germany, Ireland, Italy, Luxembourg, Netherlands, Spain, Portugal, the United Kingdom and the European Commission;
- the public.

The final MAEP will take these opinions into account.

1.3. Objectives to be achieved by the MAEP

1.3.1. The international framework of the fight against climate change.

All countries are concerned by climate change. France has been involved internationally since the start of the development of international policy to combat climate change under the auspices of the United Nations. By approving the Paris Agreement in 2015, the States undertook a commitment to act to keep global warming under 2°C by 2100, by stepping up efforts to avoid exceeding 1.5°C.

The international agreement drawn up under the French presidency deals, in a balanced way, with attenuation - i.e. efforts to reduce greenhouse gas emissions - and with the adaptation of societies to existing climate disruptions.

The “Paris climate alliance” is broken down into 4 components:

1. A universal agreement that establishes rules and mechanisms that can progressively raise the ambition to respect the limit of 2°C;
2. The presentation by all countries of their national contributions in order to create a knock-on effect and to demonstrate that all States are moving, in accordance with their national situations, in the same direction;
3. The financial component helps support developing countries and finance the transition to low-carbon, resilient economies;
4. The strengthening of the commitments of civil society and non-state actors in order to bring all actors together for concrete action without waiting for the agreement to come into force.

1.3.2. The European framework

European energy policy has developed strongly since the 2000s. In particular, several European texts have set targets for:

- limiting greenhouse gas emissions;
- increasing energy efficiency;
- increasing the energy generated from renewable sources.

The guidelines laid down in the MAEP are part of this framework and make it possible to specify the objectives and benefits of the internal energy market.

The climate energy package, adopted under the French EU presidency in 2008, set the "3x20" targets for 2020:

- - 20% GHG emissions;
- 20% improvement in energy efficiency;
- 20% renewable energy in final EU energy consumption.

The European Union has recently adopted targets for 2030, namely the reduction of the EU's greenhouse gas emissions by at least 40% in 2030 compared to 1990. The Renewable Energy Directive sets targets and the framework for the coming decade.

The objective of reducing GHG emissions will be achieved through the revision of the European Trading Scheme (ETS) and the distribution of effort among Member States for non-quota sectors where the objective is to reach at least 32% renewable energy in energy consumption, binding objective at the European level. The directive also provides for a target of 14% renewable energy in transport, with a ceiling for first generation biofuels, as well as new provisions for renewables and recovered energy for heating and cooling.

The text revises the existing directive to adapt it to the post-2020 period. It sets a target of 32.5% for the EU's energy efficiency improvement and extends the provisions of Article 7 (energy saving obligation mechanisms), including a requirement for real energy savings of 0.8% per year beyond 2020.

A new governance regulation now requires each Member States to publish a ten-year integrated national energy-climate plans, which basically match the Multi-Annual Energy Plan and the Low-Carbon National Strategy. In addition to the public consultation, Member States shall consult neighboring countries and the European Commission.

Stronger exchanges are taking place, notably with Germany, with the Benelux countries in the context of the Pentalateral Forum and with Spain and Portugal

Box 1: Cooperation with Germany

France and Germany are committed to ambitious diversification of their electrical mix. These diversifications are based in particular on sustained development of renewable energies, notably solar and wind energy.

The two countries are particularly interconnected, with exchange capacity of 1.8GW for export and 3GW for import (for France). New projects are also underway.

The security of supply of the two countries is interdependent and any decision by one has an impact on the other (border exchanges, security of supply, cost of electricity, etc.).

The two countries are aware of these challenges and are therefore engaged in in-depth discussions on the evolution of their electrical mix in order to share the development outlook and its impacts.

1.3.3. The national framework

The Law on Energy Transition for Green Growth (LTECV) sets the energy policy framework. This framework is very broad and the Multi-Annual Energy Plan must:

- promote the emergence of a competitive, job-rich economy through the mobilization of all industrial sectors, including green growth;
- ensure security of supply and reduce import dependency;
- maintain an internationally competitive and attractive energy price and enable consumer energy expenditure to be controlled;
- protect human health and the environment, in particular by combating the worsening of the greenhouse effect and major industrial risks, by reducing the exposure of citizens to air pollution and by guaranteeing nuclear safety;
- guarantee social and territorial cohesion by ensuring the right of access to energy for all without excessive cost in relation to household resources;
- eliminate fuel poverty;
- contribute to the establishment of a European Energy Union.

The LTECV goes over the European commitments and proposes ambitious national targets in terms of energy:

In 2020: 23% of energy consumption should be from renewable sources;

By 2025: reduce the nuclear share in the electricity mix to 50 % of power generation . The government propose to the Parliament to delay the date to 2035.

By 2030:

- - 40% greenhouse gas emissions (compared to 1990);
- - 20% of final energy consumption (compared to 2012);
- - 30% of primary fossil energy consumption (compared to 2012);
- +27% energy efficiency;
- 32% of energy consumption from renewable sources. This target is broken down by energy vector (40% of electricity generation; 38% of final heating consumption; 15% of final fuel consumption and 10% of final gas consumption must be from renewable sources);
- multiply the amount of heating and cooling from renewable sources and recovery in heat networks by five (compared to 2012).

In 2050 : - 75 % of greenhouse gas emissions (compared to 1990).

The LTECV has adopted national objectives and decided that several multi-annual energy plans will cover respectively the Metropolitan continental France, the Corse, and the over seas collectivities. This document deals with the Metropiltan continental France. The over seas collectivities and the Corse use less than 2% of the final French energy consumption. The objectives adopted in the other plans has a very small impact on the domestic objectives, that is the reason why the objectives of the plan for Metropolitan continental France are the same as the domestic ones.

The law has specified that the MAEP must contain developments on (article L141-2 of the energy code):

1. Security of supply;
2. Improvement of the energy efficiency and decrease of the primary energy consumption, with a focus on fossil energy consumption;
3. The promotion of renewable and recovered energies;
4. The balanced development of networks, storage, flexibilities and to increase local production of energy, the development of smart grids and self-production;
5. The preservation of the purchasing power of final consumers and the price competitiveness of the energies;
6. The assessment of professional skills needs in the energy sector and the adaptation of trainings to the new needs.

This MAEP has a comprehensive approach on all energy consumption for an energetic purpose. It does not deal with energy consumption as raw materials, other policies are in charge of governing them.

1.3.4. Carbon neutrality by 2050: challenges in terms of supply-demand adequacy in energy

The Climate Plan adopted in July 2017 aims to achieve carbon neutrality by 2050. The National Low Carbon Strategy (SNBC) sets out the main guidelines for achieving it. Energy plays a major role in climate issues: in 2016, energy consumption accounted for 74% of French greenhouse gas emissions. That is why meeting this objective depends on the France's ability to:

- develop carbon sinks to offset non-avoidable greenhouse gas emissions from gases other than CO_2;
- get the carbon out of the energy sector in making very ambitious efforts in terms of energy efficiency and sobriety and in replacing all fossil fuels usages by carbon-free energies, energies that do not emit greenhouse gases.

The challenge of the MAEP is to encourage the system to move in this direction by its time-frame: 2028. The government is not betting on mass development of technologies that do not yet exist, but which, alone, would enable carbon neutrality to be reached by 2050. Technological progress will play a role and it is important to focus it properly, but the current system must move towards ambitious actions without simply waiting for or expecting a realistic use of new technologies.

The MAEP and the SNBC are very closely linked: from the point of view of energy consumption and energy mix, the MAEP is devoted to the first 10 years of the SNBC that goes up to 2050. In the MAEP, these 10 years are very practical for government action, when the following years projected by SNBC are only ideas of a possible trajectory to reach the carbon objectives of France. The SNBC also deals with all the other greenhouse gas that are not treated in the MAEP.

Non-greenhouse gas emitting energy sources in 2050

The scenario of SNBC stipulates that by 2050, the final energy requirement could be 1060 TWh, including international maritime and air transport[1]. By 2050 all energy must be decarbonized. This means that there will be only four sources of energy:

1. Non-biomass renewable heat: geothermal, solar thermal, heat pumps; the generation of non-biomass / non-biogas renewable heat could be between 90 and 100 TWh of final energy;

2. Biomass: wood, biofuels, biogas.

   Around 400 to 450 TWh of gross biomass resources could be mobilized by 2050 (compared to 180 TWh in 2016): in the scenario of SNBC, that means mobilization of 230TWh of agricultural biomass including biomass from agroforestry, 100 TWh from forest biomass and 100 TWh from waste, livestock manure and other residues. This is an ambitious mobilization hypothesis, which is rooted in enhanced recovery of the potential of resources

The final usable energy amount depends on the energy vector used:

- the final energy produced by wood used in a boiler room or in a cogeneration plant depends on the efficiency of the installation. Uses that offer the best energy yields and which therefore promote the recovery of heat from biomass should therefore be prioritized;
- the final energy produced by a liquid or gaseous fuel also depends on the energy performance of the application in which it is used; it must also be weighted by a loss resulting from transformation into a usable energy vector. In the scenario of SNBC, this loss is of 20% for gas and 30% for liquid by 2050;

3. Recovery energy: use of fatal heat from industry;

4. Non-carbon electricity produced by renewable energies (hydraulic, wind, photovoltaic, marine energy, geothermal, wood, biogas) or nuclear energy.

   By 2050, the consumption of decarbonized electricity could reach from 580 to 610TWh, loss excluded. To compared, in 2016, electricity production reached 531 TWh, of which 473 TWh was consumed domestically. This demand may be covered by a range of electrical mixes:

   - This 580 to 610 TWh level is compatible with the technical stocks identified for renewable energies, but for the period beyond 2028 would require a major acceleration in deployment rates compared to those envisaged by the MAEP and the availability of new means of storage and flexibility to ensure that the electrical system functions as it should.

[1] . For this work, in international transport, for a Paris-New York journey, for example, only half of the fuel consumption is associated with France, the other half being associated with the United States.

- Keeping the share of nuclear to 50% in 2050, i.e. 250 to 325 TWh, would therefore be lower than current nuclear generation (360 to 420 TWh). Given the age of the current nuclear power stations, this would mean the commissioning of new reactors by 2050.

Energy vector constraints resulting from the source of the need

Some uses can be managed by using a range of energy vectors. In others, different energies are not fully interchangeable, even if the substitution options change over time: for a long time only oil was used to power cars whereas today electricity can also be used. Some uses remain captive: only electricity can supply electronic electrical equipment.

Given current knowledge, known technologies whose dissemination can be reasonably expected, some identified needs can only be satisfied by a specific energy vector while others can use different energies. These choices guide the allocation of resources by sector. In particular, there are strategic choices to be made in relation to the use biomass, which will become a scarce resource in 2050:

- 220 TWh can only be managed by electricity: lighting, powering electrical and electronic equipment. These are known as specific electricity needs;
- 200 TWh can only be managed by solid, liquid or gaseous fuels: air transport (around 130 TWh, liquid fuel), maritime transport (around 30 TWh) and industry for certain specific uses (around 40 TWh);
- 430 TWh can be managed either by electricity or by fuels: industry for non-specific uses (around 200 TWh), passenger and freight road transport (around 100 TWh) and agriculture (around 30 TWh);
- 200 TWh can be provided by any energy vector, including heat.

The vision of the 2050 scenario was built by seeking to minimize primary energy consumption and by considering co-benefits such as air quality and technological plausibility. The SNBC’s 2050 scenario is not predictive - it is a way of achieving carbon neutrality, in the knowledge that there are other possibilities.

By 2050, the 1060 TWh of final energy consumed could be produced as follows:

- 90 TWh by renewable heat (excluding biomass);
- 390 TWh by biomass or other fuel made from electricity including:
  - 110 TWh by solid fuels (wood and other decarbonized fuels) using 110 TWh of raw biomass resources;
  - 100 TWh by liquid fuels (biofuels) using 140 TWh of raw biomass resources;
  - 180 TWh by gaseous fuels (biogas) using 200 TWh of raw biomass resources;
- 580 TWh by electricity (excluding hydrogen production).

2

Improvement in energy efficiency and decrease of fossil energy consumption

2. Improvement in energy efficiency and lower fossil energy consumption

This chapter presents the energy consumption trends in France the last 15 years and analyses the main reasons of the progressions of energy consumption to identify the public policies the government can use to reduce these consumptions.

The scenarios of the projected consumptions in 2023 and 2028 are established with a model including the policies and measures described in this chapter.

The macro-economic hypothesis

A scenario has been elaborated based on macro-economic parameters considered the more likely to happen. As the law ask for, a scenario including different macro-economic hypothesis has also been elaborated. The government has chosen to simulate progressions of the parameters that make the energy consumption raise. The macro-economic parameters that changed are the growth of the population, the GDP and the prices of energies.

Population

The scenario of progression of the French population considered as the most likely to happen is the "central trend" of the scenarios made by INSEE. The other hypothesis is the "high trend" of the scenarios made by INSEE.

Year	2015	2020	2025	2030
Number of people (central trend)	64 293	65 684	66 918	68 064
Number of people (high trend)	64 334	66 058	68 093	70 151

Table 1: Progression of the population in Continental France (in thousands)

Prices of energies

The scenario of progression of the international energy prices considered as the most likely to happen follows the recommendation of the European Commission[2]. The other hypothesis considered prices deflated by 10% each.

	2015	**2020**	**2025**	**2030**
Pétrole (Brent crude oil)	48.19	75.01	85.15	93.8
Charbon (CIF ARA 6000)	11.47	14.31	17.09	20.51
tcam pétrole		9.25%	2.57%	1.95%
tcam charbon		4.52%	3.61%	3.72%
Gaz (NCV, CIF moyenne EU import)	38.8	48.25	52.21	56.77
tcam gaz		4.46%	1.59%	1.69%

Table 2 : Importation prices of fuels (in €2013 /boe)

The modelization of energy prices for final consumers takes also into account the costs of networks, and the taxes, in particular the carbon tax.

[2] « EU reference scenario » of 2016

Taxation

Taxation of carbon for ETS companies

The level of carbon price for companies involved in the emission trading system (ETS) are the ones proposed by the European Commission in the report « EU reference scenario » of 2016. No other alternative has been simulated.

2015	2020	2025	2030
7.5	15	22.5	33.5

Table 3: European carbon price in ETS in €2013 constant/tCO_2

Regarding the non-ETS sectors, some have a specific carbon taxation, the carbon component of the TICPE. Other sectors are exempted or have reduced taxes.

The carbon component of the TICPE

Whereas the carbon price of the ETS system is an output of the European system and is not related to the SNBC measures, the carbon tax is a measure modelized in the scenario: it is supposed to reach 86,2 €/tCO_2 in 2022 and 225 €/tCO_2 in 2030.

Economy growth rate

The technico-economic models use the GDP has a parameter. The GDP is supposed to follow the guidelines of EU for France[3]. The growth rate used is in the lower rate of the scenarios used to anticipate the progression of retirement allowances by the Council for retirement orientation (COR).

2015-2020	2020-2025	2025-2030
1.6	1.3	1.4

Table 4: Annual growth rate of GDP (in market price) in %

The other hypothesis of GDP growth rate simulated is 1.7%/year for the period 2015-2028

Growth rate of the added value of the industry sector : it is the EU benchmark

2015-2020	2020-2025	2025-2030
1.4	1	1.1

Table 5: Annual growth rate of the added value of the industry sector (in%)

The progression of the added value of the industry sector is related to the GDP. The hypothesis done on the progression of GDP has an impact on the progression of the added value of the industry sector.

3. The final macro-economic modelization gives a GDP as output which is different than the GDP used as input. A complete consistency is not yet possible.

Box 2: Modelization of energy demand

The baseline scenario of energy demand of Ministry for ecological and solidary transition (MTES) used in the MAEP is the scenario called "With additional measures" in the SNBC for the corresponding time frame. In the MAEP, two different scenarios are simulated using different GDP, population growth rate and energy price. The difference between the two scenarios gives an idea of the range of extra policies that would be necessary in case of an evolution of the economic context that would increase the greenhouse gas emissions.

The scenario has been projected up to 2050 with results in 2015, 2020, 2025, 2030 and 2050. The results for the periods of MAEP (2023 and 2028) are estimated from these results. The scenarios are built with several models, articulated in 2 steps:

1. Sector's technico-economic models

These models take as input the macro-economic parameters, the trends of technologies costs data and the decided public policies. The energy consumption is an output of the model:

- In the building sector, MENFIS is used to assess energy consumption from household and a model developed by the ministry itself (CGDD) is used to assess the energy consumption for the tertiary sector ;
- In the transportation sector, MODEV gives the traffic assessment and the shares of the different transportation modes. On this basis, the ministry (DGEC and DGITM) makes assessment on the vehicle fleets.
- CLIM'AGRI a model developed by ADEME, gives the energy consumption of the agriculture sector.

2. Aggregation the energy consumption of the different sectors with MEDPRO

The second step is realized with MEDPRO: the results are amended to match with the Energy Bilan for France, and completed with other data. The energy consumption of industry is assessed at this step.

2.1. Decrease of final consumption – Global approach

France's final energy consumption grew steadily until 2001. Since 2001 it has been stabilized, 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, the final energy consumption for energy purposes has slightly decreased. 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.

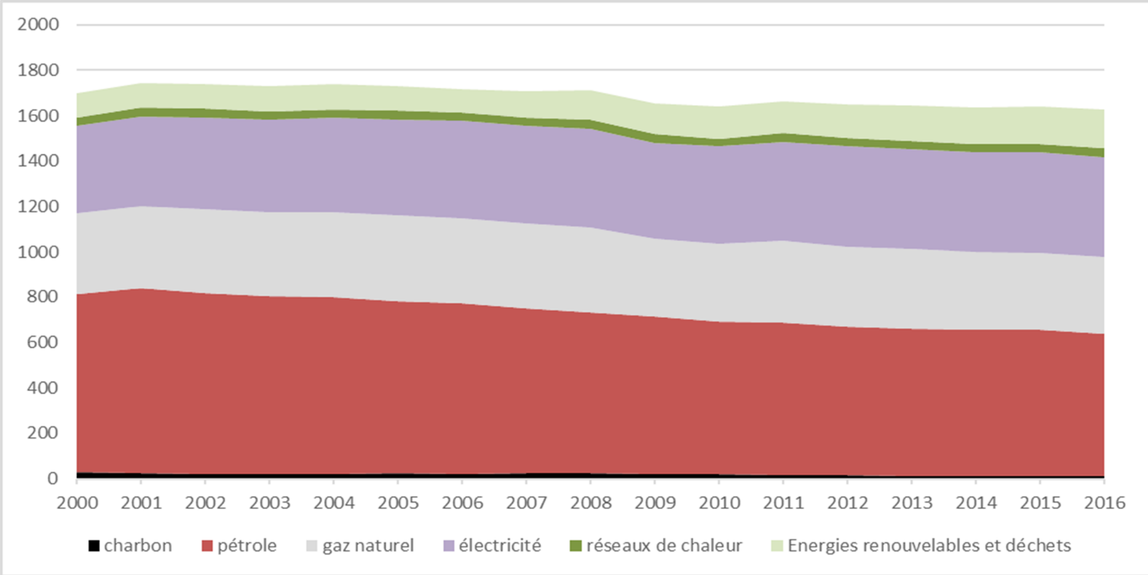


Figure 2: Energy final consumption per form of energy – Data adjusted for climate variations, in TWh
Source: SDES calculations, sources per form of energy

Final energy intensity is the ratio of final energy consumption to GDP (Gross Domestic Product). The lower the indicator, the more added-value the economy produces from the use of energy. The average annual decrease in energy intensity is now at -1.4% per year.

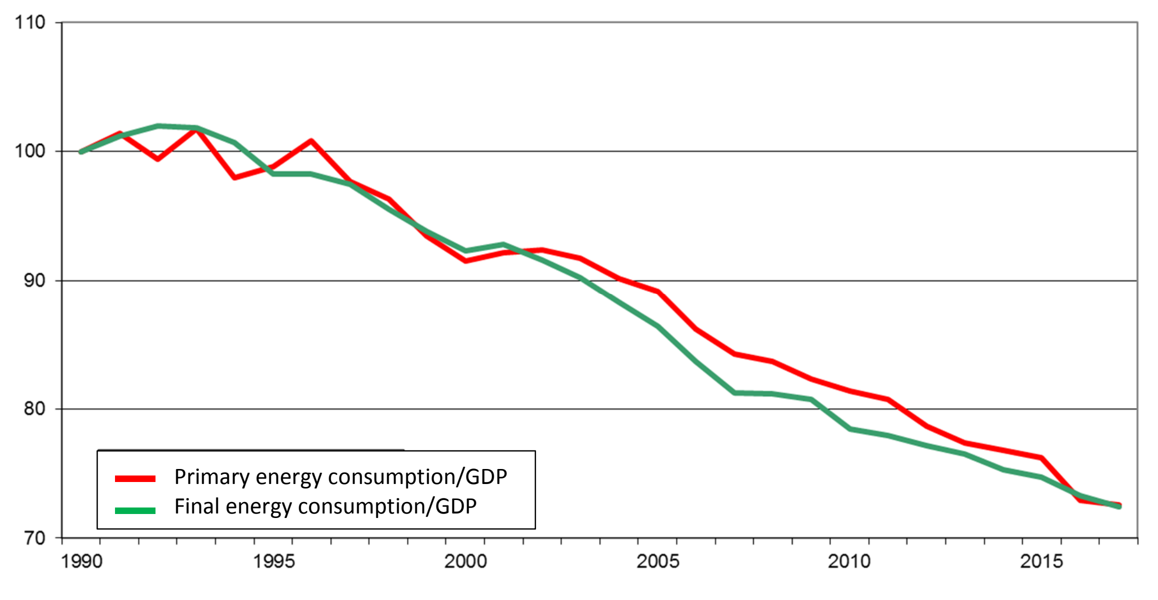


Figure 3. Progression of final and primary energy intensity 1990-2017 (source: SDES)

Pursuant to Article 3 of directive 2012/27/EU on energy efficiency, France has set itself the dual objective of reducing its energy consumption to 1528 TWh of final energy and 2557 TWh of primary energy in 2020 (excluding international air transport, excluding non-energy uses). In 2016, final energy consumption for energy use (excluding international air transport), corrected for climatic variations, is 1633 TWh. The graph below describes the progress made towards achieving these objectives (data corrected for climate variations - expressed in base 100).

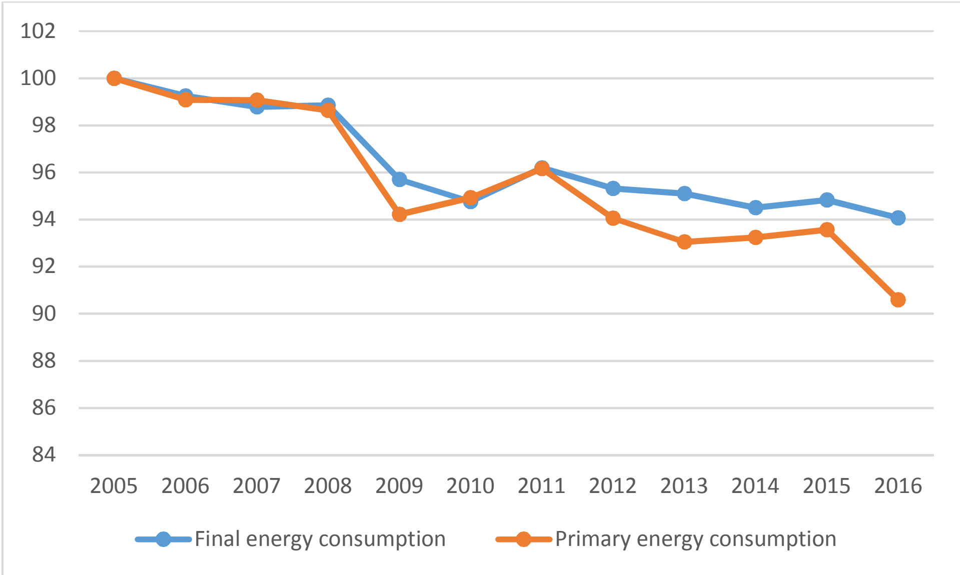


Figure 4: Progression of final energy consumption and primary energy consumption (base 100 index in 2005) – Source SDES

While France is globally in a process of reducing its final energy consumption, the current pace is insufficient to reach the 2020 target of the Energy efficiency directive. The central SNBC-MAEP (National Low Carbon Strategy & Multi-year Energy Programme) scenario in its current version specifies that the objective for 2020 would not be reached until 2026. Achieving the objectives for 2020 would require a rapid increase in new or existing measures.

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).[4]

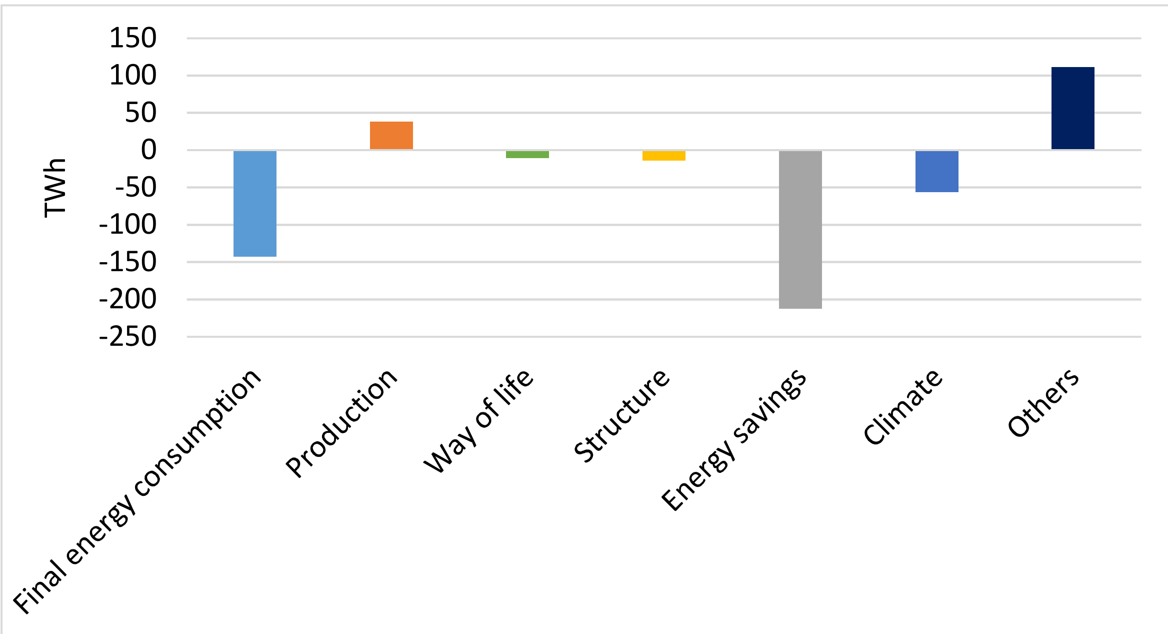


Figure 5. Breakdown of the progression of final energy consumption in France between 2005 and 2015 (in Mtoe) (Source: Odyssée, 2018)

4 http://www.indicators.odyssee-mure.eu/decomposition.html

The overall amount of the market for energy services and energy efficiency, excluding energy supply, is estimated at €8.4 billion in 2015 (nearly €13.5 billion including the supply of energy and the services contributing to energy efficiency).

	Energy supply (1)	Services contributing to energy efficiency (2)	Energy services (3)	Energy efficiency services (4)	Total
Asset analysis		403			403
Design and engineering		1748			1748
Operation	2861	-	6866	1577	11304
Total	2861	2151	6866	1577	13455

(1) Example: energy supply for collective boilers; (2) Example: energy performance diagnosis, energy orientation advice; (3) individual heating maintenance; (4) Example: tertiary and industrial metering.

Table 6. Summary of markets related to energy services and energy efficiency (in millions of euros) (Source: ADEME/ GALLILEO – 2016)

The energy audits and diagnostics market was valued at €212 million in 2015. Energy efficiency services related to metering and sub-metering represent a market of €232 million. Energy services linked to the operation of collective heating systems (excluding energy supply) are valued at €2.8 billion, and energy efficiency services for these boilers represent a €1 billion market. The Energy Performance Contracts (EPC) market is valued at €208 million, plus €60 million related to EPCs agreed under public-private partnerships for public lighting.

The reduction of energy consumption is the first pillar of the energy transition. This is why the measures to be taken must be suitable for meeting the challenge of bringing about changes in behaviour and decision-making.

In 2016, the final energy consumption was :

	Coal	Oil products	Gas	Thermal renewables and waste	Electricity	Heat sold	Total
Industry	11	26	114	18	117	16	302
Transport		462	1	35	11		509
Residential	0	67	140	105	159	14	486
Tertiary	1	33	80	10	146	9	279
Agriculture		39	3	2	9		52
Total	12	588	335	168	433	39	1628

Table 7: Final energy consumption per sector and type of energy in 2016 (TWh)

Pricing carbon fairly across the whole economy

The price of carbon must induce changes in the decisions made by energy consumers in their purchases or uses. It must also serve to accelerate the development of efficient technologies by making them more competitive than those using more fossil fuel. The climate plan had set a developmental trajectory for the carbon component of energy taxation, rising to € 86/tCO_2eq in 2022. Following the cancellation of the rise for 2019, a new trajectory will have to be defined, up to 2022, as well as over the second period of the PPE. This taxation has to be coupled with support measures for transition so they appeared to be efficient and equitable.

The current carbon component does not cover energy-intensive industries subject to international competition which fall under the European Emissions Trading System (ETS). The quota market price, however, is not yet sufficient to induce major changes to modes of production. France supports in particular the implementation of a floor price mechanism for the carbon in electricity at European level to speed up the decarbonisation of industry.

A transversal action for energy efficiency: Energy Saving Certificates

Energy efficiency improvements rely principally on a market device: the Energy Saving Certificates (Certificats D'Économie D'Énergie, CEE). They put the supplier under the obligation to carry out energy efficiency actions, directly or indirectly. Each energy-saving action triggered as a result of the CEE scheme is credited with certificates which can then be exchanged to meet the obligation. This system enables discounted cumulative savings of about 530 TWh of energy per year by generating investments of between € 2 and 3 Bn. The industry, local authorities and citizens benefit from it in addition of other targeted public policies incentives.

The PPE plans to extend the CEE scheme over the whole period covered, progressively increasing the goal based on estimated savings potential.

The energy scenario projected the final energy consumption in 2028. The figure below shows the area in which the final energy consumption would probably be, the two curves giving the higher and lower situations depending on the macro-economic contexts. The sectoral trends are developped further in next sections. In the central trend, the MAEP allows to reduce final energy consumption by 14% in 2028 compared to 2012.

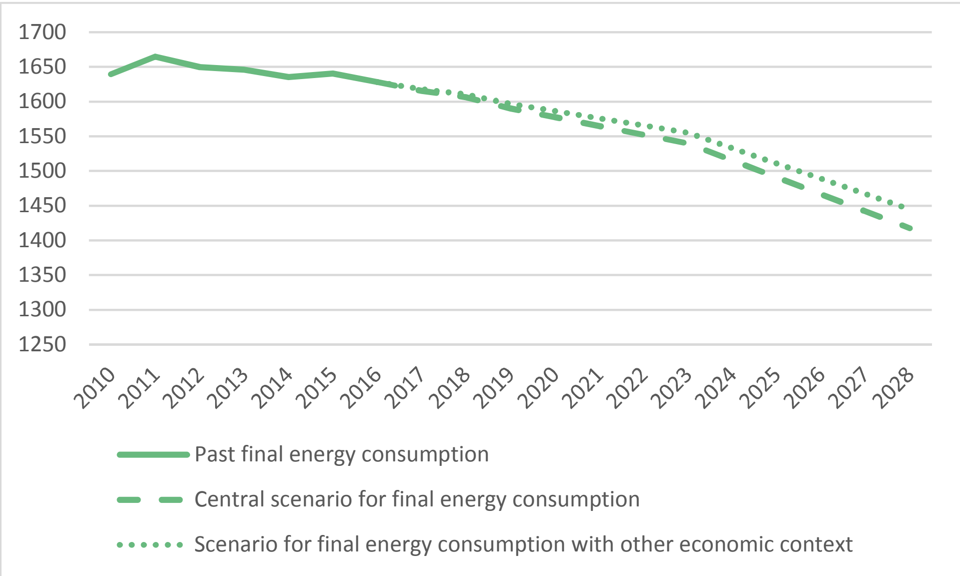


Figure 6: Past final energy consumption (2010-2016) and scenarios (2016-2028) of final energy consumptions expected with the implementation of the MAEP (TWh)

The table below summarises the targets for final energy consumption to be achieved as a result of the energy management measures (including the measures developed in the sectoral section).

Targets for lower end-use energy consumption and measures

	2017	2023	2028
Final energy consumption (TWh)	1643	1540	1420
Reduction percentage compared to 2012	0.4%	6.60%	14%

To meet these targets, sectoral measures will be taken in addition to cross-cutting measures:

- Define a new carbon price trajectory (carbon component of the energy tax) that takes into account feedback from the big national debate of the 1st quarter of 2019;
- Define between now and the start of 2020 the goal and methods of the next two periods of the Energy Saving Certificates (CEE) scheme based on an analysis of energy saving potentials;
- Support an ambitious and effective European policy on the eco-design of energy-related products and energy labelling for these products;
- Push for a floor price mechanism for the carbon in electricity at European level, as well as setting a price for carbon for all sectors that fall outside of the European carbon trading scheme.

The measures have been decided to answer to the baseline scenario. If ever the economic context would be different, with the same measures, the final energy consumption could be 34TWh higher in 2028, that is a rise of 2.3% of the consumption. The French government will pay attention to the evolution of the final energy consumption and will assess if new measures are necessary to reach the adopted target.

2.2. Lower final energy consumption – Sectoral approach

The sectors do not all have the same impact on final energy consumption: the two major contributors are transport and tertiary-housing, followed by industry. Energy consumption in industry declined in 2008, during the crisis, and has been stable since. Energy consumption in transport and tertiary housing is stable.

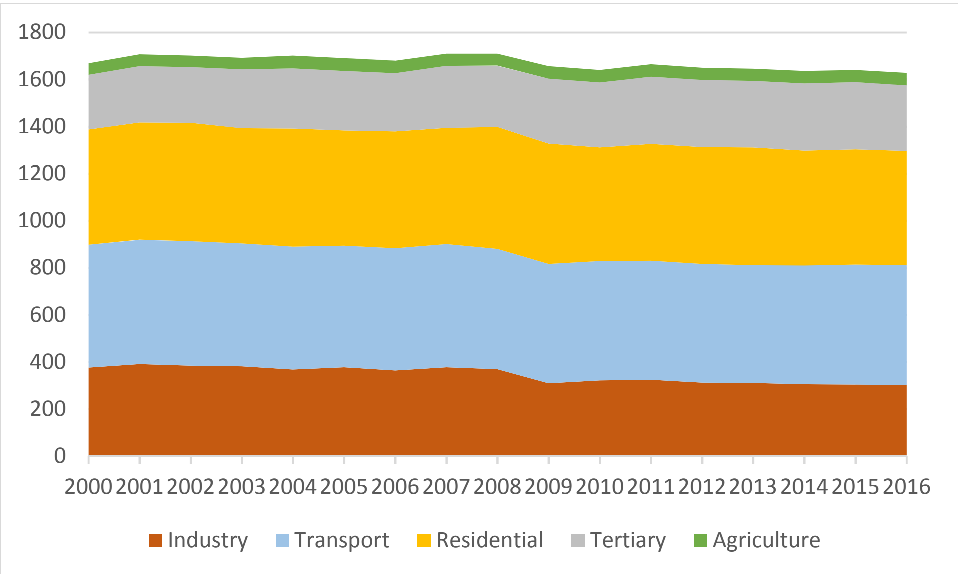


Figure 7: Evolution of final energy consumption by sector – Data adjusted for climate variations, in TWh
Source: SDES calculations, sources per form of energy.

2.2.1. Building sector: residential and tertiary

Residential

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.).

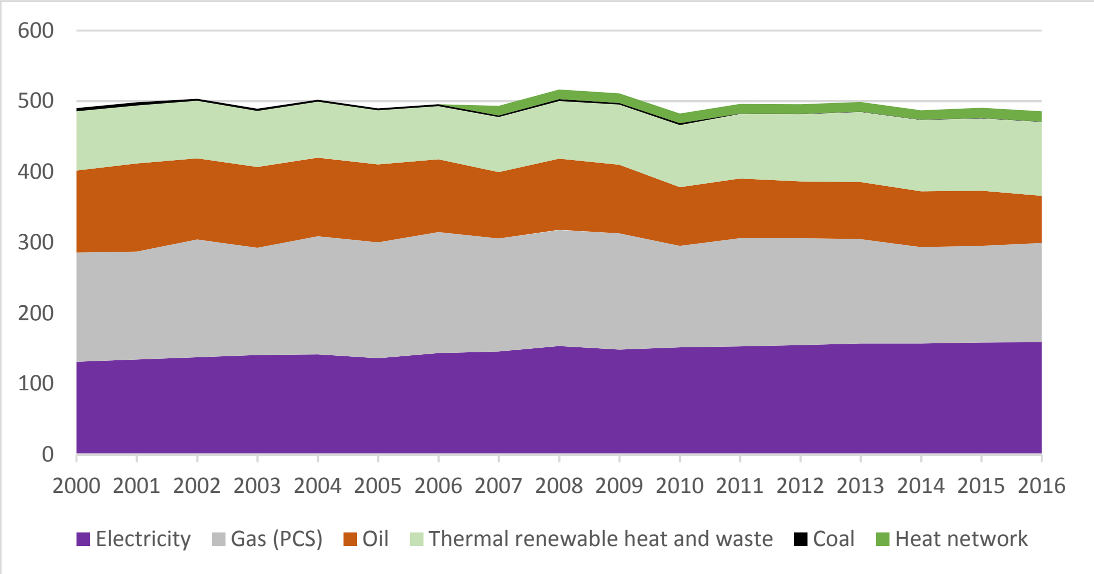


Figure 8: Final energy consumption in the residential sector – Data adjusted for climate variations, in TWh
Source: SDES calculations, sources per form of energy5.

In 2016, real energy consumption in the residential sector, which was largely related to heating needs, jumped 5.1% due to harsher weather than in 2015. It stood at 468.7 TWh. Adjusted for climate variations, it decreased by 1.0%, after having been stable overall between 2007 and 2015.

5 . Heat from heating networks has only been isolated since 2000.

Box 3: The Plan for energy renovation of buildings

The Plan for energy renovation of buildings makes the energy renovation a national public priority. It decides:

- To create a guarantee fund of more of 50 millions euros to help 35000 low-income households each year;
- To simplify the incentives for everyone, switching from a tax refund to a bonus and adapt the 0% green loan;
- To get reliable the energy labeling of houses, energy efficiency diagnosis to install confidence;
- To train professionals and control the quality of works with a reform of the labeling RGE (validated for environment), with an investment of 30 millions euros in the professional training and 40 millions euros in innovation;
- To promote a large renovation program in public buildings of State end local authorities with a budget of 4.8 billions euros.

The government will dedicate 200 millions euros to implement the renovation plan with the white certificate scheme.

Tertiary

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.

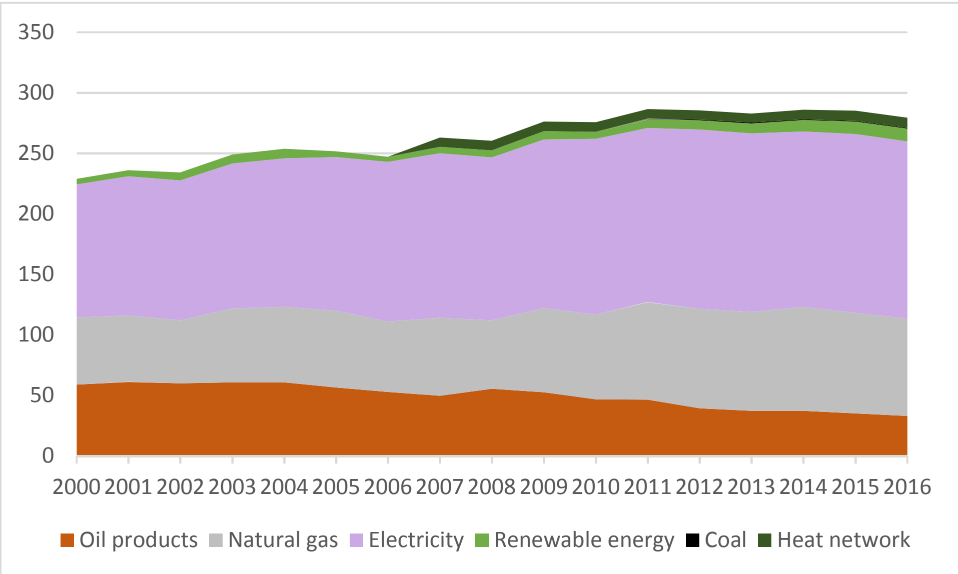


Figure 9: Final energy consumption in the tertiary sector – Data adjusted for climate variations, in TWh
Source: SDES calculations, sources per form of energy

In 2016, real energy consumption in the tertiary sector increased by 1.7% to 279 TWh. Adjusted for climate variations, it decreased by 2.0%. Confirmation of this reduction would mark a reversal of the trend compared to the 2000s, a decade in which consumption grew almost steadily before stabilising from 2011. This reduction is likely due both to efforts to control consumption in existing buildings and by the improved thermal performance of new buildings.

Towards a decrease of 12% of energy consumption of building sector and an increase of 50% of renewable heat in 2028

In the baseline scenario, the raise of requirements from energy regulation for new buildings is introduced in the via a maximum greenhouse gas emissions of the buildings through their life cycle.

There will be 300000 complete renovation equivalent[6] each year during 2015-2030 (that means approximatively 1 million renovation acts[7] act each year).

The energy mix trend is less and less intensive in carbon with more usage of heat pumps and urban heat networks. The scenario supposes that buildings equipements are getting more efficient.

The scenario integrates also a decrease of energy needs on some usages thanks to the spread of new management technologies (smart management system, efficient mitigator…), a different organization of buildings (design…) and virtuous behavior (heat temperature lowered by 1°C in 2050).

The energy scenario projected the final energy consumption in 2028. The figure below shows the area in which the final energy consumption would probably be, the two curves giving the higher and lower situations depending on the macro-economic contexts.

[6] The energy improvement realized with a complete renovation is the energy improvement realized when renovating a building at an efficient level. The scenario doesn't differentiate renovations done at once or in several times.

[7] The quantity of acts of renovation include any act realised on opaque wall (wall, roof…), but not on windows.

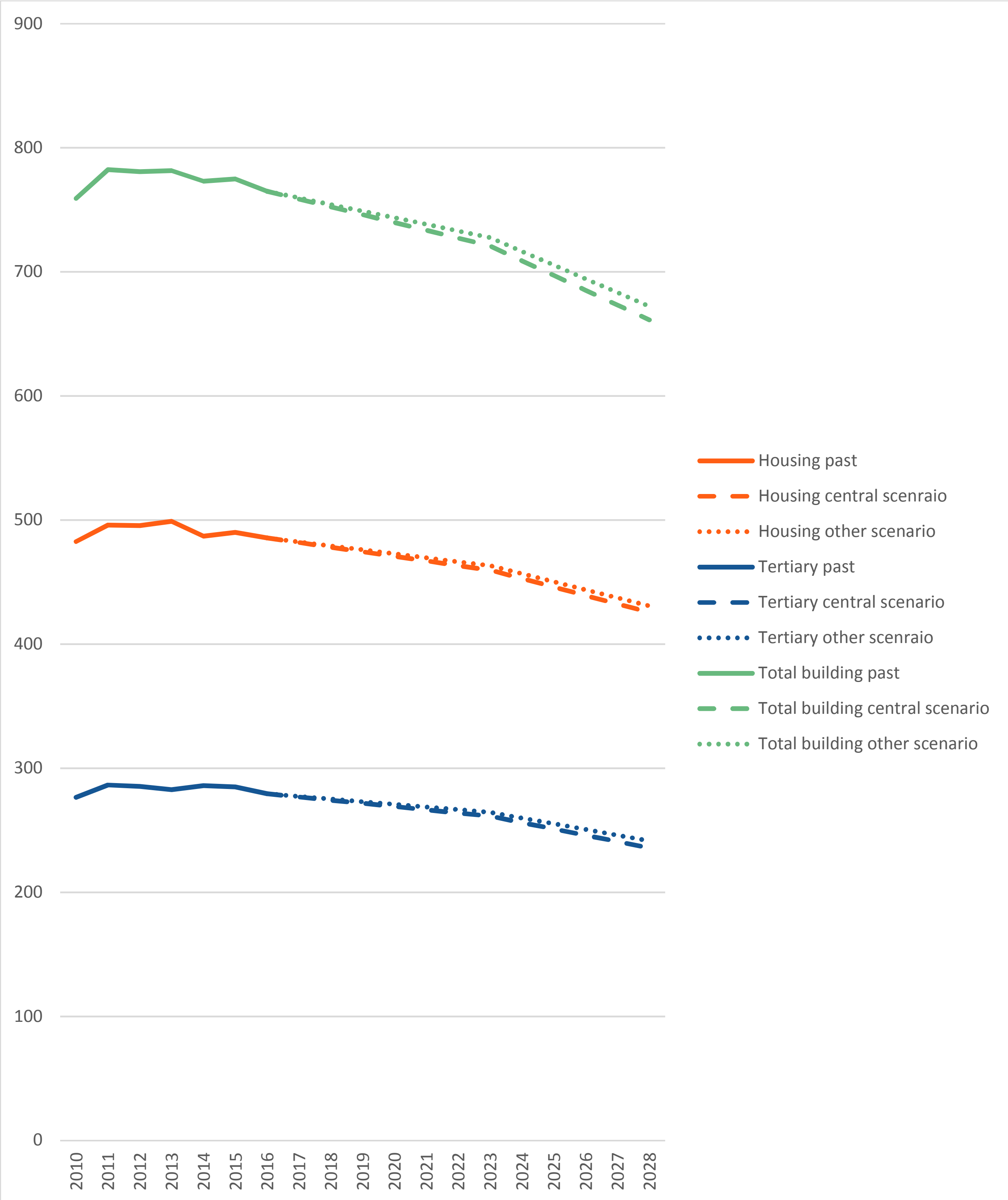


Figure 10: Past final energy consumption in buildings (2010-2016) and scenarios (2016-2028) of final energy consumptions in buildings expected with the implementation of the MAEP (TWh)

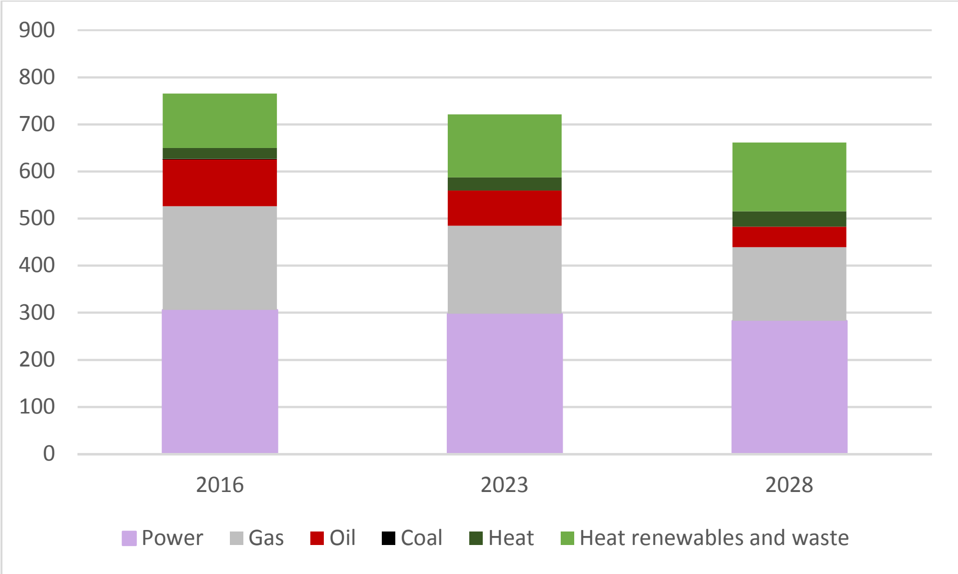


Figure 11 : Expected Trend of final energy consumption in building expected with the implementation of MAEP by energy (TWh) in the baseline scenario

Objective for reduction of final energy consumption in the building sector and measures to achieve it

	2016	2023	2028
Final energy consumption in buildings (TWh);	748	721	661

Measures to reduce energy consumption in buildings:

- Implementation of the Plan for energy renovation of buildings

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 for all new buildings (individual, collective, tertiary) by 2020;
  - Updating the conversion factors in primary energy for electricity used in the regulation of new buildings (RT 2012, E+C- Label, RE 2020) to take account of the projected electricity mix in 2035 in the MAEP. The calculation method used will be the method selected by the European Union as part of the revision of Directive 2012/27 / EU on energy efficiency.
  - Adopting a criteria on greenhouse gas emissions on the all life cycle of the building, being careful not to have a negative impact on electricity peak demand;
- For tertiary buildings, applying energy efficiency obligations to 40 % of existing tertiary buildings in 2030 by targeting all business sectors and limiting exemptions to only cover buildings of less than 1,000 m².

For private individuals:

- Make the Energy Transition Tax Credit (Crédit d'impôt pour la transition énergétique, CITE) more efficient via a new fixed rate scale in 2020, which will take into account the energy efficiency of the actions and will be defined after wide consultation with stakeholders in the sector;
- Extend the CITE to **landlords** in 2020.
- From 2019, extend the CITE for lower income households to cover the **installation of renewable heat equipment** and the disposal of **oil tanks**;
- Make the CITE payments through the French National Housing Agency (Agence nationale de l'habitat, ANAH) at the time of the work, for the households in the first four deciles (current scope of ANAH aid). The rate of aid will be increased for these households, so that public aid is a real catalyst of building work to escape fuel poverty;
- Maintaining the VAT rate at 5.5% for energy renovation works eligible for the CITE and related works;
- Enable the ecoPTZ (interest-free loan) to be applied at a fixed rate for single initiative work, without a work package (e.g.: installation of central heating powered by renewable energies);
- 100% funding of an energy audit for lower income households who own heat sieves (performance certificates F or G). Make this audit mandatory prior to letting a private category F or G dwelling and during transfer of a dwelling classified F or G between now and 2021, to encourage homeowners to initiate building work.

The measures have been decided to answer to the baseline scenario. If ever the economic context would be different, with the same measures, the final energy consumption of the buildings could be 12TWh higher in 2028 (6TWh in housing, 6TWh in tertiary). To keep the final energy consumption of the building sector at the same level, the government would have to adopt new policies and measures. The scale of the difference between the two scenarios represents:

- 25000 more houses renovated each year to reach 300000 more houses over the period, that means 1.5% of the housing stock;
- 1.25Mm² more per year in the tertiary to reach 15Mm² more, that means 1.5% of the housing stock.

2.2.2. Transport sector

In 2016, final energy consumption for transport uses was stable compared to 2015, at 509 TWh. This stabilisation follows a two-year increase (+1.5% between 2013 and 2015). After a period of growth between 1990 and 2001 (+1.5% annual average), consumption had been slowly decreasing by 0.3% per year on average between 2001 and 2013. Stability of consumption in 2016 contrasts with the sustained growth in traffic, both in passenger transport (+2.3% in passenger-kilometres) and goods transport (+1.2% in passenger-kilometres). The first figures for 2017 show a somewhat upward trend.

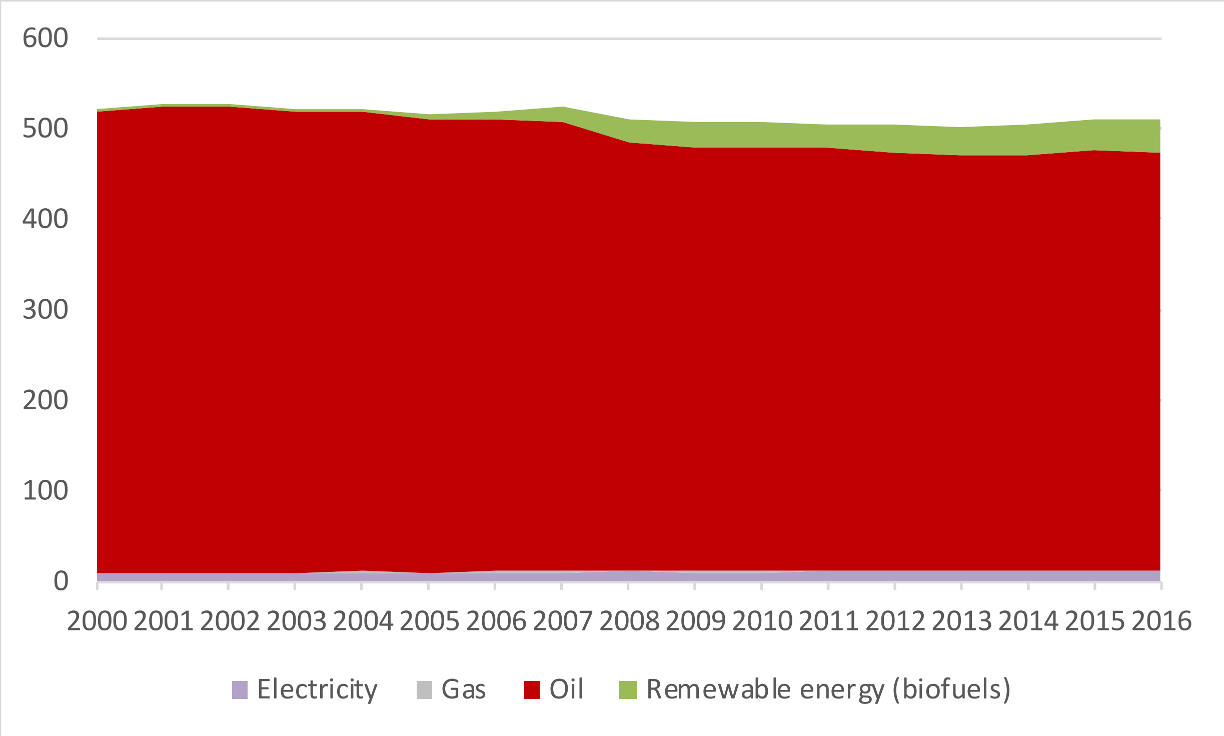


Figure 12: Final energy consumption in transport, in TWh. Source: SDES calculations, sources per form of energy

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:

- Inland freight transport (all modes combined) rose sharply until the 2008 crisis, then remained relatively stable at around 330 billion tonne-kilometres (338.4 billion t.km in 2016).
- Since 1990, the total volume of domestic passenger transport has increased steadily for all modes. After an important rise in 1990’s, the automobile traffic stabilized between 2000 and 2013 befor another raise. The domestic air transport in metropolitan area, after a decrease between 2000 and 2005, increased after 2010. The train transport had an important increase since 2000, in the same way of urban collective transports. The figure below shows these changes.

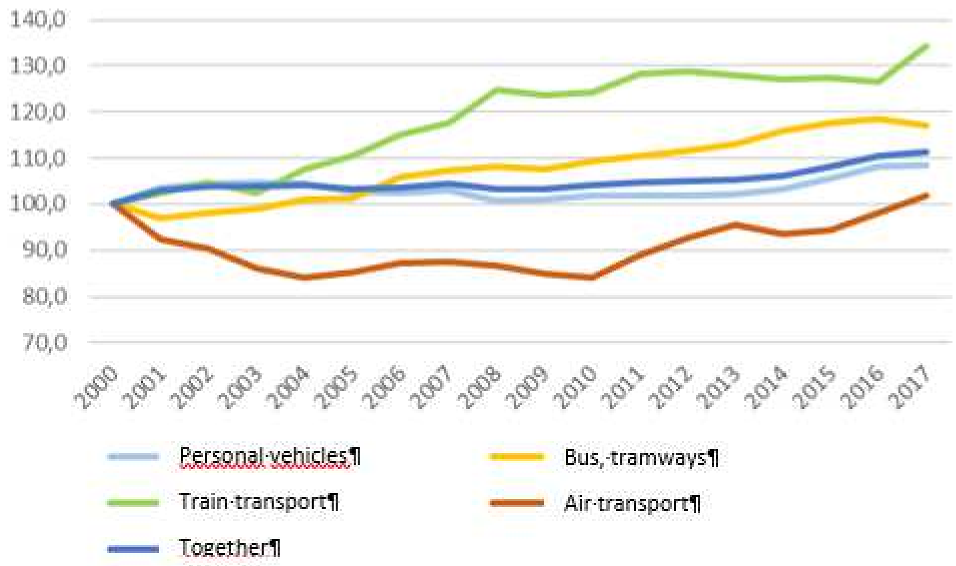
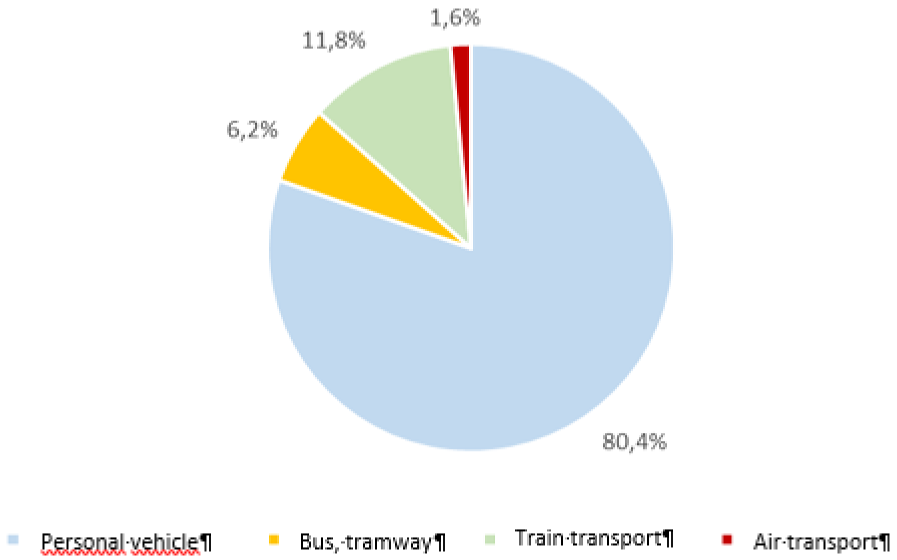


Figure 13: Evolution of domestic passenger modes of transport since 2000 - Source: SDES

Road transport accounted for almost 94% of the energy consumption of the transport sector in 2016. This share has been stable for 10 years and is higher than the share of road transport in traffic (85% freight, less than 90% for passengers).



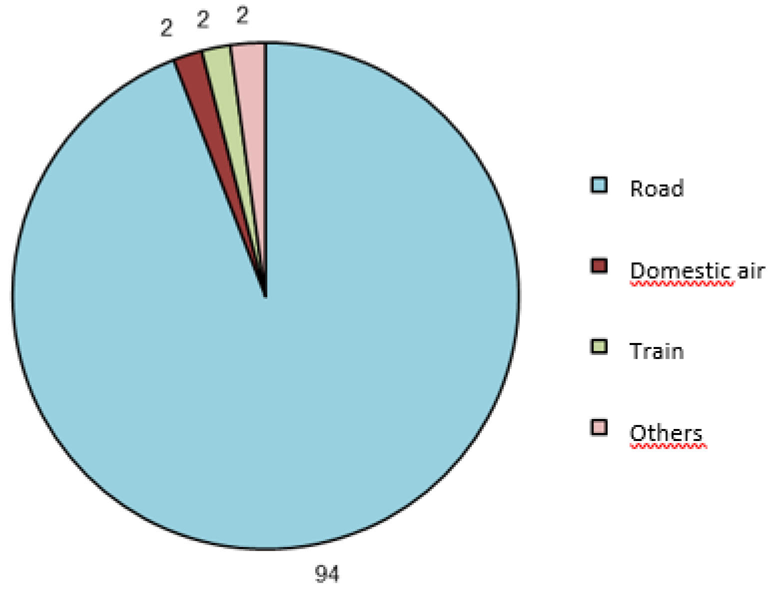
** including vehicles registered abroad and motorised two-wheelers. ** trains, subways, RER.*

**** domestic flights to metropolitan France only.*

Figure 14: Distribution of domestic transport per mode, in 2017 – Source: SDES

Of the energy consumed in road transport, around 60% is used for passenger transport and 40% for the transport of goods. Domestic air transport accounted for 2% of consumption in 2016. When international air transport (international air bunkers) are included, air transport accounts for 15% of transport consumption. Rail transportation (including railways, metros and trams) accounts for only 2% of the sector's energy consumption. This share is much lower than the share of rail in passenger and freight traffic and reflects the superior energy performance of this mode compared to road and air.

The energy mix in the transport sector is largely dominated (91%) by petroleum products, followed by biofuels (7%) and electricity (2%) - (*following figure*).



Note: The journeys covered are only those within metropolitan France and do not include international maritime and air bunkers.

Figure 15: Share of each mode in final energy consumption of transport in 2016, in %. Source: SDES calculations, sources per form of energy.

The hypothesis made for transport in the scenario are developped in Annex 9, dealing with the strategy for clean mobility development (SDMP).

The scenario is base on an electrification of transport, 3 times more efficient than thermal solutions in energy efficiency, particularly for personal vehicles. The sales of electric vehicles are supposed to be multiplied by 5 by 2022. In 2030, the scenario reaches a share of 35% of electric personal vehicles and 10% of hybrids personal electric vehicles in sales (respectively 27% and 7% in 2028). Important progress are also realized on energy consumption efficiency of thermal vehicles. The scenario aims 4l/100km in sales in 2030. The detailed evolution of vehicles park is presented in Annex 9.

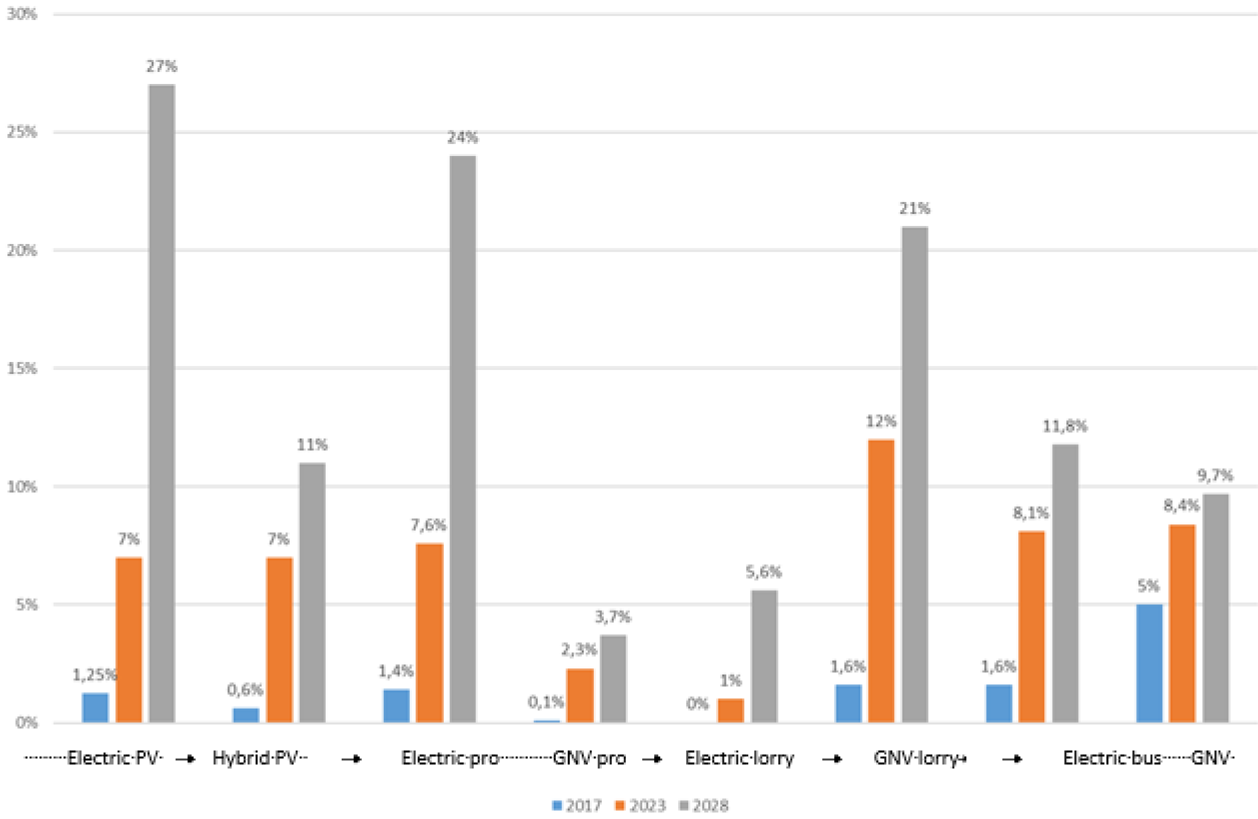


Figure 16: Evolution of market shares of registration (new vehicles)

The modal report towards zero carbon modes is encouraged. The share of vehicle decrease by 5 points between 2015 and 2028. The share of the bicycle is multiplied by 3.3 by 2024 and by 4 by 2028. Collective transports develop and their share increase by 3 points. Train transport for long distance increase by 20% between 2015 and 2028, that means +1.4%/year, collective transport for short distance increase by 30% between 2015 and 2028, that means 2%/year.

Bicycles	3.3x the modal share of bicycles as early as 2024 and 4x in 2028
Public transport	+3% in modal share
Road transport (travellers)	5% shift towards active modes and public transport
Mass transport (freight)	Stabilisation of modal shares of rail and river freight

Table 8: Evolution of modal shares 2015-2028

In the scenario, the rise of the traffic is supposed to be controlled for personal transport and freight transport. The personal mobility increase by 7% between 2015 and 2028 due to economic demographic growth. This growth is different by transport mode: the collective transport increase of 24%, the use of bicycle is multiplied by 4, the personal vehicle mobility increase only of 2% between 2015 and 2028 and the personal vehicle traffic (in vehicle-km) decrease of 2% due to the increase of the number of persons per vehicle. The freight traffic in t-km increase of 15% between 2015 and 2028. The quantities per lorry raise from 9.75 to 10.4 tons per lorry. The traffic of lorries raise of 8% by 2028. The traffic of light commercial vehicle raise of 8% in 2028.

Private vehicles	From 1.63 in 2015 to 1.69 in 2030
HGV	From 9.75 tonnes in 2015 to 10.4 tonnes per vehicle in 2028

Table 9: Evolution of vehicle occupancy rates 2015-2028

The evolution of traffics, the improvement in energy consumption of vehicles and the evolution of the energy mix lead to a decrease of energy consumption of transport sector. The energy scenario projected the final energy consumption in 2028. The figure below shows the area in which the final energy consumption of the transport sector would probably be, the two curves giving the higher and lower situations depending on the macro-economic contexts.

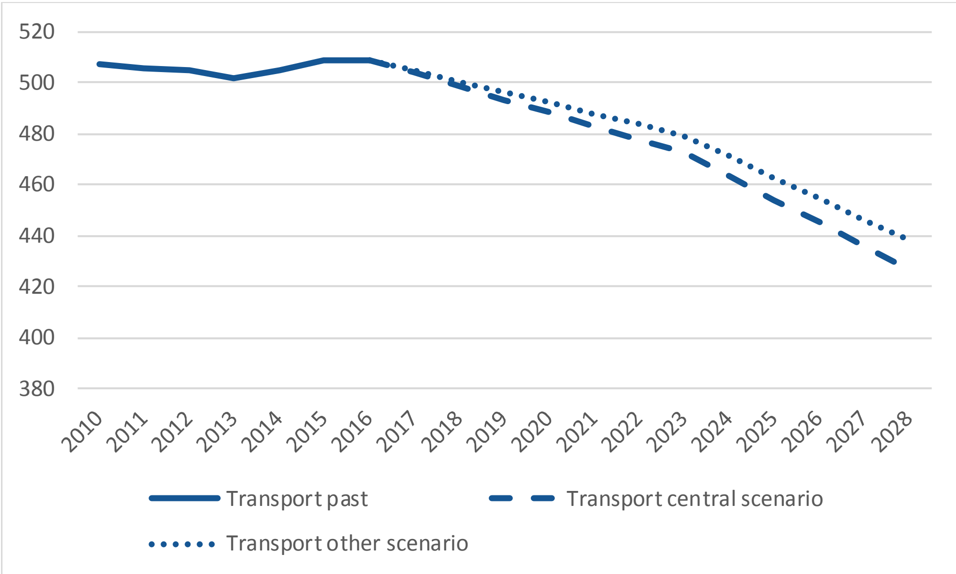


Figure 17: Past trend (2010-2016) and future scenario (2016-2028) of final energy consumption in transport with MAEP implementation (TWh)

The energy mix of the sector will become more balanced (renewable gas, electricity, biofuels).

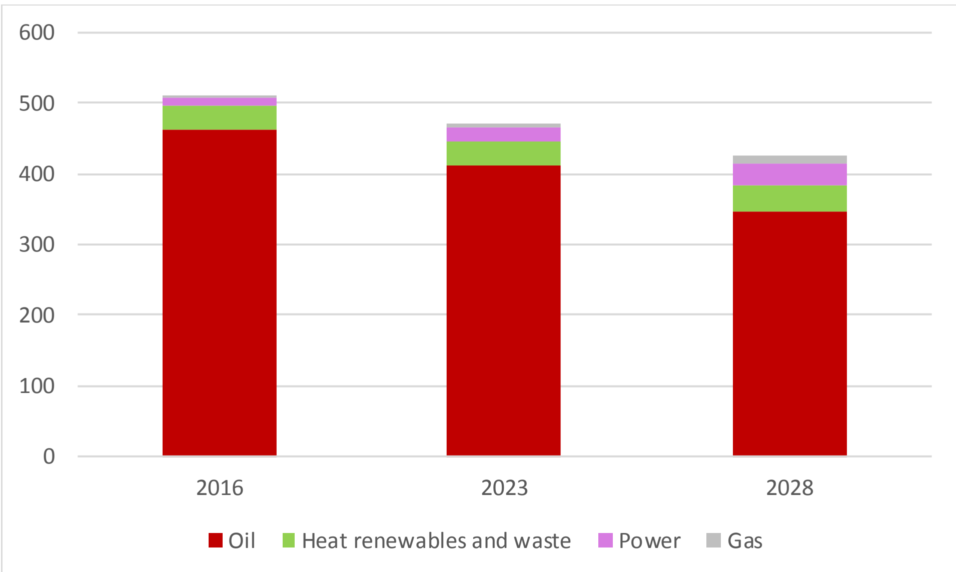


Figure 18: Evolution of final energy consumption of transport sector with implementation of MAEP per energy (TWh) in the baseline scenario

Box 4 : Guidelines and action plans for the development of clean mobility adopted in the Clean mobility development strategy (cf. 9-Annex 2)

For the production of these scenarios, the main guidelines and courses of action are notably derived from the national Consultative Meetings on Mobility. The draft Mobility Law (LOM) will be the main implementation process.

Enabling all areas to benefit from clean mobility and freeing up innovation

- Make clean mobility accessible to all by providing each area with a Mobility Organisation Authority (AOM) and extending the role of the AOMs to active or shared mobility and mobility services of a social nature. The objective is to ensure that anyone can choose its mobility within a range of services of mobility more diversified, more efficient, more connected, more shared in any area.
- Facilitate experimentation and implementation in new mobility solutions, including driverless vehicles travelling on public roads through a dedicated legislative and regulatory framework.

Managing mobility demand

- Optimising travels by implementing incentives procedures, enhancing the role of employers and the coordination of local public authorities and giving incentives to companies to adopt action plans to reduce emissions on the whole logistic chain;
- Promote more virtuous behaviours by implementing low-emission areas in conurbations and valleys affected by air pollution issues.

Developing low-emissions vehicles (included river, sea and air ones) and improving fleet efficiency by building on the alternative fuels market

- Set ambitious growth targets for the market share of low-emission (light and heavy) vehicles and using purchase and tax incentives to achieve these targets (bonus-malus, grants to switch vehicle), accompanying all people;
- Support this development through the deployment of alternative fuel distribution infrastructures by increasing funding for electric charging stations, simplifying the right to install charging facilities, and creating new gas stations (CNG) and hydrogen stations;
- Speed up the energy transition of fleet, for companies, state and local public authorities;
- Support this development through the deployment of alternative fuel distribution infrastructure, by supporting and facilitating the installation of electric charging points (right to plug) and of gas stations (NGV and hydrogen);
- Promote energy efficiency of river and sea domestic transport and reach the carbon neutrality, allowing the distribution in low carbon energy in every French harbour and facilitating the switch to other low carbon technologies (battery, biofuels, hydrogen, sail…);
- Limit air transport greenhouse gas emissions with huge energy efficiency improvement and an important switch from fossil fuels to biofuels (50%).

Favouring modal shift for passenger transport

- Developing multi-modal mobility as a result of the accelerated opening of the data and the possibility for the actors to offer a journey planning and ticket payment service integrating all links for the same journey;

- Boost the share of active modes in daily mobility by creating a national fund of €350M to make cycling safer (secure parking, anti-theft tagging of bicyclcles, bike box at traffic lights…) and creating incentives (grant for sustainable mobility) and more accessible (cycling proficiency);
- Develop public, shared and collaborative modes of transport by investing in rail infrastructures, in collective transports, in clean mobility through calls for tender and by encouraging the use of shared transport thanks to a sustainable mobility grant and dedicated ways.

Promoting modals shift and freight transport towards river routes and railways and improving efficiency

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

Objective for reduction of final energy consumption in the transport sector and measures to achieve it

	2016	2023	2028
Final energy consumption in the transport sector (TWh)	509	472	427

Main measures complementing cross-cutting measures:

- Enhance the premium for lower-income households to go on the conversion of a huge number of old vehicles in new ones or existing ones with much lower emissions: the prime is doubled in 2019 for lower income households and working people under the ceil of taxation that have long journeys to go to work, and it is higher to be more attractive towards an electric vehicle or a hybrid one. The objective is to reach 1 million people by 2022.
- European objective for greenhouse gas emissions of 95gCO_2/km on average for cars by 2021

  Objective for 2030: -37.5% for private vehicles and -31% light goods vehicles

  End of sales of new vehicles emitting greenhouse gases in 2040;
- Removing barriers to the development of electric vehicles: total cost of ownership (including costs in addition to the purchase), usage constraints (battery life, charging infrastructure);
- Balancing the total cost of ownership: continued rise in carbon tax levels; subsidy mechanisms and/or taxes; regulatory measures (development of low emission zones);
- Annual reduction of the penalty trigger threshold -3gCO_2/km;

- Extra-depreciation: extension of the heavy goods CNG extra-depreciation scheme until 2023; enhancement of the scheme for HGVs of less than 12t; technological neutrality (extension to hydrogen and electricity);
- Promotion of clean mobility for 2/3-wheel vehicles: introduction of a penalty similar to the car penalty; enhancement of the conversion premium (allowing the disposal of a 2/3-wheel vehicle);

  Deployment of the charging infrastructure network: mobilising financing tools (PIA, TURPE, CITE, EEC ADVENIR scheme); removing the barriers to installation (right of condominiums, terminals on demand); facilitating charging in companies (benefits in kind).

The measures have been decided to answer to the baseline scenario. If ever the economic context would be different, with the same measures, the final energy consumption of the transport could be 14TWh higher in 2028. To keep the final energy consumption of the transport sector at the same level, the government would have to adopt new policies and measures. The scale of the difference between the two scenarios represents an improvement of energy consumption pf vehicles of 17.5% to reach 3.3l/100km in 2030 for thermal vehicles instead of 4l/100km.

2.2.3. Industry sector

The industry sector includes manufacturing, covering agri-food, and construction. It does not include the energy transformation sector, which includes power plants, coking plants, refineries and, by international statistical convention, blast furnaces. Moreover, the energy uses of energy are to be distinguished from its non-energy uses, i.e. the use of molecules as raw materials. The vast majority of these non-energy consumptions involve industry, with the consumption of petroleum products for the production of plastics and of natural gas for the synthesis of fertilisers.

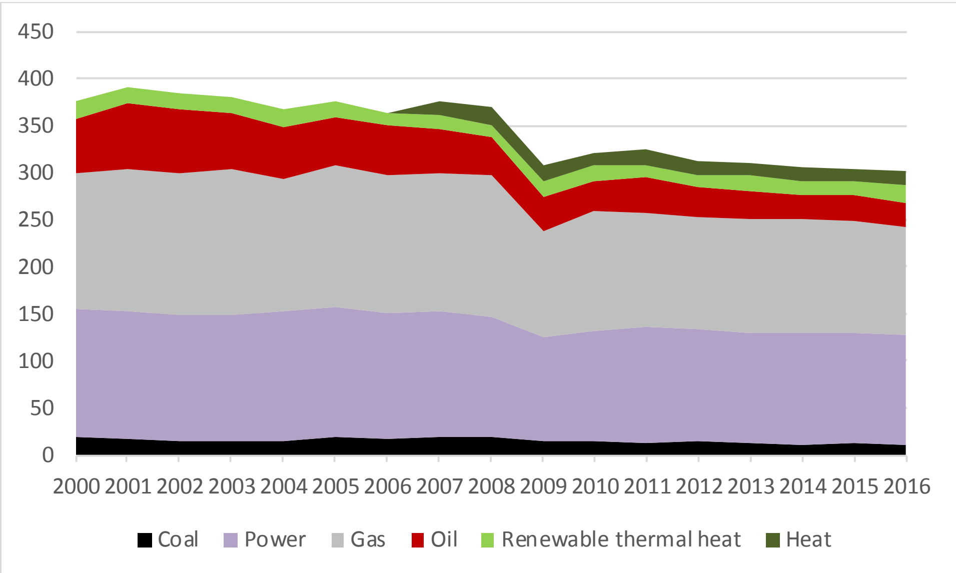


Figure 13: Final energy consumption in the industry sector – Data adjusted for climate variations, in TWh
Source: SDES calculations

Between 1990 and 2007, energy consumption in industry remained relatively stable. Since then, there has been a significant reduction in consumption related to the 2008-2009 economic crisis, followed by a rebound between 2009 and 2011. Energy consumption in industry is currently in a downward trend. Real final energy consumption in 2016 was in line with this trend. It stood at 302 TWh. At constant climate, it is down 0.9% and is at its lowest level since 1990.

The fall in consumption in 2016 must be compared with the almost stable production of manufacturing industry (+0.1%), which consolidated a modest recovery following a steady decline between 2011 and 2014, and the net rebound in construction (+3.5%) after a fall in 2015 (-4.5%). These developments overall reflect continued energy efficiency gains in industry at a sustained pace.

The final energy mix in industry has not changed much since the end of the 2000s. In 2015, electricity was the leading energy consumed in industry, with 39% of the mix, almost equal to gas (38%). Since 2010, the share of electricity has tended to increase slightly at the expense of gas. Petroleum products are the third form of energy consumed in industry. Their share fell from 12% in 2007 to 9% in 2016. As for renewable energies, their share has increased since 2007, from 4% to 6% in 2016. The heat purchased by industrialists represented 5% of the mix in 2016. Excluding the consumption of blast furnaces, coal represented less than 4% of the final energy mix in industry compared to 5% in 2007.

The fall in end-consumption in industry in 2016 was more or less marked depending on the energy type. Adjusted for climate variations, electricity demand was almost stable in 2016 (-0.1%), after a drop of 1.2% in 2015. A drop in consumption in the paper and cardboard, iron and steel, and non-ferrous metals (aluminium production) sectors, in a context of declining production in these sectors, was offset by an increase in consumption in the automotive and chemical sectors, which both expanded in 2016.

In a constant climate, gas consumption fell by 3.7% in 2016, the third consecutive year of decline, after -0.9% in 2015. The key sectors in this decline are agri-food (where production was almost stable), paper and iron and steel. The consumption of chemistry, where activity grew by 2%, was relatively stable.

Coal consumption in industry dropped sharply by 8.9% in 2016, to less than 11 TWh. Consumption by steel blast furnaces, which is not included in this total, was 38.4 TWh, also down (-6.4%) mainly due to the decline in steel production by the iron and steel industry, a sector that consumes coal.

The consumption of petroleum products in industry is sharply down in a constant climate (-5.0% in 2016), continuing the trend of the last 20 years. The main reason for this is substitution between energies, to the detriment of petroleum products, which are generally more expensive and pollute more.

Industrial consumption of thermal renewable energies and waste rose by 11.1% in 2016 compared to 2015, to 17.4 TWh. Over a longer period, the consumption of thermal renewable energies has been relatively stable since 1990. The production of paper and cardboard represents around 60% of this consumption. Thermal renewable energies, directly consumed in industry, almost exclusively consist of biomass, including wood, wood waste and black liquor, a by-product of paper pulp manufacture.

The heat purchased by manufacturers amounted to 16.3 TWh in 2016, up 19.4% from 2015. The level of this consumption in 2016 was very close to the consumption at the start of the series in 2007.

The table below summarises the targets for final energy consumption to be achieved as a result of the energy management measures in industry listed below.

The scenario related to industry considers the process will become more power based and more efficient. They will also use raw materials with low carbon impact. The improvement in energy efficiency are different between sectors. In 2030, the scenario supposes improvement from 10% to 30%. A more circular economy is implemented with recycling rates significantly raising and more eco-design.

The following figure shows the area in which final energy consumption from industry would probably be, the two curves giving the higher and lower situations depending on the macro-economic contexts.

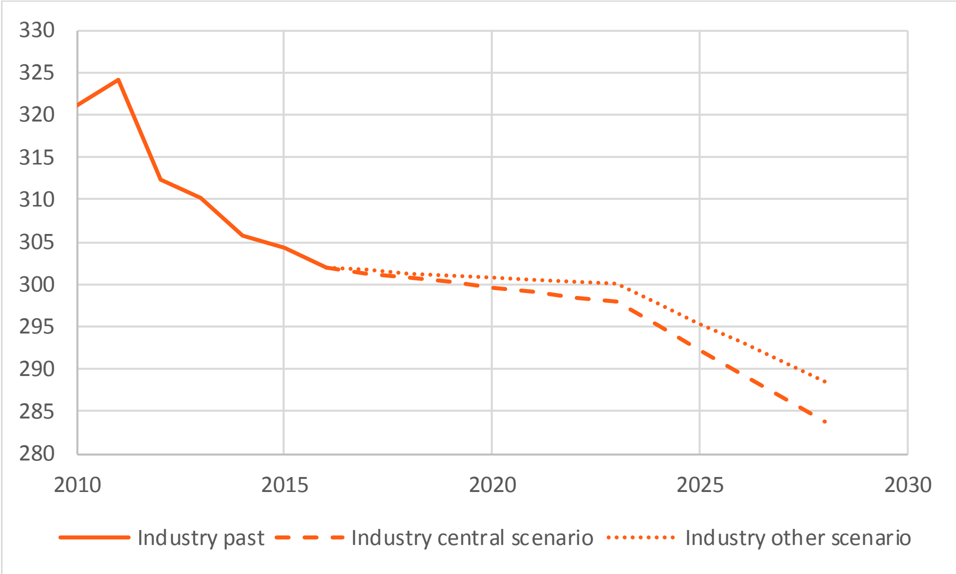


Figure 20: Past trend (2010-2016) and future scenario (2016-2028) of final energy consumption in industry with MAEP implementation (TWh)

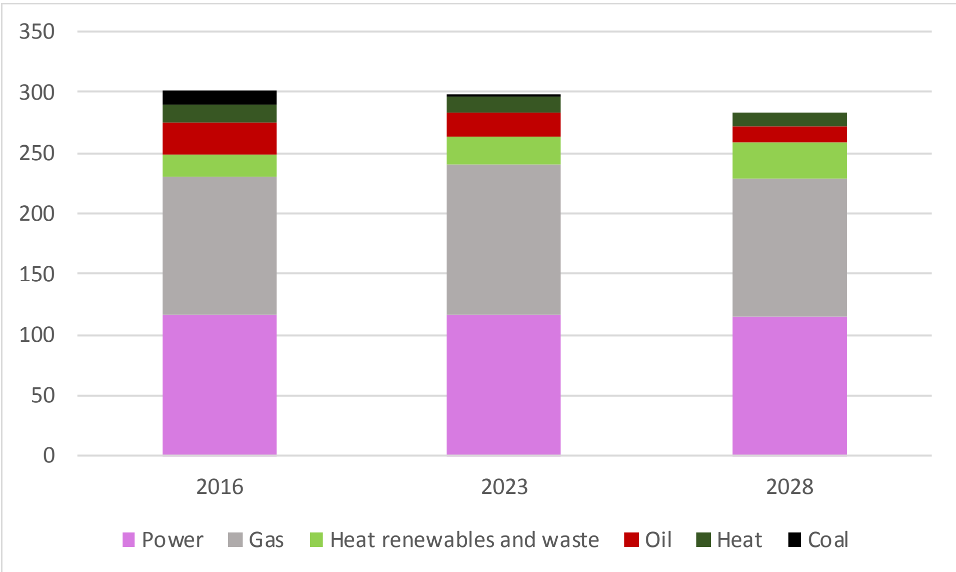


Figure 21: Evolution of final energy consumption of industry sector with implementation of MAEP per energy (TWh) in the baseline scenario

Objective for reduction of final energy consumption in the industry sector and measures to achieve it

	2016	2023	2028
Final energy consumption in industry (TWh)	302	298	285

Measures to reduce industrial energy consumption and greenhouse gas emissions in industry

- Testing a managed release of the first energy saving certificates for energy saving operations carried out in facilities covered by the European carbon trading system;
- Including a technical-economic evaluation of solar or geothermal heat production in the energy audits of large and medium-sized companies;
- Continuing to increase applications for the eco-energy loans (PEE) made available by BPI France, for SMEs and micro-companies engaged in work qualifying for energy saving certificates. Prolonging the PEE scheme until 2025;
- Promoting the deployment of energy management systems (ISO 50 001 type) and energy benchmarks in industry.

The measures have been decided to answer to the baseline scenario. If ever the economic context would be different, with the same measures, the final energy consumption of the industry could be 6TWh higher in 2028. To keep the final energy consumption of the industry sector at the same level, the government would have to adopt new policies and measures. The scale of the difference between the two scenarios represents an improvement of energy efficiency from 2.5% to 3% depending upon the sectors.

2.2.4. Agriculture-Forestry sector

The final energy consumption in the agriculture-forestry sector has been stable for a decade and is particularly sensitive to fluctuations in agricultural production, which experienced a fall of 5.6% in volume in 2016. In 2016, the sector's final consumption was 52 TWh.

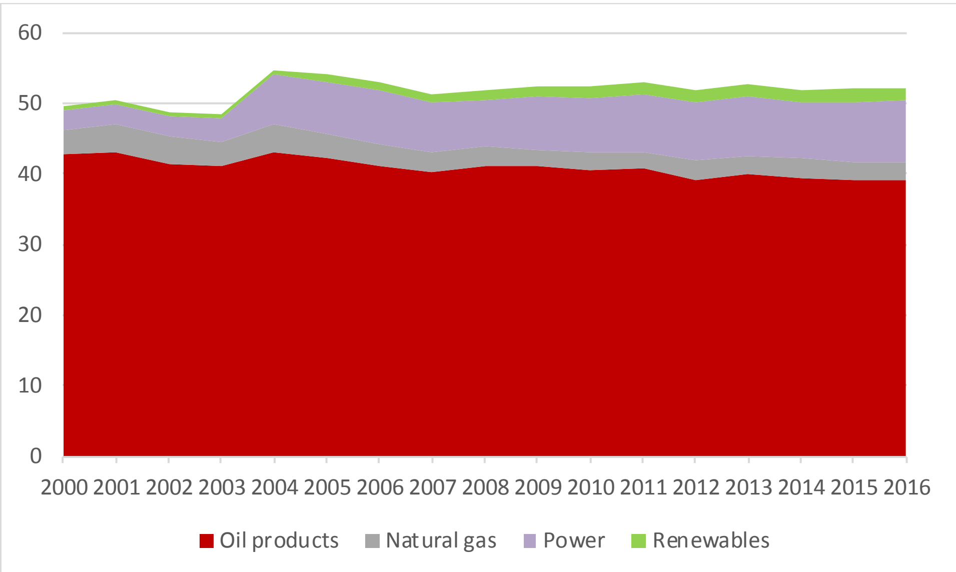


Figure 22: Final energy consumption in the agriculture-fisheries sector, in TWh. Source: SDES calculations, sources per form of energy

In 2016, petroleum products represented 75% of the sector's consumption. The trend in this share is downward, in favour of electricity, natural gas and renewable energies, which in 2016 represented 16%, 5% and 4%, respectively, of the agriculture energy mix.

Fishing accounted for 6% of the overall energy consumption of agriculture-fisheries: this is essentially the diesel consumed by fishing boats. Its final energy consumption decreased in 2016 (-3.6%).

The following figure shows the area in which final energy consumption from agriculture would probably be, the two curves giving the higher and lower situations depending on the macro-economic contexts. The energy efficiency grows and the renewables share is doubled. The scenario is not really dependant on economic evolution.

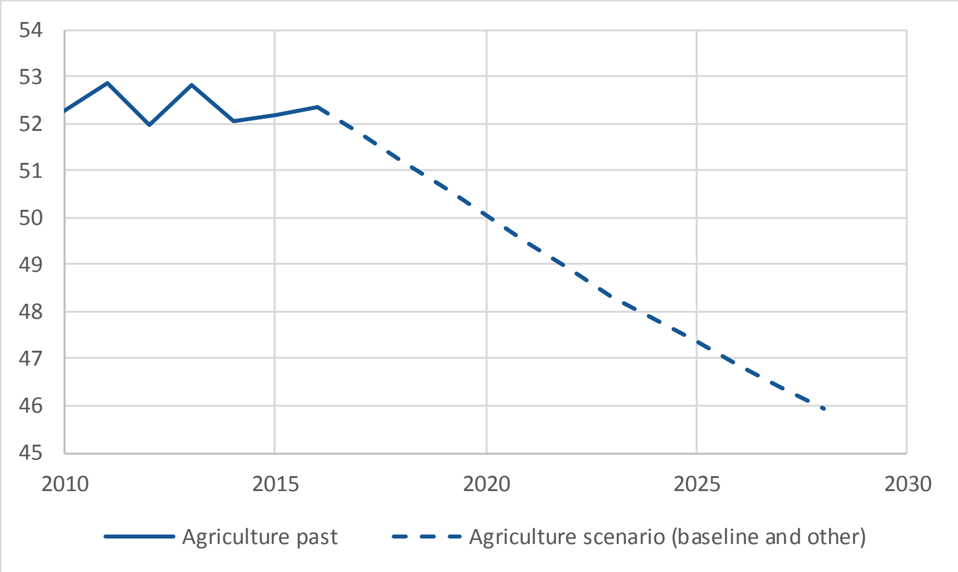


Figure 23: Past trend (2010-2016) and future scenario (2016-2028) of final energy consumption in agriculture with MAEP implementation (TWh)

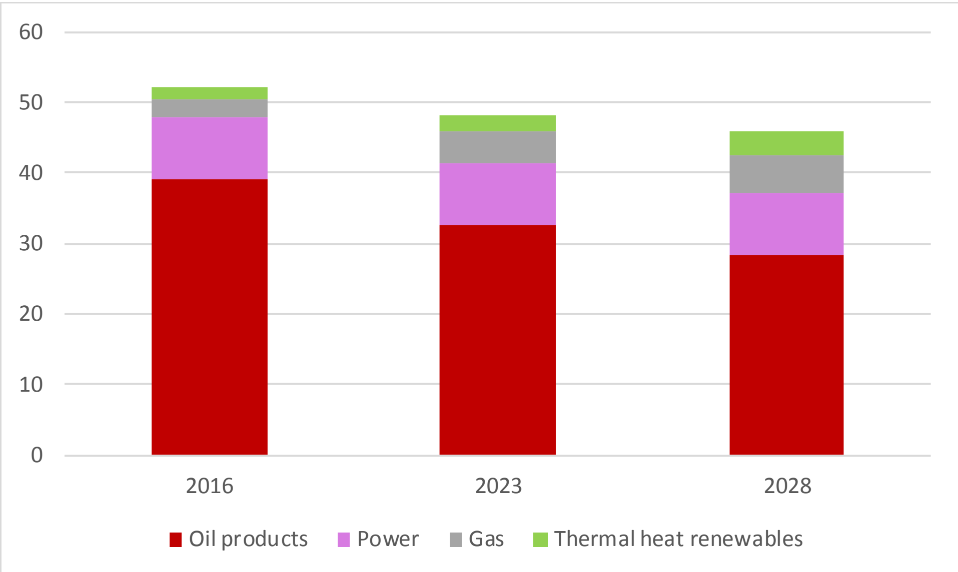


Figure 24: Evolution of final energy consumption of agriculture sector with implementation of MAEP per energy (TWh) in the baseline scenario

Objective for end-use energy consumption in the agricultural sector

	2016	2023	2028
End-use energy consumption in the agriculture sector (TWh)	52	48	46

2.3. Decrease in consumption of fossil fuels

2.3.1. History of the evolution of primary energy consumption and reduction target

The energy mix is changing slightly: renewable energies are growing at the expense of fossil fuels. This change is, however, taking place slowly. Consumption of natural gas is relatively stable.

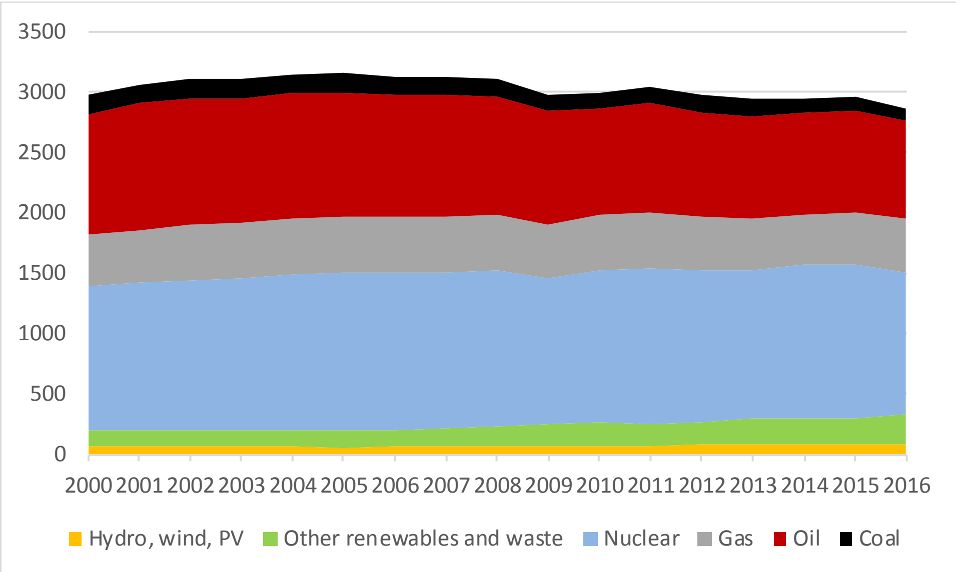


Figure 25: Primary consumption by energy form – Data corrected for climate variations, in TWh
Source: SDES calculations, sources per form of energy8

In 2017, the primary consumption of mainland France, excluding non-energy uses, amounted to 2747 TWh, an increase of 0.7% compared to 2016. Corrected for climate variations, it actually increased by 1.6%, a result, firstly, of the increase in final demand and, secondly, the increased losses during energy transformation. These are happening in particular because of the increased use of fossil-fuel fired thermal power plants to offset the drop in hydroelectric power generation. The decrease in the share of thermal plants in the electricity mix should lead to a reduction in this trend.

The +12% rebound in coal consumption in coking plants and blast furnaces, net of the production of gas derivatives, also explains the rise in consumption of the energy transformation sector.

8 Nuclear energy is accounted for as a primary equivalent to production (heat released by nuclear reaction, then converted into electricity), net of the electricity export balance.

Overall, the real primary energy mix in Metropolitan France consists of 40.4% nuclear, 29.1% oil, 15.5% natural gas, 3.7% coal and 11.2% renewable energies and waste (*see Figure below*). The energy independence rate is 53%.

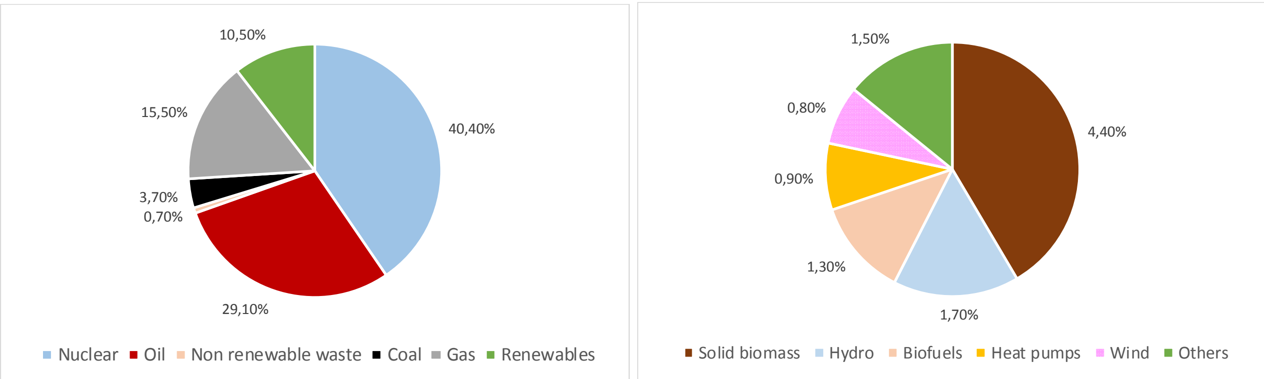


Figure 16: Real primary energy mix in 2017 (Source SDES)

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 climate. Adjusted for climate variations, emissions remain 17% lower than in 2005, having fallen steadily between this date and 2016.

In 2017, France mobilised 2747 TWh to meet a final consumption (corrected for climate variations) of 1644 TWh. The difference consists of internal losses and uses of the energy system, net electricity exports, and international air and maritime bunkers, conventionally excluded from consumption.

The final energy mix is still dominated by oil. In 2016, petroleum products accounted for 39% of end consumption for energy use, followed by electricity (27%), gas (21%), renewable energies and waste (10%), heat (2%) and coal (1%). In line with the trend observed since the mid-2000s, the share of fossil fuels in the energy mix fell by 2% in 2016, while electricity and renewable energies increased. Heat, which shows no clear long-term trend, also rose in 2016.

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 tables below summarise the particular fuel-specific measures whose effect will supplement the energy control measures.

The implementation of the measures presented below in the energy scenario shows the decrease in the Figure below. The figure shows the area in which the primary energy consumption of fossil fuel would be in 2028, the two curves showing different cases depending upon macro-economic conditions.

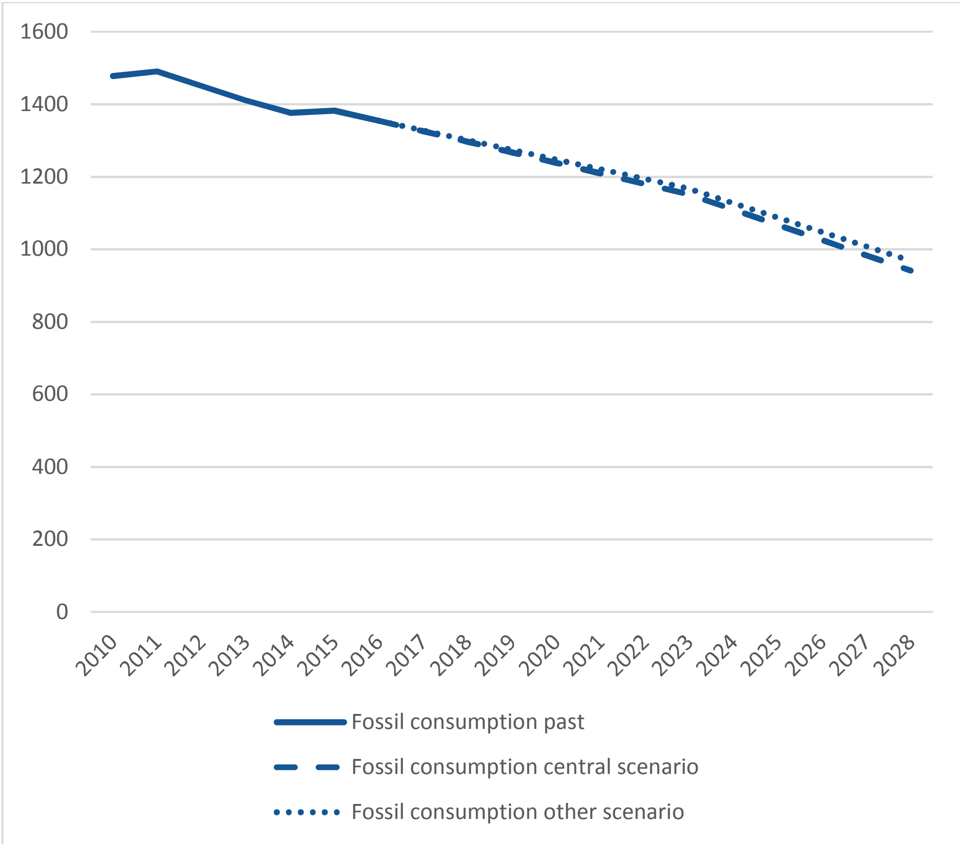


Figure 27: Past trend (2010-2016) and future scenario (2016-2028) of primary energy consumption of fossil fuels with MAEP implementation (TWh)

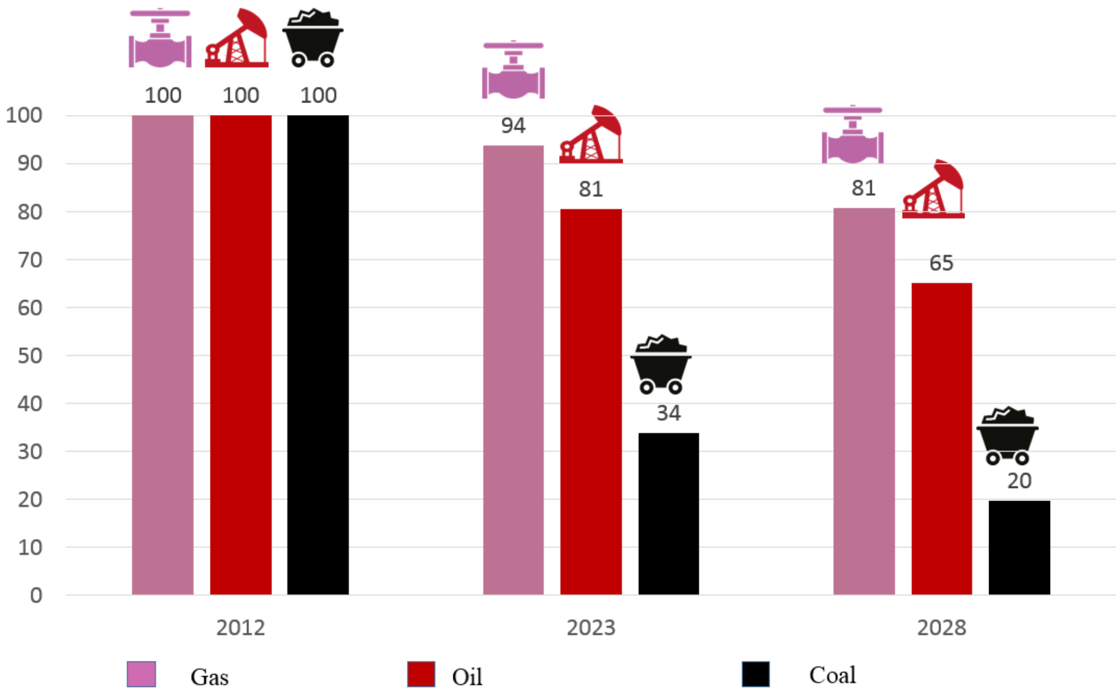


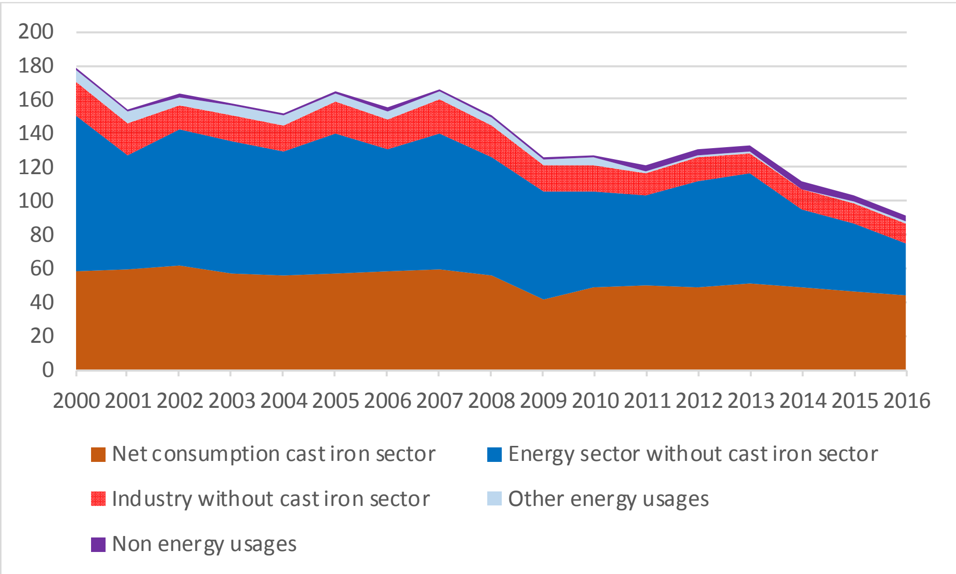
Figure 28: Reduction in the primary consumption of fossil fuel by energy vector

Objective for reduction of consumption of primary fossil energy and measures to achieve it

	2017	2023	2028
Primary consumption of fossil energy (TWh)	1412	1151	942
Primary consumption of coal (TWh)	110	47	27
Primary consumption of oil (TWh)	843	699	565
Primary consumption of natural gas (TWh)	459	406	349

2.3.2. Objectives and measures of the MAEP specific to the reduction of primary coal consumption

After a significant drop in 2014, coal consumption decreased by 3% in 2015 and reached a historic low of 158 TWh (figure below). In addition to power generation plants, we observe consumption in the industrial and residential sectors. In the steel industry, this fell by 7%, as a result of the scheduled shutdown of one of the five largest blast furnaces operating in France, for a complete overhaul, during the second half of 2015.



Source: SDES calculation from EDF, Uniper France Power, FFA, Insee, Customs, COCIC and SNCU

Figure 29: Primary consumption of coal (excluding statistical deviation) corrected for climate variations (in TWh)

The total consumption of coal-coke in industry was estimated in 2014 at 74.5 TWh. 80% 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 the 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	Coal-coke consumption (TWh)
Steel industry	59.6
Chemistry (including plastics)	6.5
Agri-food industry	4
Non-metallic materials (glass, cement, tiles and bricks)	2.6
Mechanical Engineering, Electronics and Metalworking (including smelting)	1.5
Paper, cardboard	0.2
Automotive and Aircraft Construction	0.1
Non-ferrous materials	0.05
Total	74.5

Table 10: Coal consumption by type of industry, excluding use of industrial coal-coke raw material. Excluding natural gas and petroleum products used in raw material

Year 2014, Final energy, Source: Ademe (2018), according to Ceren.

Uses of coal in industry

As regards heat, there are already possible uses of waste or biomass for industrial needs. For cement/plaster manufacturers, and given the constraints in terms of temperature, waste could be recycled for 80% of demand, while biomass, SRF or biogas could be used in other industries including agri-food, cardboard, sugar, beet and alfalfa drying.

Increasing the share of renewable and recovered energy in urban heating networks 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.**[9] In this sector, it is not certain that mass substitution of coal is possible. Different solutions are tested not only in terms of a change in the industrial process, with the development of carbon-free production technologies such as the production of steel by hydrogen, but also its adaptation with the substitution of coal in blast furnaces by roasted pellets. This last indication, which would offer the possibility of partial substitution up to 25% but which could pose difficulties relating to its supply as biomass, is currently being researched in the context of future investments.

For all these industries, the recovery of waste heat is also to be integrated at the point of coal substitution.

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 35 TWh in 2016 according to the energy balance sheet.

9 Steel is manufactured in a blast furnace from blast furnace combustion of ore and coke.

Energy use of coal in the residential sector

There are 10 coal-fired heating networks: in 2016, their consumption was 238,575 tonnes of coal, equivalent to about 1.9 TWh, or 6% of inputs.

Coal consumption in the residential sector is estimated at 0.46 TWh. This consumption is equivalent to 20,000 dwellings. The ANGDM (National Agency for the Rights of Miners) estimates that the vast majority of coal-heated dwellings are in the Haut-de-France region, mainly because of its mining and industrial past. The use of coal as heating energy accounts for 3% of all dwellings. The ANDGM, in particular, has identified between 500 and 1000 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 (most often with an air-conditioning option). For reasons of investment and usage costs, it is proposed that we prioritise replacing coal heating with biomass stoves.

The implementation of the measures mentioned in the scenario will reach a decrease in the coal consumption presented in the figure below. The scenario is not dependant upon the economic context.

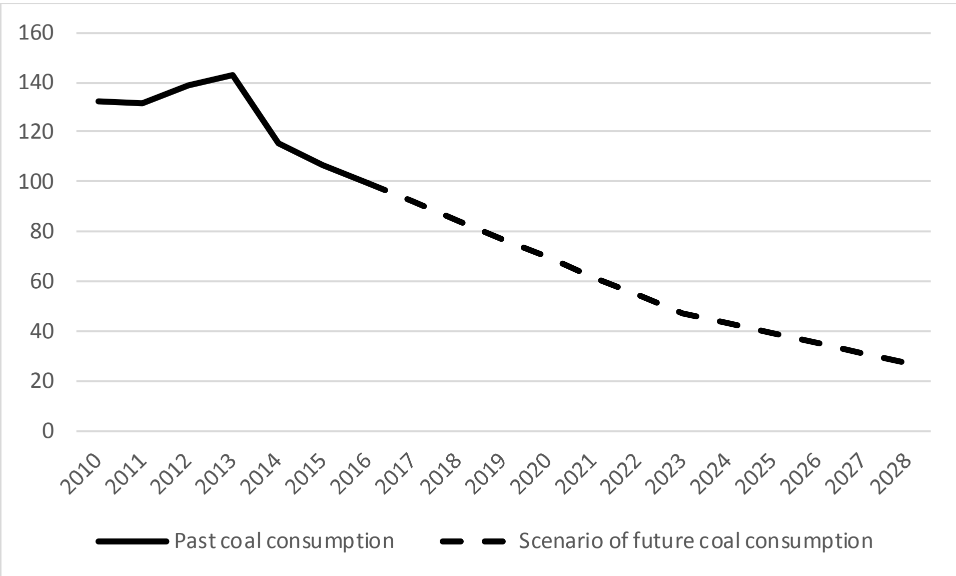


Figure 30: Past trend (2010-2016) and future scenario (2016-2028) of primary energy consumption of coal with MAEP implementation (TWh)

Objective for reduction of primary coal consumption and measures to achieve it

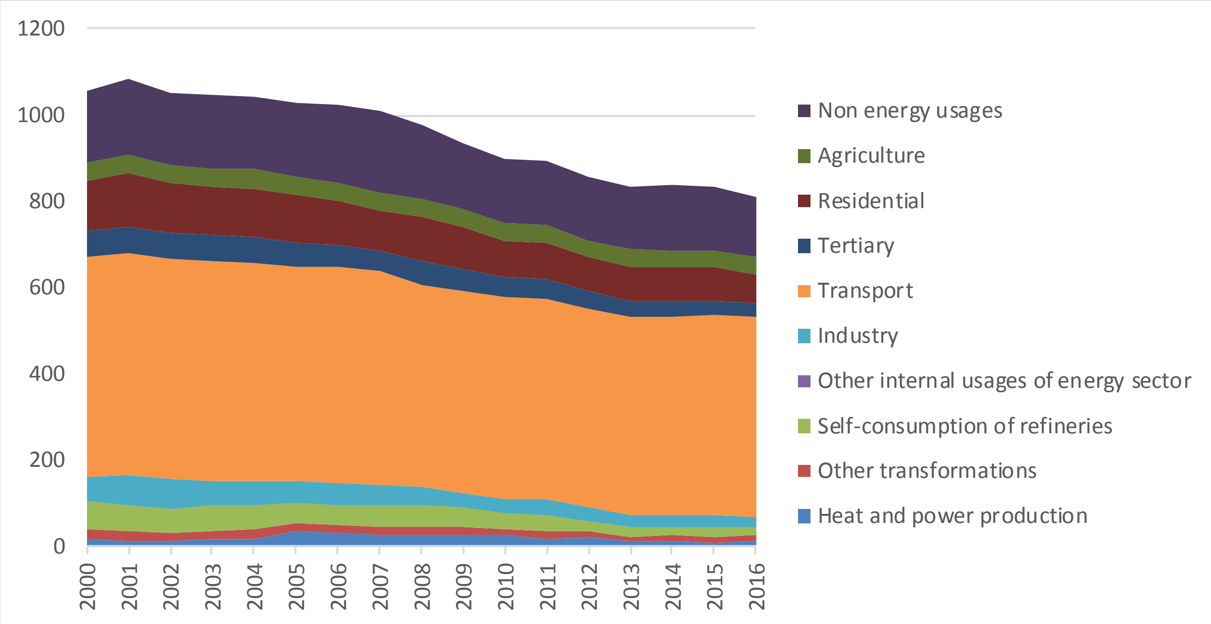
	2017	2023	2028
Primary coal consumption (TWh)	110	47	27
Evolution of primary consumption of coal/2012	-21%	-66%	-80%

Measures complementing the cross-cutting measure to reduce coal consumption:

- **For professionals, 75 % reduction in coal consumption in industrial sectors, excluding steel between now and 2028. To do this:**
    - As part of the Heat Fund, prioritise the substitution of biomass for coal and continue the Waste Fund's call for Refuse-Derived Fuel projects to make the necessary adaptations (about € 400m in grants over 20 years would make it possible to remove coal from the agri-food and paper/cardboard industries, and € 20m for the other industries);
    - For heat networks, in the Heat Fund, prioritising the substitution of renewable and recovery energies for coal and increasing the heat fund's means.
- **In the iron and steel sector:**
    - Continue experiments to set up processes that emit less CO_2 in blast furnaces through the use of loans from the future investments programme;
    - Over the period covered by the MAEP, establish demonstrators of innovative processes enabling the complete replacement of coal;
    - Continue the 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 conformity with the guidelines that prioritise projects to develop biomass in heat form, the State will not grant any financial support for those focusing on producing electricity using biomass;
    - No new authorisations for power stations producing electricity exclusively from fossil fuel.
- **For citizens, abandonment of coal heating for private dwellings by 2028:**
    - Maintaining CITE assistance for the installation of efficient renewable heater. A renewable heater is heat from heat pumps, biomass stoves, solar combined systems or connection to a renewable heat network;
    - Extending the existing ESC "boost" for fuel oil to the substitution of wood burning stoves for coal;
    - Mobilising the ANGDM as a vector of information.

2.3.3. MAEP objectives and measures specific to the reduction of primary coal consumption

In 2016, domestic consumption of refined petroleum products (excluding biofuels) was 808 TWh, down 2.1%. 2016 fits the long-term downward trend that began in the early 2000s (see figure below).



Source: SDES calculations, from CPDP, CFBP, Insee, SSP, SFIC, Uniper, Customs, DGEC, Ministry of Defence, EDF, Citepa

Figure 31: Total consumption of refined petroleum products by sector (excluding biofuels)[10] (TWh)

Oil is the fossil fuel that causes the most greenhouse gas emissions after coal. Reducing its use is therefore an issue to be addressed. The outcomes of oil demand scenarios, taking account of the measures that will be adopted, are shown in the table below.

Measures to control sectoral energy demand will play a role in reducing the demand for coal, including carbon contribution and all measures taken to reduce energy consumption in transport. Some specific measures that complement them are also planned.

The implementation of the measures mentioned in the scenario will reach a decrease in the oil consumption presented in the figure below. The figure shows the area in which the primary energy consumption of oil would be in 2028, the two curves showing different cases depending upon macro-economic conditions.

10 . Data corrected for climate variations, not including international air and maritime bunkers.

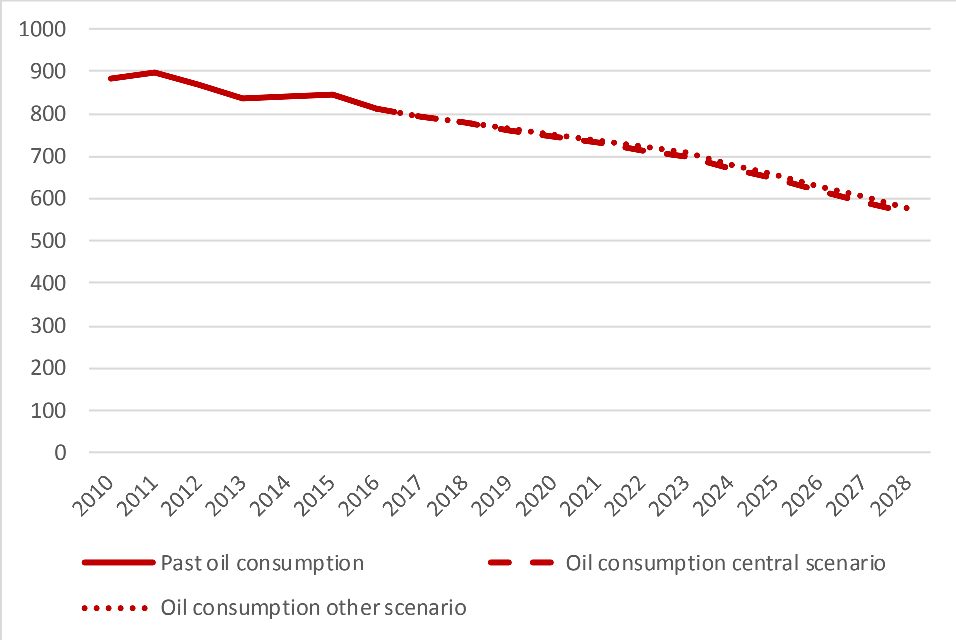


Figure 32: Past trend (2010-2016) and future scenario (2016-2028) of primary energy consumption of oil with MAEP implementation (TWh)

Objective for reduction of primary oil consumption and measures to achieve it

	2017	2023	2028
Primary oil consumption (TWh)	843	700	570
Evolution of primary oil consumption/2012	-3%	-19%	-35%

Measures complementing the cross-cutting measure:

- No new authorisations for power stations producing electricity exclusively from oil;
- Continuation of the ESC help for ending the use of fuel-oil boilers in favour of a renewable heater: heat from heat pumps, biomass stoves, solar combined systems or connection to a renewable heat network;
- Extending the existing ESC "boost" for the disposal of oil tanks for low income households.

2.3.4. MAEP objectives and measures specific to the reduction of primary natural gas consumption

Natural gas is a fossil fuel that, as such, will have to be removed from the energy mix by 2050. However, it is the fossil fuel that causes the least greenhouse gas emissions, which explains why the temporary transfer of some use of coal or oil to natural gas is already an improvement. This explains why there are no specific measures to reduce natural gas. 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 implementation of the measures of demand side management will reach a decrease in the natural gas consumption presented in the figure below. The figure shows the area in which the primary energy consumption of natural gas would be in 2028, the two curves showing different cases depending upon macro-economic conditions.

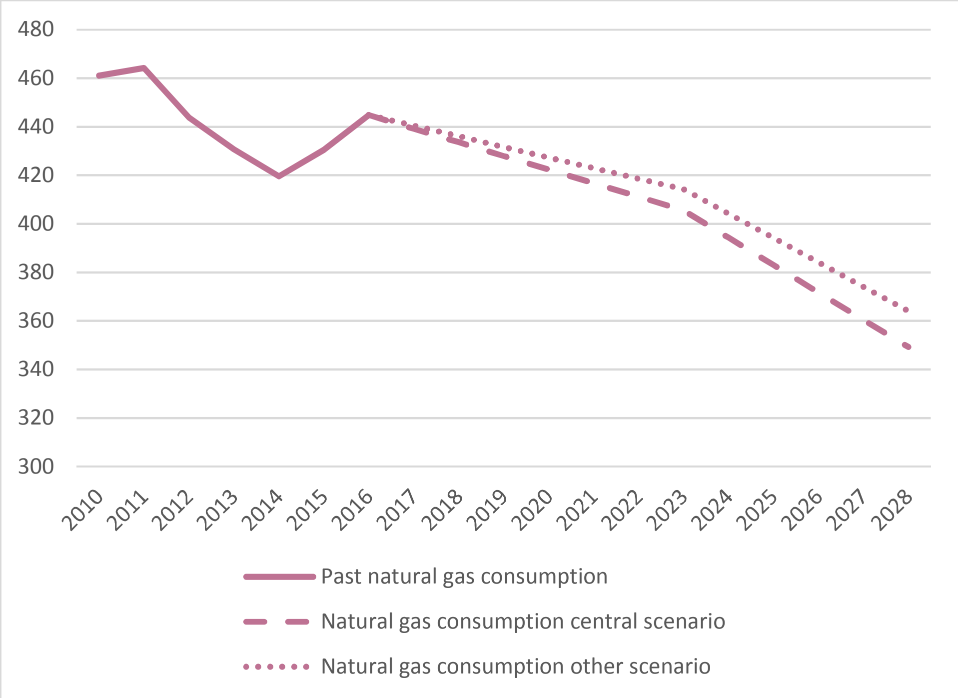


Figure 33: Past trend (2010-2016) and future scenario (2016-2028) of primary energy consumption of natural gas with MAEP implementation (TWh)

Objective for reduction of primary natural gas consumption

	2017	2023	2028
Primary natural gas consumption objective (TWh)	459	405	350
Evolution of natural gas primary consumption/2012	+3%	-6%	-19%

3

Energy supply / Promoting the renewable and recovered energies

3. Energy supply / Developing the use of renewable and recovered energies

Measures to promote renewable energies are set to achieve the objectives set by law. As these targets are expressed in terms of share of renewables in the energy consumption, the amount of renewable energy targets depends on the amount of energy–consumed. The consumption of energy depends on the macroeconomic context. That is why the 2028 targets are expressed as a range (high and low) that will achieve the goals of the law. Depending on the macroeconomic context, to maintain the same share of renewable energies, the government could strengthen the policy measures.

3.1. Renewable and recovered heat and cold

Heat represents 42% of end-use energy consumption in 2016, i.e. 741TWh. The tertiary and residential sector accounts for 65% of end-use heat consumption, while industry accounts for 30%, with the share related to agriculture being low.

Heat is mainly produced from gas, at 40%, followed by renewable energies (biomass, heat pumps, geothermal, biogas, solar thermal), at 21%, electricity and petrol, at 18% and 16% respectively and, marginally, from coal, at 5%.

The share of renewable energies has grown by 0.8% a year since 2010. This significant increase is the result of simultaneous growth in heat production from renewable sources, together with a reduction in end-use heat consumption. In 2028 the heat production from renewable sources could be between 218 and 247 TWh.

Total heat demand is projected to be 690TWh in 2023 and 635TWh in 2028.

The Energy Transition for Green Growth Act (LTECV) sets a 38% target for the share of renewable energy in end-use heat consumption in 2030. To achieve this goal, the increase of the share of renewable heat must be accelerated to reach an average increase of 1.2% per year, 1.5 times faster than that recorded between 2010 and 2016. The LTECV also sets a target of a five-fold increase in the amount of heating and cooling from renewable sources and from waste heat and cold supplied by district heating and cooling between 2012 and 2030.

France also has European commitments with an overall target of 23% renewable energies by 2020, broken down for into a target of 33% renewable heat by 2020. This target does not seem to be achievable by the planned deadline. The Renewable Energy Directive has been recently updated and published, it requires each Member State to increase the share of renewable and recovery energies in the heating and cooling sector by at least 1.3 points per year between 2020 and 2030. This objective is compatible with the framework set by the LTECV and the targets of the Multi-Annual Energy Plan (MAEP).

The table below illustrates the progress of renewable heat and the comparison with the targets set by the previous MAEP for 2018-2023.

2012	2016	MAEP Objective 2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
127,7 TWh	154,6TWh	173TWh	200TWh	221TWh

Table 3: The renewable heat targets set by the MAEP adopted in 2016 and the achievements for 2012 (baseline year) and 2016.

To boost heat renewable production, measures that stimulate all types of renewable technologies (cross-cutting measures) will be adopted. For certain technologies, they will be sufficient , for others they will have to be supplemented by specific measures that will be mentioned in the corresponding paragraph.

The following table shows the target of end-use renewable heat consumption that can be achieved through the implementation of the mentioned measures.

Objective of increasing heat from renewable sources and measures to achieve it

	MAEP Objective 2023	Lower MAEP Objective 2028	Higher MAEP Objective 2028
Renewable heat	196TWh	218TWh	247TWh

Cross-cutting measures to develop renewable heat:

- Make mandatory a minimum level of renewable heat to be installed in all new buildings (individual, collective and tertiary) starting from 2020 (future environmental regulation for new buildings);
- Give feedback on the calculation engine in the RT2012 and on the E+C- experiments to give more added-value to thermal REs, in particular thermal solar, in the upcoming 2020 environmental regulation;
- Build up the Heat Fund from 2018 with a Heat Fund budget of € 255m in 2018 and € 307m in 2019 then € 350m in 2020;
- Ensuring the use of both renewable heat and renewable electricity in the E+C- system (studying the elimination of the 6th use of "specific electricity", to open the active management of energy in the residential sector);
- Increasing the Heat Fund from 2018 in order to reach €315 million in 2019 and €350 million in 2020 and simplify the use (for instance switching from reimbursables loans by primes);

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Allowance to commit Heat fund (M€)	255	307	350	350	339	319	299	279	259	239	219

- Simplify the heat fund rules: remove the requirement for refundable advances for heat fund projects and replace them with subsidies (and therefore adapt the COP ADEME objective concerning refundable advances), get closer to European guidelines by becoming aligned on maximum levels of support for heat networks and by applying the most advantageous European framework as soon as possible for non-economic activities; develop regional contracts for renewable energy development, which will allow clusters of small projects to be subsidised;
- Including a technical-economic evaluation of solar or geothermal heat production in the energy audits of large and medium-sized companies;
- Build labour costs for the installation of renewable heat for lower income households into the CITE in 2019, then make changes to this tax credit in 2020 to make it fixed rate, differentiated according to technology and take particular account of the production of renewable heat provided by each type of equipment;
- Maintain VAT at 5.5% for renewable heat equipment eligible for the CITE and related works (e.g.: smoke flue, pellet silo);

- Starting from mid-2019, enable the zero-rate eco-loan to be applied at a fixed rate for all work eligible for the CITE (e.g.: loan of up to 18,000 Euros to install a geothermal heat pump), instead of requiring at least two types of work (e.g.: heat pump plus wall insulation) to benefit from these advantageous loans.

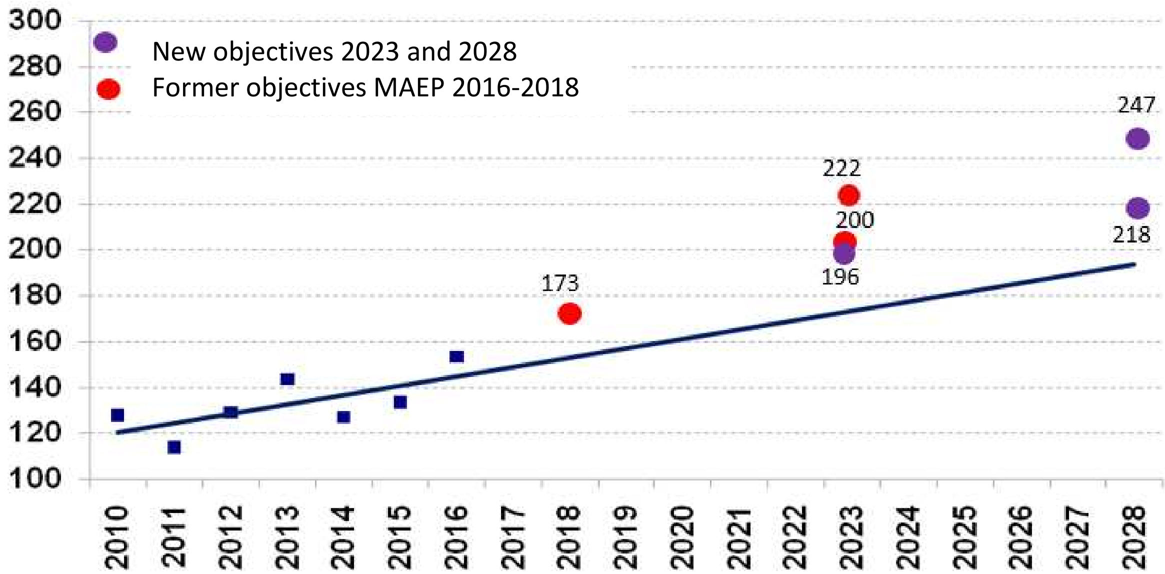


Figure 34: Past et future trend of final consumption of renewable heat (TWh)

3.1.1. Solid biomass

State of play in the sector

Solid biomass is the leading renewable energy in France – in 2016 it represented 80% 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 2016 (domestic end-use wood consumption in 2016 was 80TWh). Additionally, between 2009 and 2016, the Heat Fund financed nearly 1100 biomass boilers, including more than 160 in industry and the rest for collective heating.

2012	2016	MAEP Objective 2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
107TWh	123TWh	139TWh	151TWh	163TWh

Table 4: The targets for renewable heat from biomass set by the MAEP adopted in 2016 and the achievements for 2012 (baseline year) and 2016.

The biomass sector is lagging behind the MAEP's 2018 target, with a more marked delay compared to the 2023 target. This delay is seen particularly in the collective and industrial sectors where biomass has progressed as expected due to low gas prices. In the call for BCIAT projects (Collective Industry Tertiary Agriculture Wood) managed by ADEME, it was noted that manufacturers are turning to solutions to recover the by-products of their business (wood waste, etc.). Territorial 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 the sales of domestic wood devices (closed fireplaces, inserts and log stoves) and a growth in the pellet stove sector (average +7% / year). The overall decline in this sector slowed down in 2016 (-9% in 2016/2015, compared to -18% in 2014/2013).

Maximum supply potential

The chapter on biomass resources is addressed in section 5.5. Security of biomass supply.

Under a European agreement, the heat generated by incinerated household 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 only to maximise the energy recovery of a resource for which the trend will be downward.

Socio-economic, industrial and environmental issues

Yields

Wood can be used directly in devices to produce heat. Biomass 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 sector, the efficiency of boilers reaches 85% on average and 95% when they supply a 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 pour heat production , should be promoted. It is also important to continue the energy recovery of waste treatment units (addressed in a dedicated chapter).

Sector support issues

The increase of the price for fossil fuels could influence in a positive way the investments into renewable heating solutions (investments have been decreasing since 2013 due to lower gas prices). Additional actions, such as the increase of the heat fund amount and the release and simplification of the heat fund rules, are needed to reinvigorate investments.

This will enable support for projects in industry, agriculture and the tertiary sector, through BCIAT project calls, and for collective boilers, possibly linked to a district heating. Support through the CITE for individual wood-burning equipment is also a major challenge for the sector.

Costs

The solid biomass sector has competitive full production costs. So, for households, 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 between €64 and €110 / MWh; for industrial biomass, production costs are between €48 and €73 / MWh.[11] 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 envisaged in terms of production costs for the biomass sector within the MAEP timescales. One of the challenges of the sector is to develop a more efficient French combustion devices industry by 2022, in anticipation of changes in European Eco-design regulations [12]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[13]. In 2016, the sector had a ratio of 179 jobs per TWh produced.

11 Source: ADEME study “renewable energy costs” Edition 2016.

12 Two European regulations have been passed on the eco-design of solid-fuel boilers with a capacity under 500kW and independent wood-fired heating appliances.

13 Source: ADEME study of the market and employment in renewable energies – July 2017.

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[14], companies positioned in the manufacture of wood boilers, and companies involved in the operation of boiler rooms for the collective / tertiary and industrial sector. The total market is €2.8 billion for the domestic wood sector, and €1.7 billion for the collective, tertiary and industrial sectors. The use of RGE- (French environmental sustainability label) certified installers sets the conditions for grants to individuals. The qualification of wood energy installers through the Qualibois and Qualibat labels will continue.

Environmental challenges

The increase of the mobilisation of biomass is one of the priorities of green growth and the fight against climate change. This mobilisation must be carried out by adhering to sustainable practices and must be an element of reflection on the best operational coordination of uses. Cultural 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.

Improved air quality is a key issue, which involves the replacement of older devices with more efficient equipments (minimum 6-star class under the "green flame" label[15]), notably by maintaining the CITE and the ADEME Air-Wood Fund. In 2016, between 7.3 and 7.8 million households used wood, 1.1 million of which were open fireplaces. Performances in terms of atmospheric emissions are progressing well. All performances will be statutory at EC level in 2020 (boilers) and 2022 (independent equipments).

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[16], 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 experiment was launched in 2013 under the Atmosphere Protection Plan (PPA) of 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 will continue, with targeted actions where relevant from environmental and economic points of view.

Finally, in order to properly assess the impact of biomass projects, emission factors need to be updated to take account of bag filter processing technologies under development. Emission values for NOx and dust from district heating plants with a capacity in excess of 20MW 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 mid-year and must continue.

14 France is the leading European country in the production of renewable heat equipment using biomass. French production was valued at €134.7M in 2015.

15 . The 5-star class was abandoned on 1 January 2018.

16 . Source: CERIC study.

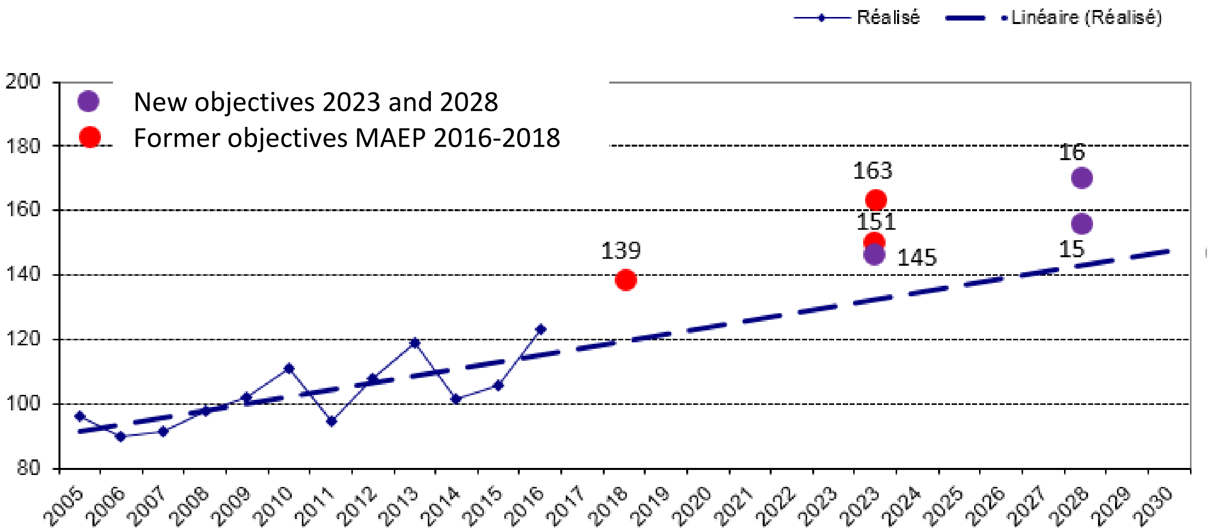
Objective of increasing heat production from solid biomass and measures to achieve it

	2016	2023	2028
Heat (TWh)	123	145	157 to 169
of which households (TWh)	80TWh (7.5M households)	80TWh (9.5M households)	80TWh (10.2M to 11.3M households)

Measures complementing cross-cutting measures:

- Promote the recovery of biomass heat before high-yield cogeneration. Heat will be clearly prioritised to obtain added energy value from biomass, with a goal of 38 % of renewable heat in final heat consumption in 2030;
- Rapidly replace low-performance independent wood fired heating devices (hearths, stoves, inserts) with better performing equipment in terms of returns and air quality (green flame, pellets etc.);
- Organisation of an awareness raising campaign on the proper domestic use of wood
- Support for boilers in collective and industrial heating via the Heat Fund.

Figure 21: End-use consumption of heat produced from biomass (TWh)



3.1.2. 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 equipments[17]. The renewable thermal production of the heat pump sector amounted to 27,6TWh in 2017. The renewable share used by heat pumps was 75% in private dwellings, 16% in tertiary, and 9% in collective[18].

17 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.

18 Overview of renewable and recovered heat – Autumn 2017

	2012	2016	2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
Aerothermal heat pumps	14.5TWh	22.2TWh	21TWh	27TWh	30TWh
Geothermal heat pumps	2.9TWh	3.1TWh	4.6TWh	5.8TWh	7TWh

Table 5: The targets for renewable heat from heat pumps set by the MAEP adopted in 2016 and the achievements for 2012 (baseline year) and 2016.

The ambitious objectives of the previous MAEP 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. AFPAC estimates the maximum potential to be 75TWh in the residential sector and 40TWh in the tertiary sector by 2050.

Socio-economic, industrial and environmental issues

Yield

Heat pumps consume electricity or fuel (gas or fuel-oil). Their performance is described by a coefficient (COP) expressing the energy consumed / energy returned ratio. The COP of 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 State support policies on the development of the sector since 2008. Heat pumps benefit from 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 thus important to maintain this support for the sector.

In collective, tertiary and industry, 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 in 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.

Thermal Regulation challenges

Thermal 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 thermal 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)[19].

19 Self-consumption is deducted from electricity needs in the case of PV while in the case of renewable heat, because it is consumed on site, renewable energy is deducted from needs.

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.

Geothermal heat pumps are a more expensive investment than aerothermal heat pumps, because 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. 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, on a market in danger (4000 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 the use of refrigerants (risk of leaking) with high global warming potential. Research and development is essentially focused on improving the performance of equipment, replacing refrigerants and reducing noise. A regulation for the application of the European Directive on the eco-design of 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 electronic electrical equipment, favouring recycling.

District cooling using geothermal heat pumps for cold production are an alternative to individual air conditioners. This solution has centralised maintenance, which enables low leakage rates to be obtained.

Objectives for increasing heat production from heat pumps and measures to achieve it

These objectives correspond for scenario B to 6.8 million aerothermal heat pumps installed in individual houses (nearly 3 times more equipments than in 2017) and more than 315,000 geothermal heat pumps installed (2 times more than in 2017).

In collective housing, scenario B corresponds in 2028 to 2.2 million aerothermal heat pumps (nearly 3 times more than in 2017) and the installation of geothermal pumps in 1000 collective housing per year.

In the tertiary sector, scenario B corresponds in 2028 to 114 million square meters of tertiary sector heated by aerothermal heat pumps (2 times more than in 2017).

	2016	2023	2028 scenario A	2028 scenario B
Aerothermal heat pumps (TWh)	22	35	39	45
Geothermal heat pumps (TWh)	3.1	4.6	7	7

Measures complementing cross-cutting measures:

- Sustaining support through the CITE for air / water heat pumps and geothermal heat pumps;

- Supporting heat pump-assisted geothermal energy and renewable cold projects through geothermal energy via the Heat Fund;
- Integrating in the energy audits of large and medium-sized companies a techno-economic evaluation of solar or geothermal heat production.

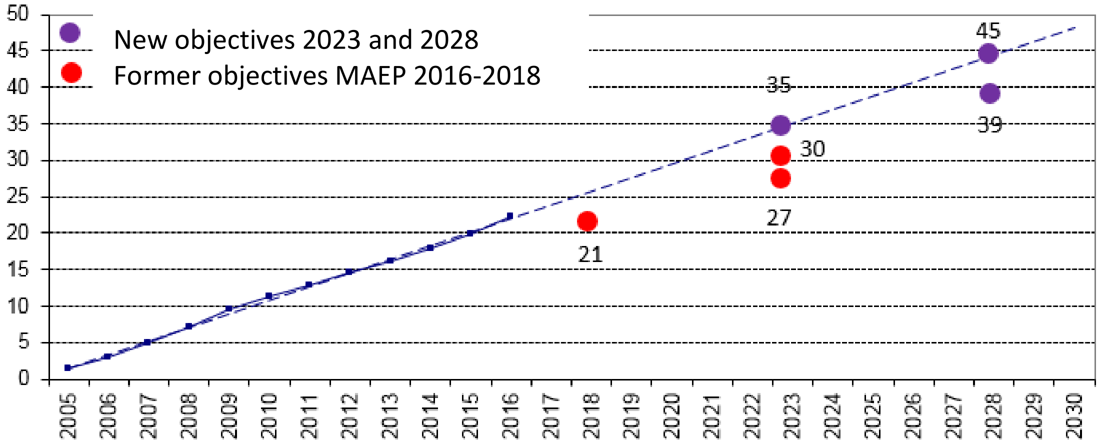


Figure 36: End-use heat consumption produced by aerothermal heat pumps (TWh)

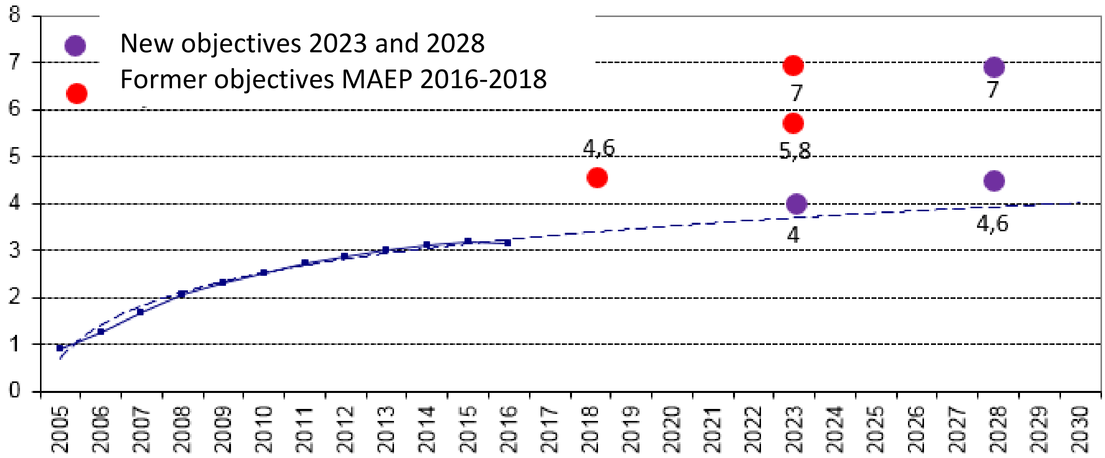


Figure 37: End-use heat consumption produced by aerothermal heat pumps (TWh)

3.1.3. 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 2000m, 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 90°C) is addressed in the electricity section (see below).

State of play in the sector

There are 71 deep geothermal energy installations in France, of which 49 are located in the Paris basin, 21 in the Aquitaine basin, with the others in Alsace, the Rhone Valley and Limagne. These installations provided a total of 1570GWh of renewable thermal generation in 2016. 90% of this production was for district heating, 8% for agriculture and 2% for thermal establishments.

2012	2016	Lower MAEP Objective 2023	Higher MAEP Objective 2023
1.2TWh	1.6TWh	4.6TWh	6.4TWh

Table 14: The targets for renewable heat from deep geothermal energy set by the MAEP adopted in 2016 and the achievements for 2012 (baseline year) and 2016.

The current rate of development of low and medium energy geothermal heat production does not match that predicted by the previous MAEP exercise. There is indeed a stagnation that could continue, as few projects are in the study phase. The current average rate is 70MWh / year between 2010 and 2016, whereas it would be necessary to reach a rate of six to ten times higher to reach the low-to-high objectives of the MAEP for 2023. It is therefore important to boost support but also to review the 2023 target downward and aim for about six operations a year of 10MW thermal units between 2018 and 2023 and 11 operations per year of 10MWh between 2024 and 2028.

Maximum supply potential

The use of deep geothermal energy is limited to sufficiently deep and permeable geological formations containing aquifers whose water has been heated deep down in contact with the rocks. One of the challenges of the sector relates to the development of deep geothermal energy coupled with heat networks in Île-de-France (creation, extension of existing networks, conversion of networks using fossil fuels to geothermal) but also other less well-known aquifers than Dogger. Other deep aquifers have a high potential deposits but their precise resource is unknown; for example, the Triassic and Lusitano aquifers in Île-de-France, aquifers in the Aquitaine Basin, Alsace, the 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 5.8TWh.

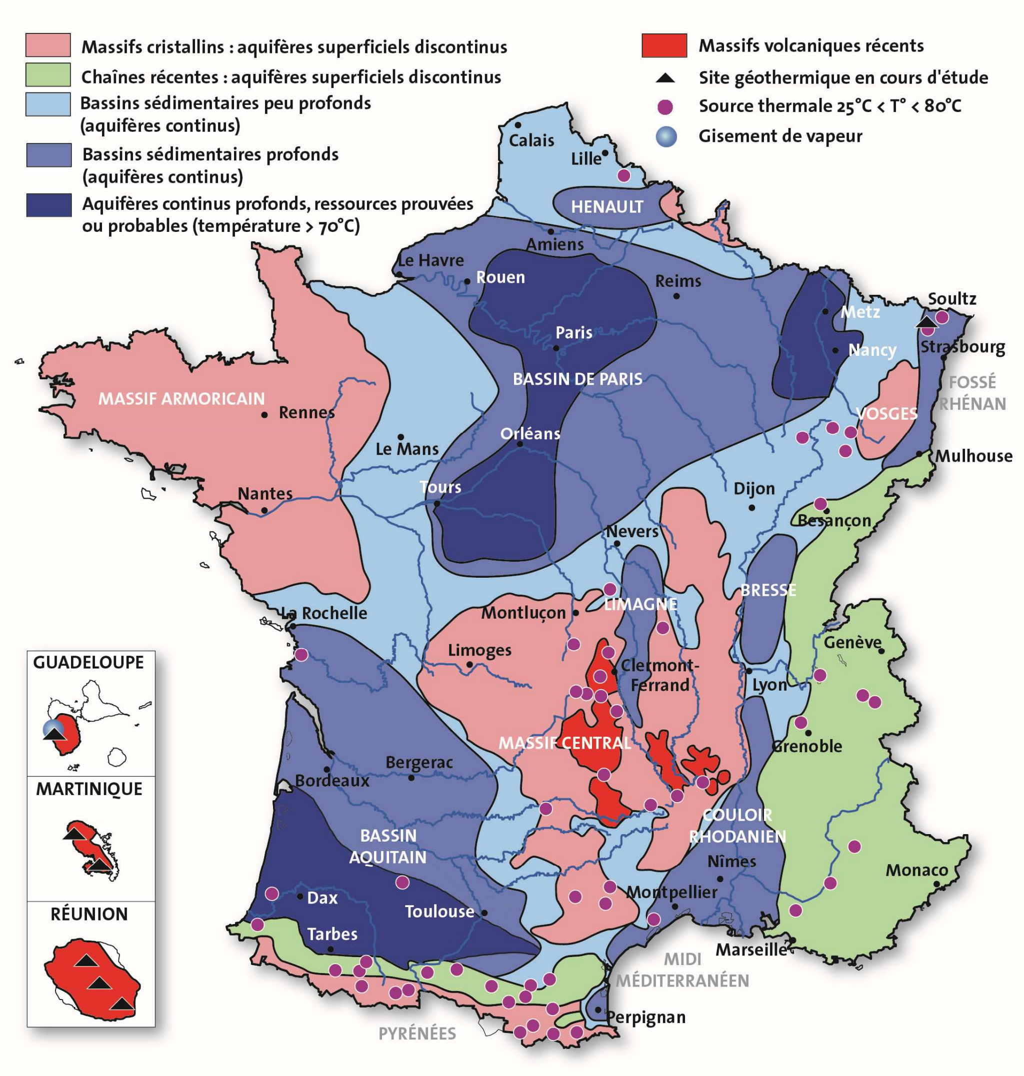


Figure 38: Map of aquifers in mainland France (Source: ©BRGM IM@Gé)

Socio-economic, 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 of development of the sector (e.g. Centre Val de Loire, Hauts de France, Grand Est). Also, at least one trained coordinator per large region would help to raise the awareness of both 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 hazards

Geological hazards linked to the discovery of a resource with the appropriate temperature and flow characteristics, hinders the development of projects. Furthermore, investment in this prospecting phase is costly, which means that the risk of an insufficient resource must be insured. Accordingly, since the 1980s, the SAF Environnement[20] Fund has covered both the short-term risk ((insufficient geothermal resources) and the long-term risk (reduced exploitability of the geothermal resource) for projects aimed at producing heat. The continuation of this mechanism, which has proved 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 hazards in the drilling phase for projects in Mainland France producing heat, and whose estimated temperature is higher than 120°C, 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). It could be planned to try to stimulate operations on insufficiently known aquifers, e.g. by financing additional prospecting activity (3D seismic surveys, etc.) to provide a guarantee for the drilling to be carried out. A study on this potential development could be conducted as of 2019 in order to determine the exact methods and the necessary staffing, 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 revision of the Renewable Energy Directive, currently being negotiated, affords a new sense of importance to renewable cold production. Furthermore, an amendment to the Mining Code explicitly mentioning cold production using geothermal energy could be used 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 ten years excluding grants), running costs are, by contrast, low, which makes this one of the least costly renewable energies over the long-term and 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 in the sector is ongoing for better identification of the costs per technology and for a better description 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 operation of reservoirs, materials, etc.). Production costs should therefore remain stable or slightly decrease.

The characteristics of the sector in terms of employment

The low-energy geothermal energy market in 2014 amounted to €53M. Drilling companies (including low geothermal energy drilling companies) account for about 2400 full-time employees and geothermal energy for grid-based heat generation also mobilises full-time grid operators. The professionals are trained and certified, and the French sector benefits from know-how. In 2016, the sector had a ratio of 1500 jobs per TWh produced.

Environmental challenges

It is mainly in the prospecting phase that certain risks and nuisances are noted, especially during drilling operations (risk of creating connections between several aquifers, lorry traffic, etc.). The existing regulatory system (Mining Code, law on water) oversees the implementation of operations to minimise nuisances.

During the prospecting 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 waste energy).

20 SAF Environnement is a subsidiary of Caisse des Dépôts et des Consignations

A life cycle analysis has been conducted on some exemplary operations (Soultz sur Forêt, Bouillante); it would be interesting to carry out a life cycle analysis on an operation typical of the Paris basin.

Objective of increasing heat from geothermal sources and measures to achieve it

2016	2023	2028
1.57 (TWh)	2.9 (TWh)	4 to 5.2 (TWh)

Measures complementing cross-cutting measures:

- Set up local coordination, with at least one ADEME coordinator specialising in geothermal energy per region;
- Support investment in geothermal energy, geothermal cooling networks, geothermal heat storage solutions, through the Heat Fund;
- Continue the Guarantee Fund (SAF) and adapt it if necessary to develop the potential of new, poorly-known aquifers, regarding the conclusions of the sizing study to be conducted by l'ADEME in 2019;
- Enable the participation of the Heat Fund in the financing of regional cartographies for Geothermal Minime Importance (GMI), and the financing of decision aids on the economic profitability of surface geothermal resources;
- Amendment to the Mining Code to explicitly mention geothermal cold production;
- Integration of a techno-economic evaluation of solar or geothermal heat production in the energy audits of large and medium-sized companies.

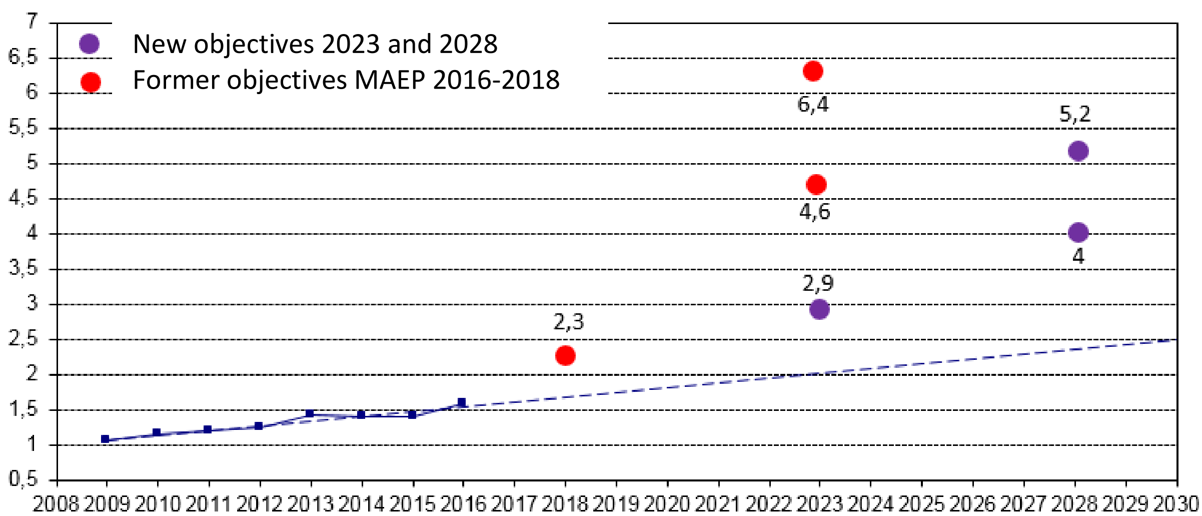


Figure 25: End-use consumption of heat produced from deep geothermal energy (TWh)

3.1.4. Solar thermal energy

State of play in the sector

In 2016, in mainland France, total solar thermal power resources occupied an installed area of 2.2 million m² with a total production of 1.17TWh / year. The installed surface in the residential sector represents 54% of the total area, 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 domestic hot water system) or for the joint production of hot water and heating (combined solar system).

2012	2016	Lower MAEP Objective 2023	Higher MAEP Objective 2023
1TWh	1.17TWh	3.1TWh	4.6TWh

Table 15: The targets for renewable heat from solar thermal energy set by the MAEP adopted in 2016 and the achievements for 2012 (baseline year) and 2016.

The previous MAEP 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 for enhancing thermal regulation in the production of renewable heat. The end-use consumption of heat from solar thermal was based on an average rate of 100,000m² installed per year in private dwellings and about 200,000m² installed per year in the collective / tertiary sector. In 2015, less than 100,000m² were installed in all sectors, so the rate was three times lower. For 2023, the MAEP objectives 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 solar in collective applications halting its decline, and growth in the combined solar segment (fewer than 500 installations per year).

Maximum supply potential

France has particularly good solar resources, ranking fifth in Europe. The maximum potential of solar thermal is estimated at 6TWh (by 2050).

Socio-economic, industrial and environmental issues

Yield

The energy yield varies depending on the climatic zone in which the solar equipment is installed:

- The productivity of the individual facilities is around 300kWh / m² / year in the North of France and 500kWh / m² / year in the South;
- The productivity of collective or on-grid facilities is around 450kWh / m² / year in the North of France and 600kWh / m² / year in the South;
- The productivity of industrial equipment in the South of France is around 700kWh / m² / year. They 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 greater than or 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 to 60% of domestic hot water (DHW) needs.
- Combined solar systems provide 30% of cumulative DHW + hot water requirements, distributed 60 to 70% DHW versus 15-25% heating;

- Collective and tertiary solar water heaters provide 50% of so-called "on tap" clean hot water requirements.

Thermal regulation issues

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 5kWh / 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 the most 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 revision of the Renewable Energy Directive, in its current wording, provides for a minimum renewable energy rate 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 actually satisfy this new requirement. The modernisation of the RT2012 calculation engine is currently being considered in order to upgrade the 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). CITE grants, differentiated based on technologies, would favour solar solutions with regard to their performance.

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 heat 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 to be taken. The Heat Fund would enable support for solar energy in these sectors. Innovative solar concentration technology is already being supported via 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 for 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 is has the immediate capacity to manufacture and install three to four times more solar thermal equipment than 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 that of thermodynamic water heaters. For combined solar systems, it is between €225 and €337 / MWh.[21] 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 interesting 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 envisaged for solar energy in industry.

21 . Source: ADEME study "Renewable Energy Costs" Edition 2016.

The characteristics of the sector in terms of employment

The solar thermal market (mainland France and overseas departments and regions) amounted to €343 million in 2015 and generated 2470 jobs[22]. In 2016, the sector had a ratio of 2111 jobs per TWh produced.

The decline in solar energy led to a fall in solar thermal jobs (-28% jobs between 2013 and 2015). 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 made it possible to make the installations more reliable. Finally, the collective sector is grouped in SOCOL[23], which has been organised with qualifications for design offices and installers, to bring stakeholders together and disseminate best practices; SOCOL brings together nearly 1000 experts, professionals and project owners.

Environmental challenges

Solar thermal energy is low in CO_2 emissions, at around 35gCO_2 / kWh (solar water heaters). The most significant impact is therefore related to the electric or gas / oil supplement (coverage rate of 50%). Finally, the end of life of heat pumps is managed as part of the waste management of electronic electrical equipment, favouring recycling.

Objective of increasing heat production from solar thermal energy and measures to achieve it

For 2023, the target is to install about 100,000m^2 per year of solar thermal energy in the building sector (half of which will be in private dwellings) and 150,000m^2 of facilities in industry (about 50 solar power plants).

For 2028, the target is to install about 150,000m^2 to 350,000m^2 per year in the building sector (70% of which will be in private dwellings based on a major development of combined solar systems) and 300,000m^2 of facilities in industry (about 100 solar power plants).

2016	2023	2028 scenario A	2028 scenario B
1.17	1.75	1.85	2.5

Measures complementing cross-cutting measures:

- Private dwellings:
  - Increased State support for solar thermal devices (combined solar systems, CESI, etc.) in the context of refocusing ISCED on the most efficient works;
  - Development of a communication kit for energy advisors on the interest of solar thermal in private dwellings, so that they are better equipped to promote this solution.
- In the collective, tertiary and industrial sectors:
  - Extension of the Heat Fund's call for projects for large solar thermal surfaces for a minimum of three years and review of the criteria for evaluating projects by 2019;
  - Allowing Heat Fund grants for the reconditioning of faulty equipment (size audit, performance instrumentation, skills upgrading, conditional grant for example if no support has already been granted for the installation or if an EPC is envisaged);
  - Simplification and standardisation of the allocation of Heat Fund support for solar thermal energy in new builds by 2019 during the transition period before the new thermal regulation for buidings ;

22 . Source: “Markets and jobs in the area of Renewable Energy” ADEME edition – July 2017
23 . Scheme launched in 2009 by Eneplan, with the support of ADEME and GRDF

- For the reduced VAT rate in district heating, taking account of the supply of district heating by solar thermal energy by the end of 2018 ;
- Including a technical-economic evaluation of solar or geothermal heat production in the energy audits of large and medium-sized companies;
- Development of communication on the interest of solar thermal energy for the agricultural environment;
- Diversification of the role of wood energy coordinators towards other renewable energy technologies such as solar.

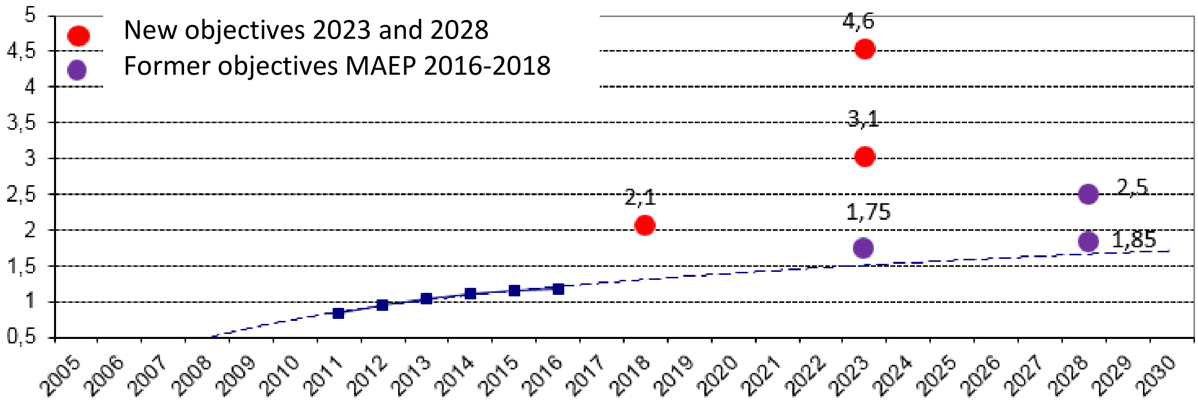


Figure 40: End-use consumption of heat produced by solar thermal (TWh)

3.1.5. Recovered heat

Waste heat is the heat generated as the by-product of a process, and which is not necessarily recovered[24]. When this waste heat is recovered and used, it is called heat recovery. There are many sources of waste heat: industrial sites, tertiary buildings (data centres, wastewater plants, etc.), energy recovery units for household waste known as WtE (Waste to Energy) units (in terms of their non-renewable part[25]) or waste processing sites (CSR, heat treatment of sludge, etc.)

The Energy Transition for Green Growth Act sets the goal of a five-fold increase in the 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 heat network, contributes to these objectives.

The quantity of recovered industrial heat currently used by district heating is estimated at 445GWh[26]. The amount of heat recovered from waste energy recovery units and delivered is 4TWh[27].

24 . The heat produced by cogeneration, for the purpose of the simultaneous production 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 rage on deliveries of calorific energy).

25 . By convention, it is considered that 50% of the production of energy by household waste energy recovery units is renewable and 50% is recovered heat.

26 . Source: Annual survey of heat networks, edition 2017, SNCU.

27 . For more details on the evaluation of the heat produced from waste energy recovery, see section 5.5.

Maximum supply potential

The potential of industrial waste heat at more than 30°C is estimated to be 109TWh[28], while the national resource of waste heat from household waste treatment units (excluding the optimisation of existing units), wastewater treatment plants and from data centers is 8.4TWh. The amount of waste heat at more than 60°C available near to existing district heating networks is quantified at 12.3TWh, including 56 sites near an existing district heating, which total 9TWh. Considering the decline in energy consumption in industry by 2035, we can estimate a maximum recoverable potential in the networks of 7.7TWh.

The maximum potential of household waste energy recovery units following optimisation / modification of existing units is estimated at 10TWh of additional heat compared to 2009, of which 6TWh could supply district heating and cooling (at an equivalent amount of waste burned). This represents a total potential of 9 to 10.5TWh in heat delivered by district heating and cooling from the energy recovery units. Finally, solid recovered fuels are also likely to contribute up to 1.7TWh to the development of heat recovery in heating and cooling networks.

There is also potential for heat recovery from wastewater. The resources in Île de France have been estimated at 2TWh of which 1.1TWh is recoverable. An estimate of the potential of each region could thus be developed during the SRADDET (Regional Planning, Sustainable Development & Territorial Equality Scheme). ADEME could also assess this potential when updating its study on fatal heat.

Socio-economic, industrial and environmental issues

The challenges of industrial heat recovery mainly concern contracting capacity between industrialists, or between an industrialist and a district heating (public or private). Issues of 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 of action to be implemented (financial, regulatory, fiscal, etc.).[29] Since 2015, the Heat Fund has been supporting waste heat recovery projects. 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 20MW with non-recovered waste heat must [30]conduct a cost-benefit analysis on the opportunity of recovering it in a district heating. Similarly, any new or substantially refurbished energy production installation with a total thermal input exceeding 20MW connected to a district heating shall prioritise the feasibility of using waste heat from sites near the network before sizing. This study, when it is legally required, is now one of the list of documents that must be provided with any grant application to the Heat Fund.

The specific issues of waste energy recovery (including WtE units, SRF, etc.) are discussed in section 3.2.

The recovery of waste heat by a factory is part of the process for 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 intensive industries are grouped are likely to favour energy exchanges between stakeholders (communities, companies, etc.).

Current and foreseeable costs

The average cost of heat recovery projects funded by the Heat Fund is €97 / MWh (excluding grants). It is of note that the cost of the heat sold by the WtE units to the heating networks is very competitive, around €10 to €25 / MWh.

28 . Source: “Industrial waste heat, edition 2017”, ADEME.

29 . Study conducted by ADEME in 2018.

30 . This relates to new installations or those being fully overhauled. A full overhaul means a renovation whose cost exceeds 50% of the cost of a comparable new unit.

Environmental challenges

The environmental issues of waste heat recovery are positive because they enable energy consumption to reduced by capturing unused thermal energy.

Development objectives and measures

The MAEP sets a goal of delivering recovered heat (from the industriy data centers and from waste units) through district heating and cooling. These objectives correspond to a five- to six-fold increase in the amount of industrial heat recovered by 2028, improved recovery of waste heat from household waste treatment units, and heat recovery from the combustion of other wastes such as solids. Scenario B for 2028 is an increase in the average rate of recovery in networks of 0.8% per year over the 2016-2028 period.

- Industrial waste heat will contribute 0.84TWh in 2023 (double the figure for 2016, the baseline) and between 2.3TWh and 3TWh in 2028 (a five- to six-fold increase over the 2016 baseline).
- Improved recovery of waste heat from household waste treatment units, and heat recovery from the combustion of other waste such as recovered solids will contribute in networks to 3.6TWh in 2023 and between 5.3TWh and 6.9TWh in 2028 in district heating and cooling (based on the fact that 50% of the contribution is already part of the target for biomass).

	2016	2023	2028 scenario A	2028 scenario B
Objective (TWh) including R&R energy from household waste incinerators	3	4.5	12	18

Measures complementing cross-cutting measures:

- Heat Fund support for waste heat recovery projects;
- Following the conclusions of the study on the financing of industrial heat recovery investments, evaluate the possibility of implementation of the recommendations by the heat fund and other adapted devices (over-damping for heat recovery equipment fatal, human support for mounting fatal heat recovery projects ...);
- Introduction of mandatory energy recovery of biogas captured in waste storage facilities;
- Increased improvements in the energy efficiency of household waste energy recovery units, with specific action on the ten or so incinerators without energy recovery and going beyond the minimum energy efficiency criterion for existing units;
- Evaluate the potential for heat recovery from wastewater through SRADDET and the updating of the ADEME study on waste heat.

3.2. Waste energy recovery

Waste use for energy production purpose contributes to the circular economy so long as recovered waste could not have been avoided or recovered in the form of materials. The LTCEV set two principles for waste energy recovery: the principle of treatment near the source and the research of efficient waste energy recovery processes. In 2016, waste energy recovery accounts for:

- 3,3 TWh produced by biogas from non-hazardous waste landfills (ISDND) ;
- 9,4 TWh produced by household waste incineration plants (UIOM) ;
- 5,5 TWh produced by biogas from methanisation.

Plants for the co-incineration of waste[31] also produce several TWh of energy recovered from waste.

Recoverable waste deposits

The circular economy policy initiated by the LTCEV should deeply change the waste energy recovery trend. Waste stream will be massively redirected. By 2025:

- 9.8 Mt fewer wastes would be landfilled in ISDND, in particular biowaste, i.e. gas emitting waste. This trend will lead to a 25% reduction of biogas production in ISDND that is to say a 2.5 TWh reduction;
- UIOM will receive 2.9 Mt lesser household waste (HHV 2300kWh/t) and an extra 1.5 Mt of recycling rejects (HHV 2800 kWh/t). It should lead to a 2.5 TWh reduction of energy production;
- 8 Mt of biowaste should be collected separately and be recovered. Half of them (4Mt) will be use through methanisation. It will lead to an extra 2.8TWh reduction of energy;
- 2.4 Mt of high calorific recycling rejects (HHV 3500 kWh/t) will be turned into solid recovery fuel and be able to generate 8.4 TWh of energy.

Some of the waste for energy recovery could be subject to thermal treatment like 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.

Considering diversion of biowaste from landfills, the European Commission outlines the 26th of January 2017 that biogas recovery from ISDND is not anymore a target as such. For that reason, the support mechanism to gas injection intended to power generation will pursue to completion but will not be extended beyond. It provides no later than 2023 an extra capacity of 60 MW of new facilities. Support mechanisms should take into account the deposit decrease and assist the concerned sectors.

Socio-economic, industrial and environmental issues

Household waste incineration plants

126 household waste incineration plants are installed in France. In 2015, the 113 installations equipped with energy recovery device have produced 2.3 TWh of electricity and 7.1 TWh of heat. These facilities are composed of:

- 52 units accounted for 56 % of incinerated waste, which are considered as energy utilisation units (>R1);
- 64 units accounted for 42 % of incinerated waste as recovery units (R1<0.6 or 0.65);
- 10 small units accounted for 2% of incinerated waste as waste disposal facilities (no recovery). These 10 units are small ones destined to close in the following years.

Lots of very small and quite old facilities are also installed and had major upgrading to standards maintenance in the early 2000s.

The current fleet of waste energy recovery plants adapt continuously and recovery of residual energy from incineration is expected to become widespread and develop. By 2025, Incineration plants without waste recovery are expected to close. Few facilities will be built in the following years. Therefore, it is crucial to support the optimisation of existing units. This could be made through a support of optimisation work as part

31 Facility for which 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.

of the Heat Fund and the Waste Fund. ADEME monitors unit optimisation work and raises awareness among local authorities about benefits of an optimal energy recovery of their facilities (economic, taxation, environmental impacts, local development, employment…).

A BREF[32] is currently under development[33]. It will make mandatory energy performance schemes[3]. This optimisation could lead to an extra heat generation between 7 and 10 TWh included 60% (4 to 6 TWh) destined to heating and cooling networks. It would be appropriate to maintain aid paid under the Waste Fund (and under the Heat Fund concerning heating and cooling networks).

In 2028, heating generation from UIOM should be between 15 and 18 TWh and electrical power generation should account for 2.3 TWh.

Facilities of energy generation coming from refuse-derived fuels (CSR) combustion

In 2017, 800 kt of CSR were produced in France: 100 kt were exported, 300 kt were used by the cement sector, 200 kt were used by facilities supported as part of the ADEME call for Refuse-Derived Fuel projects and 200 kt don't find any outlets. By 2025, CSR annual deposit is expected to be 2.5 Mt included 1 Mt for co-incineration in ciment factories. A 1.4 Mt deposit (around 4.9 TWh) could be geared towards CSR energy recovery units. Nevertheless, this stream is expected to decrease over time because of the efficiency of prevention and material recovery improvement policies.

Waste energy generation 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 is therefore given to heat production.

Deposit for CSR without any identified outlet has therefore a potential of 200 kt in 2018 with an increase of approximately 150 kt each year until 2025. A annual potential of 200 kt will be geared towards the ADEME call for Refuse-Derived Fuel projects, paid under the Waste Fund of up to €30 million corresponding to 100 MW PCI each year. The support cost of this call for projects amounts to €3.5/MWh on average over a 20-year period in the form of investment aids.

The Waste Fund finances via the call of Refused-Derived Fuel projects metropolitan CSR (100% CSR) heat generation. Concerning the Heat Fund, it finances the heating networks which recovered energy generated from CSR by way of recovery energy, in compliance with the LTECV objective of a 5-fold increase of the amount of renewable heat and cooling and of the recovery in these networks by 2030. The reduced rate VAT of 5.5% is also already applicable to networks which used more than 50 % of renewable and recovery energy included waste.

Biofuel and biogas production

The inputs that can be used in a methaniser include mainly household and professional waste (food waste, vegetable waste), plant waste, sewage sludge (urban and industrial), livestock effluents, by-products from agri-food industries and agricultural biomass (energy crops, agricultural residues…) or other recoverable organic waste from sanitation. Some of these inputs, such as fats, offer resources that can also be used for the production of biofuels. Others are by-products from agri-food industries whose existing recoveries should not be unbalanced.

The methanisation sector is introduced in the biogas part.

The overall deposit of household food waste (biowaste exclusive of green waste) is estimated at 8 Mt, half of which could be geared towards methanisation after source separation and accounts for a deposit of 4 Mt/year by 2025. Besides, the collect of all professional bio-waste accounts for approximately 2 Mt of food waste,

32. BREF : Best Available Techniques Reference.
33. The decree related to the regional waste prevention and management plan in accordance with the NOTRe act provides for the improvement in energy efficiency of waste energy recovery units by limiting the part of incinerated waste in units, which do not reach the "R1" standard, to 50% of the incinerated waste in 2010 by 2025.

knowing that the main part of the current mobilised deposit is used for methanisation, that is to say an extra 1 Mt of food waste. This deposit of 5 Mt of methanised waste could generate 3.5 TWh of primary energy.

Wood waste

In addition to the part that could be used as CSR, the end-of-life wood resources are introduced in part 5.5.

Environmental issues

All waste treatment plants subject to the ICPE regulation and have a strict framework on the evaluation of their impacts and pollutants.

The aim is not to maximise energy power coming from waste but to maximise energy recovery of waste which could not be avoided and which are not recoverable as materials. Waste energy recovery should neither reduce waste prevention measures nor capture waste which could have been recovered as materials. Waste energy recovery is aligned with the European Commission communication of 26th January 2017: « 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, 3.5 TWh used by the cement industry and 2.3 TWh of electrical power produced.

Half of heat generated by UIOM is considered as renewable and counted in the biomass target. The other half is considered as recovery energy. It contributes between 4.5 and 5.2 TWh to the recovery and renewable energy integration target. Among the 4.9 TWh of heat generated by CSR, it is estimated that around 2 TWh could be recovered by heating networks and be counted as recovery energy.

Development objectives and measures

There is no quantitative objective in terms of waste energy production. The orders of magnitude are mentioned in the relevant sections.

- Further develop the improvement in energy efficiency of household waste energy recovery units, have a specific action for the 10 incinerators without energy recovery and go beyond the minimum energy efficiency criteria for existing units, in line with the publication of the BREF for this sector : the inspectorate of classified installations may be asked to examine the energy efficiency ratio for each energy recovery unit so that it reaches the best possible ratio in the admissible range;
- Maintain the aid paid under the Waste Fund for improving the energy efficiency of the household waste incineration plants (UIOM) and under the Heat Fund for connection to the heat recovery networks;
- Rerun the ADEME call for Refuse-Derived Fuel projects.

3.3. Liquid fuels

In 2016, domestic consumption of refined petroleum products (excluding biofuels) was 808TWh, down 2.1%. This fits the long-term downward trend that began in the early 2000s (see figure below).

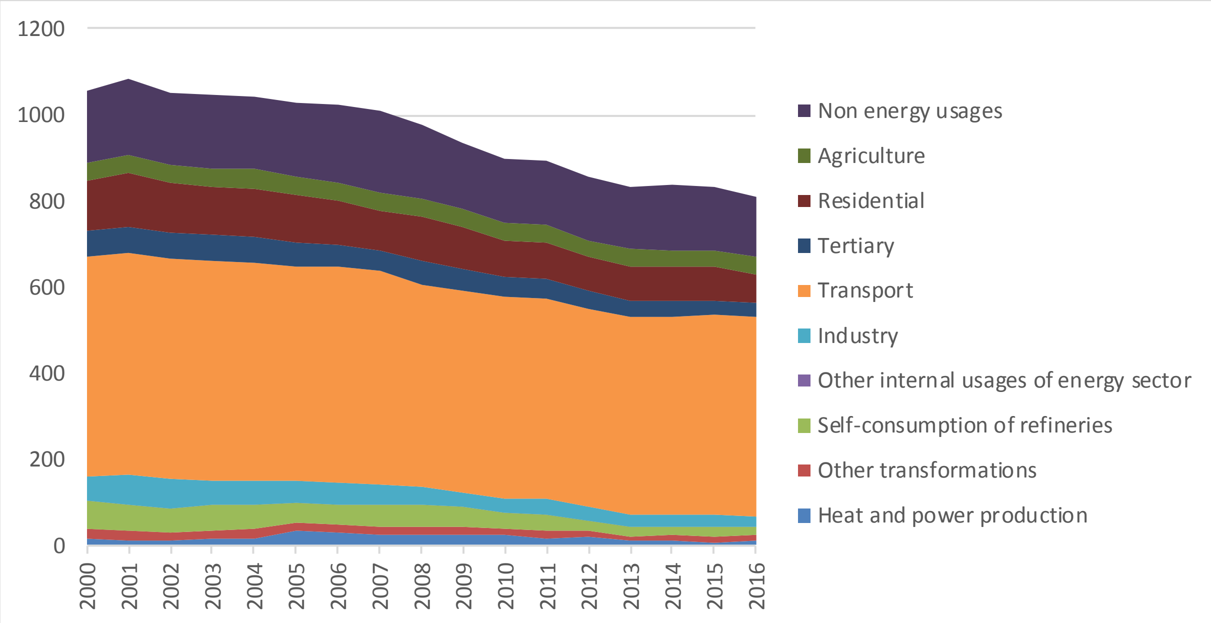


Figure 41: Total consumption of refined petroleum products by sector (excluding biofuels) in TWh[34]

The consumption of liquid fossil fuels will decrease as a result of consumption control measures, in particular those relating to mobility: changes in mobility, lower individual consumption of vehicles, replacement of thermal vehicles by electric vehicles, or replacement of fossil fuels by bio-based fuels. In 2023, the end-use consumption of liquid fuels should be 406TWh and 348TWh in 2028.

In 2015, the "ILUC"[35] Directive 2015/1513, confirmed a target of 10% renewable energies in transport in 2020 with a ceiling of 7% for biofuels in competition with food competition and an indicative target of 0.5% in 2020 for advanced biofuels. It defines the list of raw materials that enable advanced biofuels to be developed. The LTECV has adopted a more ambitious target of 15% renewable energy in end-use fuel consumption by 2030. Achieving this goal requires an increase in the rate of incorporation of biofuels, but also an increase in alternative fuels with lower carbon emissions than traditional fossil fuels.

The ENR Directive[36] defines the renewable energy targets for the transport sector by 2030 and the 2020-2030 trajectories for the different categories of biofuels. It confirms the European desire to limit the use of conventional biofuels, i.e. competing with the production of foodstuffs, while retaining the investments to date and the desire to promote biofuels from waste and residues, known as advanced biofuels, beyond the objectives

[34]Data corrected for climate variations, not including international air and maritime bunkers.
* Army consumption is included in this report in the tertiary sector.
** This item represents semi-finished products from the petrochemical industry returned to refineries for reprocessing. It also contains small amounts of petroleum coke in coke ovens until 2009.
Source: SDES calculations, from CPDP, CFBP, Insee, SSP, SFIC, Uniper, Customs, DGEC, Ministry of Defense, EDF, Citepa.

[35]. EU Directive 2015/1513 of the European Parliament and of the Council, dated 9 September 2015, amending Directive 98/70 / EC on 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) **known as "CASI" or "ILUC"**.

[36]. Directive 2009/28 / EC of the European Parliament and of the Council dated 23 April 2009 on the promotion of the use of energy from renewable sources, amending and repealing Directives 2001/77 / EC and 2003/30 / EC (Text with EEA relevance).

set by Directive 2015/1513 'ILUC'. It also plans to limit the use of raw materials with the greatest impact in terms of land use change (like oil produced from palm or soybean).

3.3.1. Crude oil production in France

National production of hydrocarbons amounts to 0.8Mt / year and represents 1% of national consumption. The law putting an end to the research and exploitation of conventional and unconventional hydrocarbons[37] will lead to a gradual halt in domestic production by 2040. In 2023 and 2028, production is estimated to be 0.7Mt and 0.6Mt, respectively.

3.3.2. Refining

In France, the refining sector was marked by the closure of several facilities in the early 2010s. Metropolitan France now has only seven refineries. They have an annual refining capacity of about 62Mt 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-energetic products such as lubricants or bitumen. Refining is also of particular importance for the petrochemical industry.

In 2017, national production of refined products, net of refiners' own consumption, amounted to 55Mt. French refineries mainly produce diesel (37% of total production in 2017), super-fuels (17%), heavy fuel oil (9,5%), and non-energy products (18%). Domestic fuel represents 7% of the total domestic production of refined products, kerosene 8%, LPG 3% and all other products 4,5%. This distribution has been stable in recent years.

The industrial tool must continually adapt to meet demand while improving environmental performance and energy efficiency. Transformations will be needed to adapt the industrial tool to consumption and sustainability criteria.

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 to limit the consumption of fossil energy but also to import fossil fuels with the least environmental impact.

Article 8 of the hydrocarbons law provides that the Government shall submit a report on the origin of imported hydrocarbons released for consumption in France to Parliament. This report should study the environmental impact of extracting and refining conventional and unconventional hydrocarbons, and in particular:

- Classify the environmental footprints arising from extraction and refining of oil,
- Identify the variability criteria of greenhouse gas emissions associated with extraction and refining of oil,
- Appreciate 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 extraction of oil, and for the traceability of physical streams of hydrocarbons.

[37]. **Law No. 2017-1839 of 30 December 2017 putting an end to the research and use of hydrocarbons and involving several provisions relating to energy and the environment, available at https://www.legifrance.gouv.fr/affichTexte.docidTexte=JORFTEXT000036339396&dateTexte=&categorieLien=id**

Measures

- Implementing the conclusions of the report to the Parliament on the origin of liquid hydrocarbons (crude oil and refined products) released for consumption in France, based in particular on their origin, the type of resource, their extraction and transport conditions.
- Support the consumption of gasoline against diesel with a rebalancing of the taxation as long as a thermal vehicle fleet remains.

3.3.3. Biofuels

State of play in the sector

In France, the 7% ceiling set for the incorporation of conventional biofuels into liquid fuels has been achieved. One of the priorities of the MAEP is to develop so-called "advanced" second-generation fuels produced from waste and residues. This was already an MAEP objective adopted in 2016.

	The situation in 2016	MAEP Objective 2018	MAEP Objective 2023
Percentage of incorporation in consumed petrol	n.d.	1.6%	3.4%
Percentage of incorporation in consumed diesel	n.d.	1%	2.3%

Table 16: The objectives set by the MAEP adopted in 2016 for the consumption of 2nd generation biofuels

The first MAEP set objectives for the incorporation of advanced biofuels (from waste, residues or lignocellulosic material) with the assumption that the new EU Directive would allow for fuels with higher biofuel content and that molasses, C starch and acid residues of edible oils would be considered as advanced biofuels. However, these three substances are not adopted under this classification. That is why the results are very far from the adopted objectives. If we calculated again the 2023 objectives with the current perimeter, they would be 1,8% in petrol and 0,85% in diesel.

The coming objectives must be set with the same perimeter as the one established in the RED2 directive, which means that they should only take into account biofuels produced from the raw materials listed in Appendix IX of the directive.

Box 5: Aeronautical biofuels

The air transport will have to use aeronautical biofuels innovative and sustainable with the continuous progress of technologies, the operational improvements and market measures as CORSIA, to answer to climate change challenge and reduce its carbon footprint. These biofuels are a strategic lever to reduce net emissions from a growing sector which has poor choice between energies. Biofuels, that can come from circular economy, would allow to reduce up to 90% of carbon emissions on the whole life cycle. Some can be incorporated up to 50% in the fossil fuel, in this case, the emissions reduction are less important.

Important improvements have been realized these last years, on efficiency and certification of aeronautical biofuels. The operational use of aeronautical biofuels is now under control. The road map of ANCRE(National alliance of research coordination for energy) assessed the potential of the French production sectors for aeronautical biofuels. In the word, 6 aeronautical biofuels sectors have been certified ASTM (American Society for Testing and Materials) and have been identified as possible renewable and sustainable alternatives to fossil aeronautical fuel. Other innovative sectors are under study, with different timelines for certification, confirming the richness of technological potential. Certified technologies for the production of aeronautical fuels can realise molecules very closed to the ones in the kerosen, and totally compatible. The use of these biofuels doesn't need any adaptation of the planes nor on airport infrastructure.

To promote a French aeronautical biofuels sector, the government, Air France, Airbus, Safran, Suez and Total have agreed, at the end of 2017, on an "Involvement to green growth" to study the implementation of such a sector. The conclusions should be written at the end of the 1st semester of 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 sludge, livestock effluents, algae, waste and residues from forestry, 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 channel makes it possible to obtain synthetic biodiesel, also known as BtL (Biomass to Liquid);
- The biochemical channel provides ethanol.

These new sectors have more favourable energy balances than those of the 1st generation and also 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 sludge, offer resources that can be used either for the production of biofuels or for the production of biomethane. Others represent by-products from industries whose existing recoveries should not be unbalanced. 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.

Socio-economic, industrial and environmental issues

The biofuel production sector is currently structured around first-generation fuels. It contributes to the economic profitability of the sugar sector in France, producing 12.5MhL of ethanol with 10.1MhL recovered as biofuels, and to the maintenance of its 8900 jobs.38 In the diesel sector, it also provides the recovery of 1.4 million tonnes of French rapeseed oil39.

The 2nd generation biofuel production chain is still emerging, and the costs or the employment content are as of yet not known.

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 amounts of first-generation fuels produced will be stabilised, but will not be increased.

There is no significant environmental issue for 2nd generation fuels.

Objective of increasing the consumption of biofuels and measures to achieve it

The objective of incorporating 1st generation biofuels is to maintain a level of 7% without exceeding it, by 2023 and 2028. The growth of the bio-sourced share in fuels is therefore exclusively obtained through the development of advanced biofuels.

There will be a major focus on meeting sustainability criteria and on the traceability of raw materials to achieve the set objectives.

Incorporation rate of advanced biofuels in fuels released for consumption	2016	2023	2028
Petrol sector objective (%)	0.3	1.8	3.8
Diesel sector objective (%)	0.35	0.85	3.2

- Encourage the development of biofuels through an incorporation incentive for economic actors who release fuels for consumption ;
- Beyond the existing ceiling for conventional biofuels, limit the incorporation of biofuels from raw materials with a high risk of indirect land use change (palm oil, soybean), as foreseen in the new ENR II Directive.

3.3.3. LPG

LPG is a gaseous fuel consisting mainly of light hydrocarbons containing three or four carbon atoms (propane, butane). This light formulation means lower unburned emissions compared to diesel and petrol. 30% of it comes from refining and 70% from gas fields.

State of play in the sector

The fleet using LPG as fuel is 210,000 vehicles, 5% of the use of LPG in France.

LPG is sold at more than 1700 stations in France. LPG is the alternative fuel that currently has the densest network of stations and is capable of supplying a fleet of vehicles ten times greater than the current fleet.

The decrease in the sale of LPG over the past ten years has undermined the viability of LPG fuel.

LPG of biological origin obtained from different biomasses should become a viable technology in the medium-term. Bio-isobutene is produced today using a mature technology that is not yet industrialized.

The LPG (fuel use) sector provides 5350 direct jobs.

[38]. Source: SNPAA

[39]. Source: Sustainability declarations

3.4. Gas

In 2017, the consumption of natural gas was 493TWhHHV. By 2023, measures to control energy demand will result in gas consumption of 470TWhHHV, and 420TWhHHV by 2028. The law has set the target of increasing the share of renewable energy to 10% of gas consumption in 2030. There are three key technologies that can be used to achieve this goal, namely methanisation, gasification and the conversion of electricity from renewable sources to syngas.

3.4.1. Natural gas

State of play and outlook for national natural gas production

France has few conventional natural gas resources across its territory. The commercial operation of the Lacq deposit – the main French natural gas deposit – is currently limited, and since 2013, its output is no longer injected into the network but directly consumed on site. Law No. 2017-1839 of 30 December 2017 also provides for the gradual cessation of research and operation of new resources.

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. In order to ensure a high level of supply security for H gas, France is equipped with an infrastructure consisting of five interconnections 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 (46% in 2017). The remaining imports are broadly diversified between different suppliers: Russia (21% of H gas imports in 2017), Algeria (9%), Nigeria (7%) and Qatar (4%). Interconnections 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.

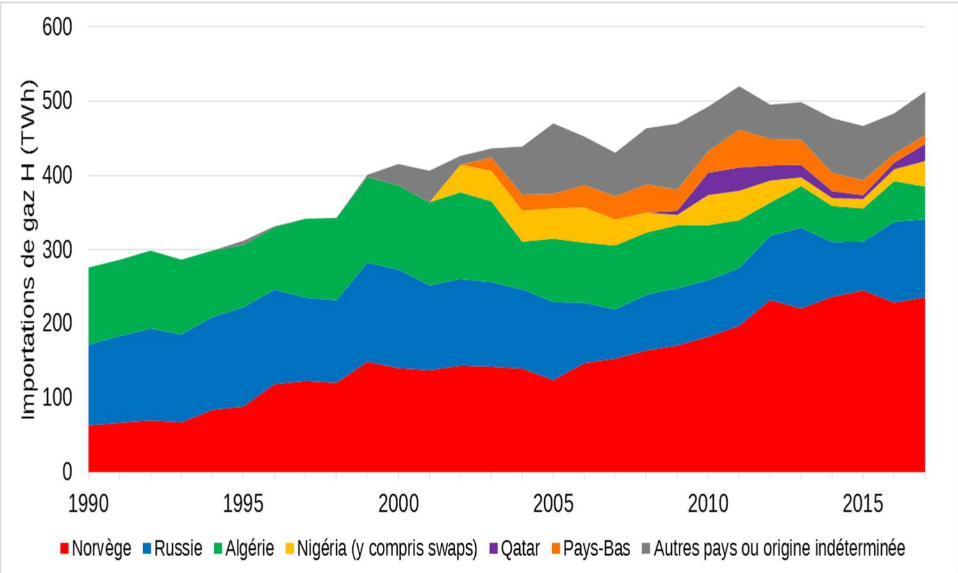


Figure 42: Origin of French natural gas imports of high calorific value 1990 (Source: SOeS and GRTgaz)

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 today pass through three interconnections 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 prospecting, development of gas fields, production and transportation.

In 2017, 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 Multi-Year Energy Programme. France's supply structure is therefore likely to change depending on the ability and interest of suppliers active in the French market in renewing their existing long-term contracts and in entering into new ones. The increasing interest of suppliers for flexible purchases on the market 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 standards, particularly in terms of composition. These are applicable to all gas sources. Accordingly, the natural gas consumed in France emits a similar amount of greenhouse gases during combustion, regardless of its origin and extraction method.

The environmental impact associated with natural gas consumption is not limited to its combustion. Its 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 deposits. These variations depend in particular on the production methods used, the quality of the extracted, gas 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 network.

In accordance with the provisions of the article of Law No. 2017-1839 – putting an end to the research and use 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.

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 deposit, 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.

In order 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 networks, 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 is beginning 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.

Measures:
- Conversion of the low calorific power gas grid as soon as possible, no later than 2029;
- The production of a report on the environmental impact of natural gas supplied for consumption in France, based particularly on its origin, the type of resource, and its extraction and transport conditions, with recommended follow-up measures.

3.4.2. Renewable gas

Renewable gas production targets

The natural gas transmission and distribution network operators indicate that at the end of 2017 there were nearly 400 planned biomethane production facilities with a cumulative production potential of 8TWh 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 2017, the average purchase price of injected biomethane was €100 / MWh HHV, compared to an average natural gas price of €18 / MWh HHV. The development of this sector therefore requires substantial public support. The prospect of envisaged cost reductions do not allow to plan a development of the sector without public support over the MAEP period.

The production costs of gasification of organic matter for injection in natural gas networks are estimated at a level higher than biomethane production costs.

In order to control the public expenditure for renewable gas support, the MAEP defines objectives to 2028 consistent with a share from 7 to 10% of the total gas consumption in 2030, linking the supports to the decrease of the production costs of the different sectors.

Methanisation

State of play in the sector

Methanisation is the decomposition by microorganisms of organic matter 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 it can be injected into gas networks 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	MAEP Objective 2023
Biomethane injected into grids (TWh)	0.4TWh	8TWh
Biomethane used to generate electricity[40]	1.9TWh of electricity, (5.5TWh of biogas)	2.6TWh of electricity, (7.3TWh of biogas)
Total biomethane consumed	5.9TWh	15.3TWh

Table 17: The objectives set by the MAEP adopted in 2016 for the consumption of biomethane.

As of 31 December 2017, 548 facilities were generating electricity from biogas, for a total capacity of 423MW. Electricity generation from biogas was 1.9TWh in 2017, i.e. using 5.5TWh of biogas.

44 facilities inject biomethane, after production and purification of biogas, into the natural gas grids, for a total production capacity of 0.7TWh 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.

The maximum potential of methanisation

Methanisation involves the use of organic matter that can easily be degraded by microorganisms. In order to reconcile the development of methanisation and compliance with land use issues, France has chosen to develop methanisation based on the use of waste 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 household waste, plant waste, sewage sludge, livestock effluents and agricultural residues. Some of these inputs, such as fats, offer resources that can be used either for the production of biofuels or for the production of biomethane. Others are by-products from agri-food industries whose existing recoveries should not be unbalanced. Agricultural waste must be mobilised by integrating a balance between the production of biogas and the return of carbon to the soil.

The availability of bio-gasable materials by 2035 are estimated at 100Mt by the ADEME, i.e. 50Mt of livestock effluents, 46Mt of vegetable matter and 3Mt of household waste, for a total of 70TWh of primary energy.

Socio-economic, industrial and environmental issues

The energy yield of a methanisation plant depends primarily on the recovery technique used to generate the biogas. For recovery by injection into natural gas networks, the yield of an energy methanisation plant is estimated at 94%, taking account of the heating needs of the methaniser. For recovery by electricity generation, the yield of a facility includes an electrical yield of about 35%.

This energy yield gap explains why alternative recoveries to electricity production are prioritised, particularly injection into gas grids, where possible.

Natural gas grids have been designed to transport natural gas from a few import points to a large number of consumers throughout the territory. The development of biomethane injection might require the grid to be reinforced in order to facilitate the injection of sources distributed throughout the territory towards the arteries of the grid.

The methanisation 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 subject to constant attention, so that it does not become a hindrance to the development of the sector.

[40]. Energy equivalence of the objective in capacities.

In 2015, the biogas sector was employing 1550 direct FTEs[41]. The employment ratio of the biogas sector is therefore 674 FTE / TWh. Equipment is mainly imported.

Current and foreseeable costs

The cost of generating injected biomethane, following purification, into a natural gas grid is about €95 / MWh HHV.

With the development of methanisation, a reduction in plant costs is expected due to a series effect on the equipment and a development of supply for maintenance-servicing operations. Technical progress may also be observed for the purification of biogas. The reduction in costs should make it possible to reach €67 / MWh HHV for injected biomethan projects selected by call of tenders by 2023 and 60€/MWh HHV by 2028.

Environmental challenges

Methanisation is developed on the use of waste and residues, so that it does not have any particular impact in terms of land use. Potential conflicts of use relating to the inputs of the biogas plants will continue to be monitored.

Objective of increasing the consumption of biomethane and measures to achieve it

The measures adopted aim to develop biogas production so as to meet the target of 7% renewables in gas consumption by 2030 if the decrease in costs targeted in the mains scenario are realized and up to 10% if they are higher.

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

Measures

- Create a higher profile by adopting a timeframe for calls to tender for injected bio methane: two calls to tender, for an annual production objective of 350 GWh HHV/year each, will be launched each year;
- Cement the biogas purchasing obligation at a regulated price and launch calls to tender allowing the production goals to be met at low cost thanks to big drops in costs:
  - The calls to tender will be built on a baseline purchase price trajectory, used to determine the size of the funding envelope with the aim of achieving an average of € 67/MWh HHV for the injected bio methane projects selected in 2023 and € 60/MWh HHV in 2028. If this average price is not reached, the total quantities will be reduced not to exceed the public expenditure level targeted. A maximum purchase price trajectory reaching an average of 87 €/MWh HHV for injected bio methane in 2023 and 80 €/MWh HHV in 2028 will also be put in place.
  - The volume of calls to tender will be adjusted upward if the average prices asked for in the tender framework are less than the baseline purchase price trajectory. The threshold price for calls to tender will be determined based on the maximum price trajectory. The “open window” feed-in tariff for small installations will be adjusted downwards if the contractualisation of biogas production capacity is higher than the goal of 800 GWh HHV per year over all the recovery sectors.

[41]. Source: “Market and employment in renewable energies”, ADEME, July 2017

- Put appropriate support provisions in place for biomethane not injected in the natural gas networks (in particular biomethane used directly for bioNGV vehicles);
- Foster NGV and bioNGV mainly through an extra depreciation for purchases of compatible vehicles.
- Accelerate the deployment of NGV: support the production of biomethane for methanisers that supply vehicles (buses, trucks) to develop local direct use, especially when away from the gas network;
- Facilitate the supply and connection of NGV stations to natural gas networks.

The calendar below marks the quarters in which a call to tender will be launched for up to 350GWh / 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 HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year		350 GWh HHV/year

Gasification of organic matter

Gasification is the thermochemical decomposition of organic material into a syngas consisting mainly of methane, hydrogen, carbon monoxide and carbon dioxide. This syngas can then be recovered in various ways. Gasification for heat production is one of the technologies used by the wood energy sector. Syngas can also be converted by a methanisation process, and then purified, for injection into the natural gas grids.

Unlike methanisation, gasification can use ligneous material. This use of ligneous material is likely to bring gasification for injection into gas grids into competition with the wood energy sector, a sector whose development requires less public support. Given this lesser need for public support, priority will be given to the development of the wood energy sector, which includes gasification for heat production, compared to support for gasification for injection.

Feedback is expected on gasification demonstrators for injection in gas grids in order to study the place that this sector could take. In particular, there will be studies of the level of energy yield of this biomass recovery method and of the environmental issues of the plants.

The possibility of developing gasification for injection without competing with the wood energy sector will be studied. Where applicable, calls to tender for the above-mentioned biomethane purchase obligation may be extended so that they are opened, under the same conditions, to gasification projects for injection into the natural gas grids.

Measures:

- Obtain feedback on gasification demonstrators for injection into gas grids;
- Study the possibility of developing gasification for injection without competing with the wood energy sector and, where appropriate, authorise gasification for injection projects in natural gas grids to participate in calls to tender for the biomethane purchase obligation.

3.4.3. Hydrogen and power-to-gas

Hydrogen

As an energy carrier, electrolytic hydrogen is a long-term solution for the integration of renewable energies into the electricity system: it is currently the most promising inter-seasonal intermittent renewable energy mass storage medium.

Electrolysers are also capable of providing other services for the electricity grid, in the same way as other storage technologies or other means of flexibility (demand management, development of interconnections).

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 mass storage and electrolysis technologies. By 2035, plans will be in place to prepare for the development and integration of the various technological building blocks of the technology for converting electricity of renewable origin into gas by establishing suitably sized demonstrators. Today there are two demonstrators in France and the objective is to multiply them to gradually change scale.

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 provide a field for experiments or even pilot deployments.

The drastically lower costs of electrolysis systems make it possible to envisage different markets as discussed below.

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 at 60Mt. In France, it stands at about 1Mt.

In 2018, the cost price of hydrogen produced in large quantities from fossil products (gas steam reforming) is €1.5 to €2.5 / kg (i.e. in the range of €38 to €65 / MWh) for industrial customers consuming large volumes (refineries). For some less intensive uses that are sufficiently stable (glass, food industry, 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 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 be needed between diffuse uses, for which the current price is higher but which involve more complex industrialisation (heterogeneity of configurations, which can raise costs) and more mass uses, where the price of current technologies is higher, but which enable the rapid deployment of series of electrolysers, 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 territories around fleets of light commercial vehicles (e.g. "Hype" hydrogen taxi fleets in Paris).

Due to a still limited volume effect, the total cost of ownership of a hydrogen vehicle remains higher than their thermal equivalents (20% to 50%). But 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 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 priced at a level (<€7/ kg, i.e. <€7 per 100km) compatible with the needs of hydrogen mobility.

These advantages are found mainly in certain heavy transports (road, rail and river), for which the weight, bulk and embedded energy of batteries are still prohibitive. These heavy transports 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 charging 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, air);
- To pursue the territorial fleets solution. In this respect, the role of local authorities in aggregating uses within territorial projects is key. Other uses may also be considered in these territorial projects (e.g. bridging between industry and mobility).

Measures related to these objectives are discussed in section 5.6. on charging infrastructures for alternative fuels.

Hydrogen for storage

The hydrogen produced by electrolysis may also be used as storage carrier, either by direct injection into the gas grid or by methanisation (production of synthetic methane).

Compared with other storage solutions such as batteries, hydrogen is currently the most promising inter-seasonal passive storage medium (see storage section).

Power-to-gas

The "power-to-gas" principle is based on the transformation by electrolysis of a quantity of electricity in the form of hydrogen, which is then transformed into synthetic methane following the recombination of hydrogen with CO_2. The hydrogen production can be decarbonised provided that the electricity used to produce it is itself decarbonised. Under these conditions, hydrogen is compatible with the objectives that France has set for renewable energy development, and the reduction of greenhouse gas emissions and pollutants.

The conversion of renewable electricity into gas is generally mentioned in situations where the production of renewable electricity would be surplus to consumption, in order to enable recovery of the surplus electricity generated. These situations are not envisaged 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, 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 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 production of renewable electricity would be surplus to consumption, thus enabling recovery of the surplus electricity produced. Power-to-gas is a seasonal storage solution that supports power grids. It is even, in the current state of the art in technology, 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 appear 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.

Objective of increasing the consumption of hydrogen and measures to achieve it

	2023	2028
Power-to-gas demonstrator (MW)	1 to 10	10 to 100
Incubation rate of decarbonised hydrogen in industrial hydrogen (%)	10%	20 to 40%
Hydrogen light vehicles (number)	5000	20,000 to 50,000
Hydrogen heavy vehicles (number)	200	800 to 2000

Measures:

- Put a € 100m support fund for hydrogen in place and launch calls to tender for projects on mobility and hydrogen production using electrolysers;
- Establish a traceability system for decarbonised hydrogen by 2020;
- Extend the extra depreciation measure on the purchase of hydrogen vehicles under *at least* the same conditions as for NGV (heavy vehicles>3.5t);
- Mobilise financial institutions (private and public financing, including the Deposit and Consignment Office (Caisse de Dépôts et Consignations, CDC), Banque Patrimoine & Immobilier (BPI)) and standardise co-financing models for ecosystem deployment projects in the regions;
- Conduct discussions with all players on simplifying and harmonising the licensing and certification procedures for boats and associated hydrogen fuelling solutions.

3.4.4. Recovery gas and pyrogasification

State of play in the sector

The gasification of inorganic waste, in particular solid recovered fuels (SRF), as well as the co-incineration of syngas in combustion plants 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 syngas from the gasification of SRF can be used directly to produce heat or be converted into methane for injection into the natural gas grids.

Additional studies need to be undertaken to specify the energy yield of SRF pyrogasification, to specify the maximum supply potential, and to identify the risk of cannibalisation of 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.

Mesures:

- Realize a feedback on gasification demonstrators for injection in gas networks;
- Study the possibility of developing gasification for injection without competing with the wood energy sector and authorizing gasification projects for injection in natural gas networks to participate in tenders for the purchase of biomethane.

3.5. Electricity

Electricity accounted for 27% of end-use energy consumption in 2017, or 481TWh. The tertiary sector accounted for 69% of the end-use electricity consumption, the industry 26%, transport and agriculture remaining low, around 2%.

In 2017, 71.6% of the electricity was produced from nuclear, 10.3% from thermal means and 16.7% from renewable energies.

The electricity requirement is estimated at 512.2TWh in 2023 and 525TWh in 2028 (including exports and grid losses). The assumption is a stability of the consumption, the decreases of the consumption linked to energy efficiency improvements are compensated by switches of usages from other fuels to electricity.

The Energy Transition for Green Growth Act set a target of 40% renewable energy in end-use electricity consumption in 2030. To achieve this goal, it is necessary to initiate a major evolution of the electrical system with an acceleration of all renewable energy sectors. The efforts to be made, however, depend on the availability of each sector, their maturity and their competitiveness.

Situation in 2017	MAEP Objective 2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
49	53	71	78

Table 18: Targets set by the MAEP adopted in 2016 for installed capacity of renewable electricity generation (GW)

Three types of cross-cutting actions have been initiated to promote the development of renewable electricity: the reform of support mechanisms, administrative simplifications and the development of crowdfunding.

Simplify bidding procedures and award nominations

The simplification of the bidding process and the designation of winners for power generation[42] facilities have contributed to the reduction of the deadlines for choosing winning projects that could take, before the publication of the 2016 decree, from 18 to 27 months.

The administrative simplifications made notably include:

- The simplification of the authorisation to operate under the Energy Code, by very significantly increasing the power thresholds of the renewable energy installations subject to this procedure in order to exempt most of them when they are developed in the framework of support structures provided by the State;
- The simplification of the legal framework applicable to renewable energies at sea by limiting appeal deadlines, by entrusting the processing of appeals to a specialised Administrative Court of Appeal (CAA) in the first and as a last resort, by extending the duration of the DPM concession from 30 to 40 years, and by reducing the time-to-file for water law authorisation. Decree No. 2016-9 of 8 January 2016 on offshore renewable energy production and transmission works was published on 10 January 2016;
- The simplification of the administrative procedures to benefit from the purchase obligation with the abolition of the CODOA procedure (certificate giving right to the obligation of purchase);The simplification of the administrative procedures by making it possible to extend the period of validity of planning permission several times for all renewable energy production works, within a limit of ten years from the issuance of the decision. Decree No. 2016-6 of 5 January 2016 on the period of validity

42 See **Decree No. 2016-170 of 18 February 2016 on the tendering procedure for electricity generation facilities**

of urban planning authorizations and containing various provisions relating to the application of land law and associated taxation was published on 6 January 2016;

- The generalisation of the single permit allowing the abolition of the need for a building permit for land wind.

Hydroelectricity	Wind	Solar-based electricity	Bio-energy
2017-2018: 15 months	2017-2018: 5months	2017-2018: 5 months land PV And 4 months building PV	2017-2018: 8 months

Table 19: Deadlines observed between the publication of the specifications and the choosing of winners after reform

Developing participatory investment and promoting local ownership of projects

Participatory investment makes it possible to strengthen the territorial anchoring of renewable installations and to facilitate projects by improving their local acceptability. Tenders launched since 2016 have systematically favoured projects that implement participative investment solutions (citizens or local authorities) by integrating criteria and bonuses related to participatory investment. The government has also relaxed the conditions for crowdfunding of renewable energy projects on financing platforms.

Sector	Number of winners	Of which involved in CF	% involved in CF
Biomass for electricity	24	2	8%
Self-consumption	286	56	20 %
Small hydroelectricity	33	6	18%
Solar power plant on the ground	336	249	74,00 %
Solar on buildings	1738	566	33 %
Innovative solar	50	36	72%
Wind	27	7	26%

Table 20: Subscription to crowdfunding by sectors on 1 November 2018 - Source: DGEC

Improving the completion rate of projects

Special attention is paid to the project implementation rate in order to optimise the effectiveness of tenders launched. For the first photovoltaic tenders launched in 2011 and 2013, the achievement rates were between 64% and 81% (see table below). For new tenders, the introduction of financial implementation guarantees and the obligation to obtain planning permission prior to the bid will particularly contribute to a decrease in the drop rates of calls for tenders.

	Number of winners	Power retained (MW)	% commissioning in numbers	% commissioning in power
2011 Call for Bids Installations from 100 to 250kWc	696	145	65.6%	67.6%
2011 Call for Bids Installations over 250kWc	88	456	81.2%	80.7%
2013 Call for Bids Installations from 250 to 250kWc	587	122	72.8%	72.6%
2013 Call for Bids Installations over 250kWc	121	380	72.0%	64.2%

Table 21: 2011 and 2013 commissioning rate for solar installations as of 1 July 2018 - Source: DGEC

Cross-cutting measures to increase the production capacities of electric renewable energies

- **Giving visibility on the tendering calendars;**
- **Continuing the administrative simplification measures;**
- **Reducing network connection costs and delays for renewable energies;**
- **Continuing to promote crowdfunding;**
- **Preparing for large-scale recycling of end-of-life facilities for the sectors for which this is not already done.**

3.5.1. Hydroelectricity

State of play in the sector

The hydroelectric potential in France is already largely exploited thanks to the construction of many installations during the XXth century. In 2017, hydroelectric power generation was 53.6TWh, or 10% of French electricity production.

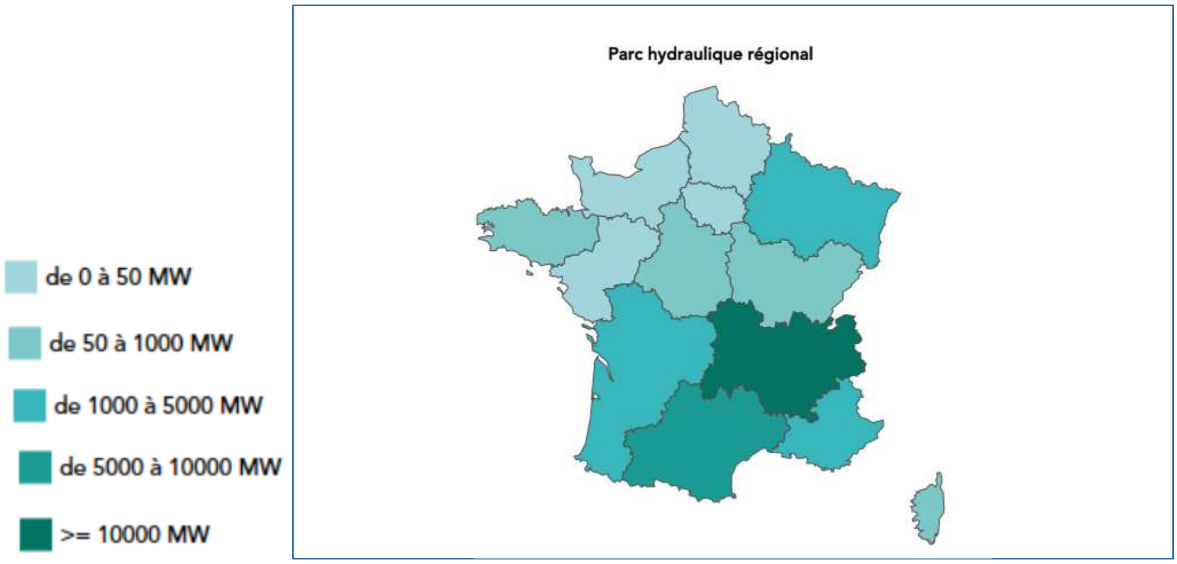


Figure 43: Regional distribution of capacity of hydraulic production per region (Source : RTE)

Situation in 2017	MAEP Objective 2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
25,294	25,180	25,680	25,930

Table 22: Targets set by the MAEP adopted in 2016 for installed capacity of hydraulic electricity generation (MW)[43]

Maximum supply potential

The table below assesses the additional deposit potential to that already exploited in France. These figures come from a ministry document assessing the deposits[44] 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 of the equipment of all the mills for electricity production.

The evaluated potential is a technical potential, which does not take into account the environmental constraints (apart from the ranking in list 1) or the economic constraints of the projects. The real potential is then significantly less.

<table>
<tr><th colspan="3">Potential</th><th>Total</th><th>Of which not in list 1</th></tr>
<tr><td rowspan="5">New power stations</td><td rowspan="2">Concessions (greenfield sites)</td><td>>10MW</td><td rowspan="2">Approx. 2090 MW</td><td>Approx. 370 MW</td></tr>
<tr><td><10MW</td><td>Approx. 120 MW</td></tr>
<tr><td rowspan="3">Permits</td><td>Greenfield sites</td><td>Approx. 750 MW</td><td>Approx. 170 MW</td></tr>
<tr><td>Existing sites (unequipped dams), excluding mills</td><td colspan="2">Between 260 and 470MW</td></tr>
<tr><td>Existing sites (unequipped dams), mills</td><td colspan="2">Approx. 350 MW</td></tr>
<tr><td colspan="3">Over-equipment and modernisation of existing licensed plants by 2028</td><td colspan="2">Approx. 400 MW</td></tr>
</table>

Table 23: Potential hydroelectric capacity (MW)

Socio-economic, industrial and environmental issues

For hydropower, facility load factors are highly dependent on:

- The nature of the development: presence of a reservoir or water line;

43 . The numbers is the MAEP 2016 are only for extra capacity. In this table, it is the total capacities that are targeted, for the sake of comparability with the other sectors.

44 Knowledge of the French hydroelectric potential, summarised, available from https://www.ecologique-solidaire.gouv.fr/sites/default/files/potentiel%20hydro_synth%C3%A8se%20publique_vf.pdf

- Technical characteristics: electric power of the power station, which is optimised according to the water resource and the cost of installation;
- Hydrology, which can vary greatly from one year to the next.

On average at the national level, the load factor is of the order of 25% (about 2200 full power equivalent hours), but it generally varies between 20 and 40% (about 1800 to 3600 full power equivalent hours). Lake power plants, which have significant installed power to produce at peak hours, have generally lower charge rates than run-of-river plants, whose power is calibrated according to the average flow rate of the river. Some plants designed to turbinate the minimum flows to be left in the rivers run at full power almost all year round.

The hydroelectric industry is essential for the transition of the electrical system:

- It is a renewable sector that can be predicted and managed;
- Its flexibility (lake and sluice installations) makes it possible to reactively manage the supply-demand balance during periods of tension on the electrical system, instead of expensive thermal means that emit greenhouse gases;
- Hydraulic storage also makes it possible to place production to monitor consumption over long periods (weekly or even seasonal).

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 equal production and consumption of electricity at all times.

Current and foreseeable costs

Hydropower is a competitive renewable energy because of the long life of the facilities subject to regular investment. Construction costs are high (civil engineering, equipment, grid connection), for relatively low operating and maintenance costs. Costs related to environmental improvements are becoming increasingly significant.

Significant disparities in costs are observed according to the characteristics of the installation and in particular according to the installed power, the height of fall used and the hydrology of the site. The average unit costs observed[45] are:

- between €30 and €50 / MWh for large installations with the flow;
- between €70 and €90 / MWh for high-power installations and operators of high falls;
- between €70 and €160 / MWh for installations of lower power.

The hydroelectric sector is a mature sector; significant changes in these costs are not anticipated.

The characteristics of the sector in terms of market and employment

In 2016, the hydropower market was €3.6 billion[46]. The French hydroelectric industry benefits from world-renowned know-how and dynamic export activity. It is studies and engineering that make up the bulk of exports. In 2016, exports in the hydraulic sector accounted for €91 million, corresponding to 300 jobs.

The hydropower sector accounted for around 12,300 jobs in France in 2016 according to ADEME, which focus mainly on mining. The engineering of EDF and General Electrics are the two main French players for major installations. An ecosystem of SMEs also exists around small hydropower, which has a strong potential to develop for export.

In 2016, the employment content of this sector is 230 FTE / TWh.

45 . LCOE - levelised cost of energy
46 . All market and employment figures come from "Market and jobs in the field of renewable energies", ADEME, July 2017

Environmental challenges

In order to preserve the quality of aquatic environments and to guarantee other uses of water, the environmental regulation applicable to hydroelectric structures has been significantly strengthened: maintaining a minimum flow in the watercourse, and restoration of ecological continuity devices to limit fish mortality, etc.

Like existing structures, hydropower 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 regime in case of a bypassed section. For a greenfield site hydroelectric project, additional impacts should be considered, like those related to flooding (hydromorphology, water quality), or those related to ecological continuity for the flow or transit of sediments. On 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 are to be evaluated when the projects already equip the watercourse concerned, particularly in terms of ecological continuity or when flooding is envisaged.

Given their higher cost and their lower profit 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, extra equipment or new facilities to improve the flexibility of the fleet must be prioritised.

Objective of increasing installed hydropower generation capacities and measures to achieve it

The 2028 target is to increase the fleet by the order of 200MW by 2023 and from 900 to 1200MW by 2028, which should allow an additional production of around 3 to 4TWh, of which around 60% by optimising existing facilities.

2016	2023	2028 Scenario A	2028 Scenario B
25.5GW	25.7 GW	26.4GW	26.7GW

Measures complementing cross-cutting measures:

- Optimising existing hydroelectric facilities, particularly through over-equipment, and promoting the installation of hydroelectric power plants on existing non-equipped dams;
- Setting up a support system for the renovation of authorised plants between 1MW and 4-5MW ;
- Launching the granting of new licenses on a few sites whose potential will have been identified
- Issuing tenders for small hydropower according to the table below.

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 related to Pumped Energy Transfer Stations (STEPs) are addressed in the storage section.

3.5.2. Land wind

Description of the existing installations

As of 31 December 2017, 1653 facilities were connected representing 13,470MW, approximately 7200 masts. In 2017, wind farms with a capacity of 1.65GW were connected to the grid. Electricity generation from wind farms amounted to 24TWh in 2017, an increase of 15% over one year. Wind energy accounts for 4.5% of French electricity production, which puts France in 4th position in EU countries.

Situation in 2017	MAEP Objective 2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
13,470	15,000	21,800	26,000

Table 24: Targets set by the MAEP adopted in 2016 for installed wind generation capacity (MW)

The Hauts-de-France and Grand Est regions have the highest installed capacities, representing nearly 57% of the total power connected in France.

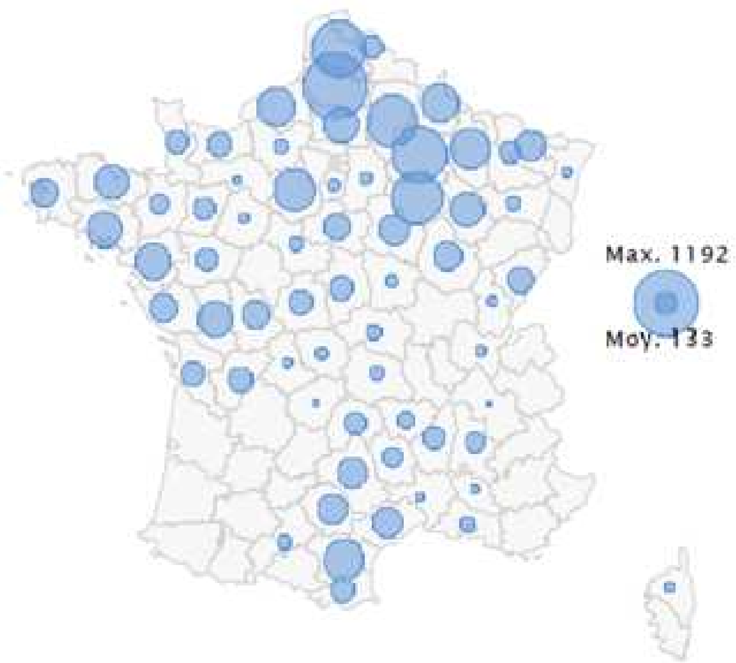


Figure 43: Regional distribution of connected wind generation capacity as of 31 December 2017 (MW) - (Source: RTE)

Maximum supply potential

As part of its study on "A 100% renewable electricity mix" ADEME published an analysis of the theoretical wind field in metropolitan France in 2015. This analysis superimposes wind speed data and maps of "exclusion constraints" making the installation of wind turbines technically impossible on these zones for technical reasons (topography, terrain, etc.) or for reasons of occupying the territory: proximity to homes, military aviation training areas, radar sensitive areas from the point of view of biodiversity.

The energy field also depends on the technology of the wind turbine. As part of this study, two types of wind turbines were considered: the standard wind turbine and the new generation wind turbine, known as the "canvas" wind turbine.

	Power installed	Production / year
Standard wind turbines	**170 GW**	**360TWh**
New generation "canvas" wind turbines	**120 GW**	**330TWh**

Table 25: National wind power potential

The first French wind farms commissioned from 2000 onwards will also mature, raising the question of their renewal during the period covered by the MAEP. The renewal of the fleets will make it possible to preserve the existing sites by equipping them with more modern machines for the benefit of the local residents. An increase in the productive capacity of the fleets could also result from the renewal of the fleets with the use of the best available techniques. Given these issues, particular attention should be paid by the MAEP to the identification of the fleets that could be renewed and to the establishment of conditions enabling their renewal. In particular, volumes to be renewed must be included in open volumes as part of tenders, in order to ensure sufficient development of new production capacities.

Socio-economic, industrial and environmental issues

Wind turbines do not operate all year round at full speed. A wind turbine operates in a wind speed range between 10 and 90km/h. Load factors (number of hours of operation per year) of onshore wind were up to now considered to be between 24% (2100h / year) to 26% (2300h / year). However, recent technological progress makes it possible to anticipate a significant growth of these load factors which, by 2023 and 2028, could respectively reach figures of the order of 28% (2500h / year) and 30% (2600h / year).

This progress is possible thanks to the use of higher machines capable of fetching stronger and more consistent winds. The use of larger rotors will also allow the capture of weaker winds and therefore wind development in areas that were previously considered difficult to exploit.

Wind energy is intermittent, and the resource's unpredictable nature adds power management constraints that are developed in part 5. Today however, wind turbines contribute to securing the French power supply by participating in the capacity mechanism. The network managers are studying the possibility of using the technical capacities of the wind farms for the adjustment of the voltage.

Current and foreseeable costs

At the global level, onshore wind has a total cost of approximately €50 / MWh. It is €67 / MWh in Europe[47]. In France, for installations with more than six wind turbines, the prices offered in february 2018 were around €66 / MWh.

Wind power is a sector that has potential for innovation[48] 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 of the order of €55 / MWh.

The characteristics of the sector in terms of market and employment

The wind power sector was able to structure itself in France and in 2016, according to ADEME, represented more than 18,000 jobs, including 12,560 direct jobs. These jobs are spread across the entire value chain: industry, development, maintenance, etc.

In 2016, the employment content of this sector was 750 FTE / TWh.

47 Renewable Power Generation Costs in 2017, IRENA, January 2018.

48 A characterisation of these innovations was undertaken in the study "Characterisation of technological innovations of the wind energy sector and maturities of the sectors" published by the ADEME in May 2017.

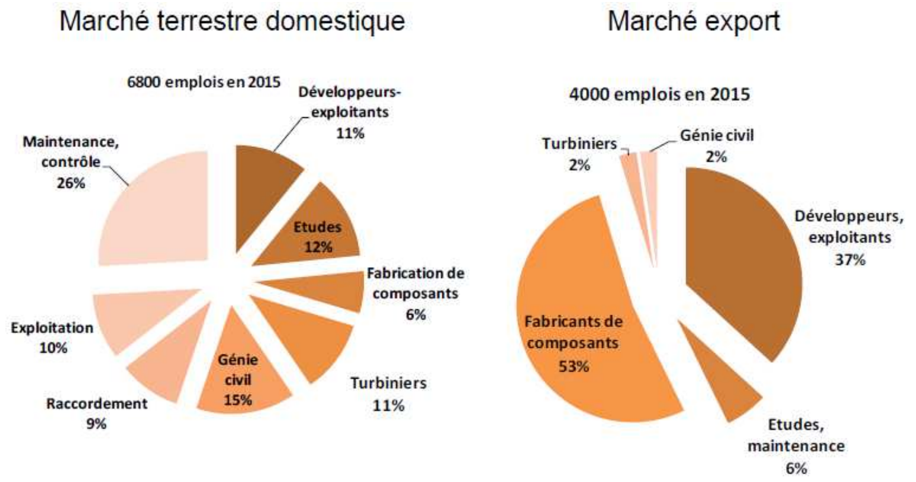


Figure 45: Distribution of direct FTE by value chain link - Source: BiPS éolien, ADEME, 2017

Jobs in the wind energy sector are marked by a local character 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 position themselves 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 2016, the market was worth €4.5 billion.

Environmental challenges

The environmental challenge of wind power is essentially its potential impact on biodiversity. However, there are other areas of acceptability in terms of landscape integration or impact on radars. Since 2011, these issues have been taken into account during the development of the project in the Regulated Environment Protection Facilities procedure (ICPE).

A ministerial decree[49] also requires the dismantling of wind turbines, delivery stations and cables at the end of their operation. It also provides for the excavation of foundations and the replacement by land of characteristics comparable to the land in the vicinity of the facility to a depth of at least one metre in the case of agricultural land.

It is also possible for the owner of the land, as part of the lease of their land to the wind farm operator, to set more stringent restoration conditions in a private law convention than those provided by the regulations.

In order to ensure that such dismantling and refurbishment works are carried out, including in the event of failures on the part of the operator, the commissioning of a wind farm is subject to the provision of financial guarantees for an amount of €50,000 per wind turbine.

Most metals (steel, cast iron, copper, aluminum) and concrete are recycled. Wind turbine blades can be recovered to produce heat or reused to make cement.

Regarding the carbon impact, wind turbines emit about 12,7g of CO_2 – according to ADEME studies – equivalent to produce one electric kWh.

49 The decree of 26 August 2011 on the restoration and constitution of financial guarantees for electricity production installations using mechanical wind energy

Box 4: Rare earths

Rare earths are a group of metals with neighbouring properties including $_{21}$Sc scandium, $_{39}$Y yttrium, and 15 lanthanides. Their use is varied (oil refining, control bar of nuclear reactors, rechargeable batteries, permanent magnets).

Although relatively abundant in the earth's crust, they are found only occasionally in concentrations high enough to be exploited profitably (China, Mongolia, Australia, United States).

Rare earth production statistics are imprecise and not often detailed by element. According to the USGS, the total production of Rare Earths at the end of 2017 was 120 million tonnes in December 2017). China estimates that it holds 30% of the world's rare earth reserves, although it currently covers almost 90% of the industry's needs. China's total production of rare earth oxides amounted to about 105,000 tonnes in 2017 out of a global production of 130,000 tonnes. Australia, the second largest producer, extracted 20,000 tonnes in 2017. Potential shortages of materials could lead to a sharp rise in the cost of finished products.

Among the means of energy production, wind is the one that uses the most rare earths. The nuclear and oil refining industry also uses them in smaller quantities. Energy storage could also use them.

Wind energy

Rare earths are involved in the composition of so-called "synchronous" generators in which the rotor is a permanent magnet. Thus, for a power of 1MW supplied by the generator, it takes about 600kg of magnets containing nearly 200kg of rare earths. An offshore wind turbine of up to 7MW of power alone therefore requires more than a tonne of rare earths.

These systems make it possible to significantly reduce maintenance requirements; operations that are particularly complicated and costly when they have to be carried out at sea. In short, the development of wind turbines with "synchronous" generators would increase the need for Rare Earths. However, studies estimate that permanent magnet recycling could contribute up to 8 to 16% in the supply of rare earths for the permanent magnet sector.

Although this area is not subject to the MAEP, the achievement of its objectives will require special attention by the State concerning this issue.

Objective of increasing installed wind power generation capacities and measures to achieve it

The table shows the objectives of the MAEP to achieve them. These targets would correspond to a fleet of 2018).

2016	2023	2028 scénario A	2028 scénario B
11.7GW	24.6GW	34.1GW	35.6GW

Main measures complementing cross-cutting measures:

- Prioritising the use of tenders to support the sector by reducing the scope of the open window to smaller fleets developed in constrained areas;
- Implementing the measures adopted on 18 January 2018 at the end of the wind energy working group of the Renewable Energy Release Plan, in particular:
  - Removing a level of jurisdiction in administrative tribunals;
  - Clarifying the rules for fleet repowering renewal projects;
  - Updating the distribution of the wind power IFER for the communes;

- Maintaining a stable regulatory framework regarding the authorisation of the fleets, simplifying it if possible and allowing reasonable development time for the project holders, while ensuring a good consideration of environmental issues and control of the impacts on the environment and neighbouring populations;
- Identifying the fleets that can be renewed and adapting the support mechanisms to allow the implementation of these projects while maintaining a sufficient number of new sites necessary to achieve our objectives;
- Mandate by 2023 the recycling of the constituent materials of wind turbines during their dismantling;
- Promote the reuse of wind farms at the end of their life to re-install more efficient machines.

Calls for tenders will be issued at the rate of 2GW / year according to the schedule below, up to 0,5GW à 1GW 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
	0,5GW	0,5GW	0,6GW		0,8GW		1GW		1GW		1GW		1GW		1GW		1GW		1GW		1GW		1GW

3.5.3. Photovoltaics

State of play in the sector

During the year 2017, photovoltaic installations with a total capacity of 0.875GW were connected to the grid. As at September 30, 2018, 418,330 facilities had an installed capacity of 8.8 GW. Photovoltaic solar energy represents 2.3% of French electricity consumption in the first three quarters of 2017-2018, an increase of 12% compared to the first three quarters of 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 power connected in France. However, there is an increasing number of projects in the North and East of France.

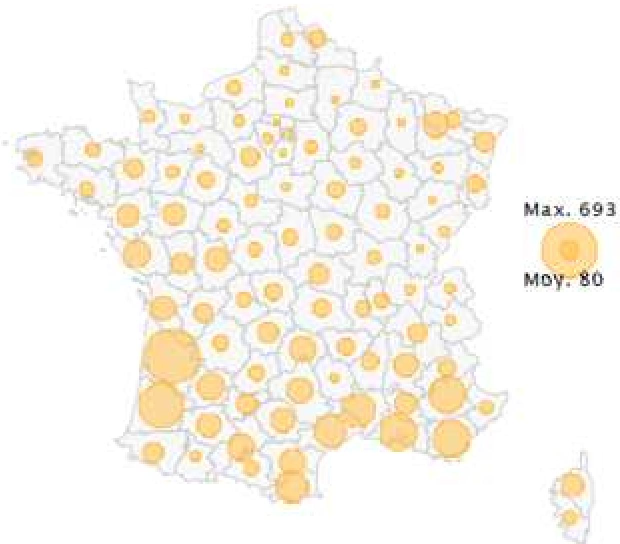


Figure 46: Regional distribution of connected photovoltaic generation capacity as of 31 December 2017 (MW) - Source: RTE

Situation in 2017	MAEP Objective 2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
7660	10,200	18200	20,200

Table 26: Targets set by the MAEP adopted in 2016 for installed photovoltaic generation capacity (MW)

In order to achieve these solar deployment objectives by 2023 with a controlled cost for the community, the 2016 MAEP directs the acceleration of the development of the solar sector towards the most competitive solutions, such as ground-based photovoltaic installations (launch tenders for capacities of 0.9 to 1.2GW / year), while developing large power plants on roofs (one-third of installed volumes) and installations on small and medium-sized roofs (target of 350MW installed per year).

Maximum supply potential

ADEME estimates the rooftop photovoltaic installation potential at around 350GW, i.e. 350,000ha of roof surface, which makes it possible to choose the most suitable locations. This corresponds to more than 350TWh.

The CEREMA has evaluated the ground and parking potential on land with no conflict of use in the southern regions of France. They estimate the mobilisable surface at about 1.5Mha, which would correspond to about 776GW.

Socio-economic, 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 130kWh / m² / year.

The average charge rate in France is 1200kWh / kWp. For new panels, technological progress improves performance and therefore increases the average charge rate. The surface yields of PV on the ground are also improving, approaching 1MW per hectare, which would make it possible to mobilise less land for an equal capacity and thus to reduce the impact on soils.

Photovoltaic electricity production fluctuates during the day, depending on the solar radiation power received by the sensors. Although it fluctuates, solar production is predictable. The forecasting tools are increasingly reliable and allow a better anticipation of photovoltaic production in the short-, medium- and long-term. The fluctuating nature of this resource adds constraints of controllability of the production and management of the electricity network. Today, these fluctuations are not greater than those induced by demand forecast errors. The stakes concerning the network of intermittent renewable energy penetration are developed in part 5.

Current and foreseeable costs

The 2009-2017 period saw photovoltaic equipment costs fall by more than 80% due to technological developments and global competitiveness gains, from >€2 / Wc to about €0.40 / Wc. The prices proposed for the last tendering periods are of the order of €55 / MWh on the ground and €85 / MWh for installations on roofs. 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 the observation of the current rates of decrease of the complete costs, the fall in costs is estimated at 4% per year for installations on the ground and 5 to 7% per year for rooftop installations. In 2028, the cost of PV on roofs could be around €60 / MWh and PV on the ground of €40 / MWh for projects commissioned.

The characteristics of the sector in terms of market and employment

The installation, connection to the network and technical and commercial development activities make implementing 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 ten FTE / MW). The photovoltaic sector represented around 6800 jobs in France in 2016[50].

French industry has suffered from very strong competition in the production of photovoltaic cells and modules (which represents only 4% of the value added of an installation), especially from Asian countries. Nevertheless, it is well positioned for certain equipment including inverters and trackers.

In 2016, the sector represented 622 FTE / TWh and the market was €3.9 billion.

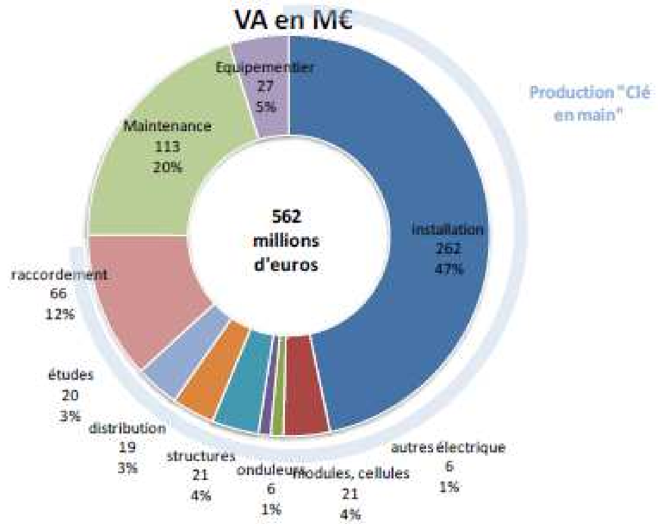


Figure 47::Added value of the PV industry Source: BiPS PV, ADEME 2016

Environmental challenges

According to their typology, the installation of solar installations presents different types of challenges:

- Solar on rooftops and shadehouses is subject to good environmental and social acceptability and poses no difficulty in terms of conflict of use. The challenges concern architectural and landscaping issues. Innovation in the sector should include technologies that are better integrated into their immediate environment;
- Solar power on the ground presents a certain number of environmental issues mainly related to the biodiversity of the site of implantation as well as the issues of land use conflicts. These are taken into account during tendering procedures, which help to orient the settlements to degraded land that cannot accommodate other developments. They are also studied on a case-by-case basis as part of the impact study to which projects over 250kW are subject to obtaining planning permission.

The dismantling of the installations, if it is well done, does not pose any particular difficulty. In addition, Directive 2012/19/EU on Electrical and Electronic Equipment Waste (EEEW) extended the scope of extended producer responsibility to include photovoltaic panels. France has transposed this regulation into French law through decree 2014/928. As a result, marketers must finance the management of their used equipment and their recycling.

PV CYCLE France is the eco-organisation approved by the public authorities for the management of used photovoltaic panels. 177 voluntary supply points now exist, making it possible to recycle 95% of photovoltaic panels.

50 . “Employment markets in renewable energies” - ADEME, 2017

Objective of increasing installed photovoltaic generation capacities and measures to achieve it

The table shows the objectives of the MAEP and the measures to achieve them. These objectives correspond in 2028 between 330 and 400km² of panels on the ground and between 150 and 200km² of panels on roofs (100km² on ground and 50km² on roof in 2018).

	2016	MAEP 2016 – Objective 2018	2023	2028
Panels on the ground (GW)	3.8	5.6	11,6	20.6 to 25
Panels on roofs (GW)	3.2	4.6	9	15 to 19.5
Total objective (GW)	7	10.2	20.6	35.6 to 44.5

Measures:

- Promoting ground installations on urbanised or degraded land, to allow the emergence of cheaper projects while maintaining high demands on agricultural soils and the absence of deforestation;
- Maintaining the bonus for degraded land, which limits the consumption of natural land;
- Implement the measures adopted June 28th, 2018, by the working group on PV, notably:
  - Facilitating the development of photovoltaics for Ministries (financial incentive for project development) and public institutions (SNCF, Ports, etc.);
  - Facilitating the development of photovoltaics in car parks (simplification of urban planning measures for parking shades);
  - Supporting local communities, particularly through the "Solar Cities" network;
  - Facilitating a better articulation between agricultural and solar projects, with the actors concerned;
  - Enabling a better integration of solar power in French heritage;
- Adopting the following tender schedule corresponding to 2GW / year for ground-based power plants and 0.9GW / year for large roof installations;
- Maintaining a target of 350MW installed per year for installations on small- and medium-sized roofs (less than 100kWc) via an open window system and pushing towards self-consumption;
- Supporting innovation in the sector via calls for tender, to encourage new solar solutions on the ground and on buildings, with a doubling of the volumes of the current call for tenders (140MW / year).

The calendar below marks the quarters in which a call for tenders will be issued for 1000MW 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
	1000MW		1000MW		1000MW		1000MW		1000MW		1000MW		1000MW		1000MW		1000MW		1000MW		1000MW		1000MW

The calendar below marks the quarters in which a call for tenders will be issued for installations on large roofs of up to 300MW 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	

3.5.4. Electricity generation from bio-energy

In 2017, the bio-energy sector produced 7TWh of electricity, covering 1.5% of electricity consumption. The 2016 MAEP did not set targets for all sectors of electricity production from bio-energy but only for the wood and biogas sectors.

	Situation in 2016	MAEP Objective 2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
Installed electricity generation capacity from wood (MW)	596	540	790	1040
Installed capacity for generating electricity from biogas from methanisation (MW)	110	137	237	300

Table 27: Targets set by the MAEP adopted in 2016 for installed capacity for generating electricity from bio-energy (MW)

Production sectors

The production of renewable electricity from biomass covers several sectors, which do not have the same degree of maturity, the same development perspectives, or the same issues.

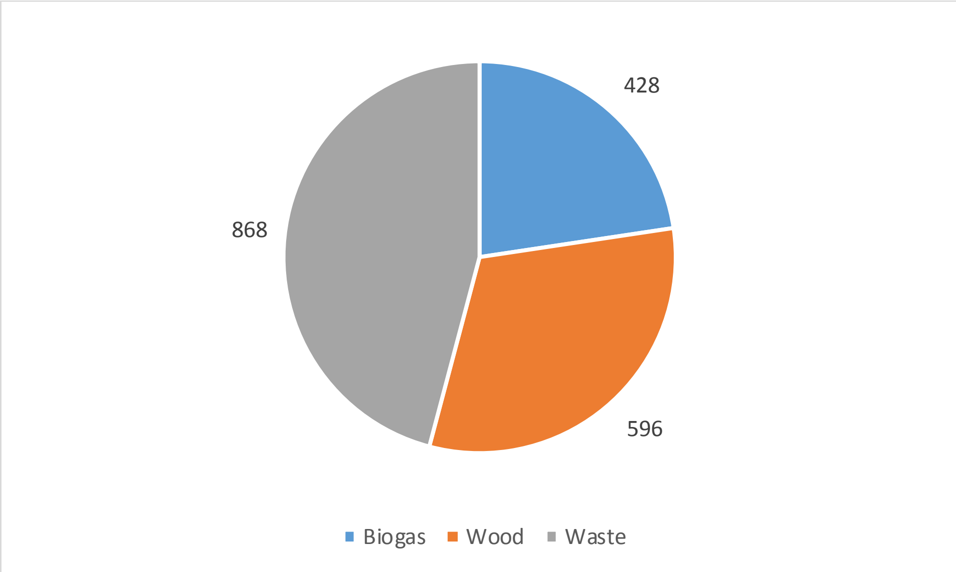


Figure 48: Distribution of electricity generation capacities from bio-energy (MW)

The biodegradable part of household waste"sector groups together the energy produced by household waste incineration plants (UIOM). Electricity generated by UIOM is half accounted for as renewable. The elimination of the guaranteed electricity purchase tariff in 2016 coincided with a weak growth in 2016 (+10MWe) and a decline in 2017 corresponding to the shutdown of a site (-13MWe).

The Wood energy"sector includes energy produced by combustion or incineration plants of forest biomass or wood waste. The average annual growth rate observed from 2009 to 2015 was stable at about + 50MWe, which corresponds to equipping about four sites per year with means of generating electricity.

The Biogas"sector includes energy produced by biogas recovery. At the end of 2017, 430 installations were generating electricity from biogas:

- 389 biogas plants with a capacity of 142MW. Only this sub-sector had a growth target in the MAEP adopted in 2016;
- 150 non-hazardous waste storage facilities (ISDND) with a capacity of 265MW;
- 28 wastewater treatment plants with a capacity of 23MW.

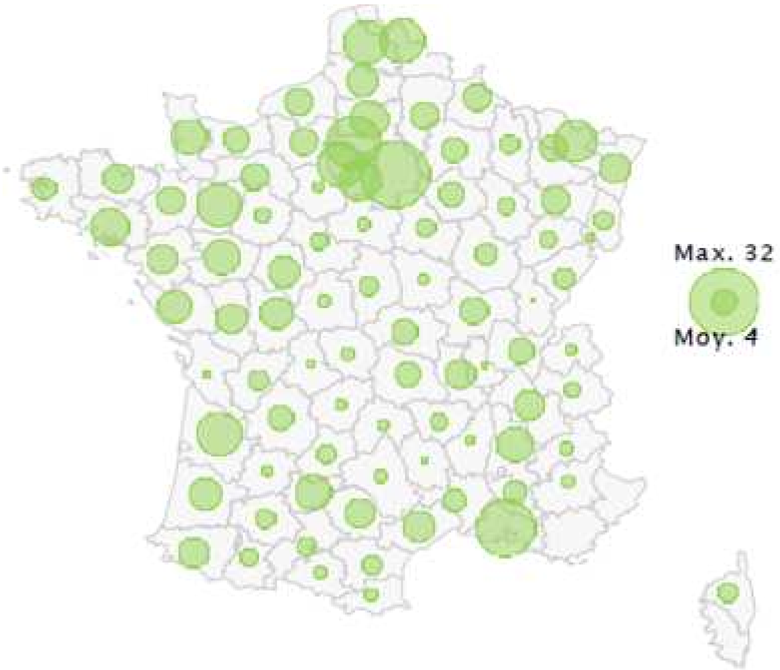


Figure 49: Regional distribution of connected biogas electrical power as of 31 December 2017 (in MW) - Source: RTE

Maximum supply potential

The National Biomass Mobilization Strategy (SNMB), sets targets for 2023 to mobilize the additional forest, agricultural and biowaste resources identified in Part 5. The potentials are:

- 52TWh for solid biomass
- 18 TWh for biogas
- 7,8TWh renewable for non-hazardous waste recovered in UIOM.

Socio-economic, industrial and environmental issues

Consistent with the priorities outlined in the National Biomass Mobilisation Strategy (SNMB), bio-energy resources are scarce. The energy interest is thus to direct them towards the sectors presenting the highest yields, in particular recovery in the form of heat. In special cases, however, it may be worthwhile to develop co-generation. The electrical sectors will have to be developed on these cases:

- The production of electricity from biogas will be reserved for methanisation sites far from the gas network and for which there is no potential for direct recovery as bioNGV or fuel. The production of a methanisation plant is relatively stable over the year, excluding the issue of availability of inputs. The operation of the co-generation can be adapted day-by-day thanks to the flexibility offered by the buffer storage of biogas. The average electrical power of methanisation plants (300kW) is lower than that of other electrical systems.
- The production of electricity from wood energy will have to be limited to particular cases for which the heat needs are not sufficient with regard to the available resource, and will have to concern installations using wood waste that can not be recovered otherwise as a priority.

The electricity production of the bio-energy 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 produced by the "biodegradable part of household waste" sector is estimated at €56 / MWh for 2016.

The average purchase price of electricity produced by the "wood energy" sector is estimated at €149 / MWh for 2016. Ce prix d'achat élevé s'explique par la nécessité de couvrir les coûts d'exploitation du site, à savoir principalement l'achat du combustible, qui représente environ 15 à 25 €/MWhLHV, et le personnel. A moderate cost reduction is anticipated over by the end of the current MAEP period, and prices could reach around €140 / MWh in 2028.

The purchase price of electricity produced by the "biogas" sector is extremely variable depending on the origin of the biogas used. For new installations in mainland France:

- The purchase price of electricity generated from landfill biogas ranged from €85 / MWh to €145 / MWh;
- The purchase price of electricity produced by methanisation or from biogas from wastewater treatment plants ranged from €120 / MWh to €210 / MWh. Technical progress may also be observed for the purification of biogas. Based on the example of findings in other countries that have massively developed methanisation, in particular Germany, the drop in costs should make it possible to reach €160 / MWh by 2028 for electricity production.

The characteristics of the sector in terms of employment

The household waste incinerator sector accounted for around 620 jobs in France in 2016 (up slightly from 2014), according to ADEME, mainly in the electricity generation sector.
The collective wood, tertiary and industrial sector accounted for around 6160 jobs in France in 2016 according to ADEME, with 630 jobs in the manufacturing sector, 350 in the installation-studies sector, and 4920 jobs in the maintenance and sale of energy (heat and electricity) sector. Les emplois de la filière sont principalement ceux associés à la production marchande de combustibles, plaquettes forestières ou bois-bûches pour le secteur collectif. In 2016, the sector market was worth €1.7 billion.

The biogas sector accounted for about 1570 jobs in France, with 150 jobs in the manufacturing sector, 710 jobs in the facility-education sector and 710 jobs in the electricity generation sector. The jobs in the sector are relatively stable compared to the previous year, as the increase in employment related to the operation and sale of energy offset the decline in employment related to investment.

In 2016, the biogas market stood at €410 million.

Environmental challenges

UIOMs have a potential impact in terms of air pollution that is controlled by ICPE regulations. The recovery of the unavoidable heat from the UIOM makes it possible to replace other forms of production of energy and thus to reduce the impact on the environment.

Biomass co-generation plants also have a potential impact in terms of air pollution, which is regulated by the ICPE regulation. The additional issue cuts across the issues of biodiversity conservation and use conflict for mobilising biomass. This issue is addressed in part 5.

Equipping landfills and wastewater treatment plants with electricity generating means makes it possible to recover unavoidable energy and to reduce emissions of methane or CO_2 to the atmosphere when the methane is flared.

If biogas is produced from bio-waste (from local authorities, agribusiness, catering, etc.) that has not been recovered to date, methanisation contributes to the European objectives for reducing organic matter landfilling.

If biogas is produced from livestock effluents, methanisation contributes to reducing the impact of farms on the climate, by capturing methane, but also on issues related to nitrogen.

Objective of increasing the installed capacities of electricity generation from bio-energies and measures to achieve it

	2016	2023	2028
Objective on biomass co-generation (GW)	0.59	0.8	0.8
Objective on biogas co-generation (GW)	0.11	0.27	0.34-0.41
SRF co-generation objective (GW)		0.04	0.04

Measures

- Given the cost of electricity production with biomass, to optimize the global cost to reach the renewable goals and to promote the highest energy efficiency, the support to these sectors will only be on heat. No call for tender on cogeneration biomass will be launched on the period;
- Opening a tariff window for methanisation plants between 0.5MW and 1MW. Beyond this, the biogas plants will have to move towards the injection of biomethane;
- Opening a tariff window for facilities recovering SRF composed of at least 80% biomass;
- Increased improvements in the energy efficiency of household waste energy recovery units, with specific action on the ten or so incinerators without energy recovery and going beyond the energy efficiency criterion for existing units;
- Renew ADEME's call for projects on solid fuels for recovery.

3.5.5. Offshore wind and renewable marine energies

Offshore wind power (fixed and floating)

The commercial development of the offshore wind power sector was initiated by the launch of two calls for tenders in 2011 and 2013 and the allocation of nearly 3000MW spread over six fleets off Normandy, Brittany and Pays de la Loire. A third offshore wind tender was launched off Dunkirk for a capacity of 400 to 600MW in December 2016. It should be awarded by the end of 2018. Regarding floating wind – technology at a less advanced stage of maturity – four pilot farm projects of 24MW each were designated winners of a call for projects launched by ADEME in 2017 as part of the future investments programme: one in southern Brittany, three in the Mediterranean. The first commissioning is scheduled for 2021.

Renewable marine energies (other marine technologies than offshore wind)

Each of these sectors has a degree of maturity and specific development prospects in the more or less long-term. Since 2009, several Calls for Expression of Interest (CEI), led by ADEME, have been launched by the State as part of the Future Investments Programme (PIA) on marine energies.

Regarding tidal turbines, a demonstrator project was immersed off Paimpol-Bréhat. A tidal pilot project off the Raz-Blanchard could be commissioned by 2021.

The tidal power plant at Rance has an annual gross output of around 500GWh for 240MW installed.

	Situation in 2016	Objective on capacities installed in 2018	Objective on capacities installed in 2023	Objective on capacities awarded by tenders in 2023
Installed capacities of offshore wind production	0	500MW	3000MW	Between an extra 500 and 6000MW
Installed capacities of renewable marine energy production	340MW[51]		440MW	Between an extra 440 and 2240MW

Table 28: Targets set by the MAEP adopted in 2016 for installed capacity for generating electricity from bio-energy (MW)

Maximum supply potential

Regarding offshore wind: the technical potential for installed wind power is 90GW according to ADEME. Due to limitations related to usage competition, the potential is currently estimated at 16GW. The technical potential for the wind turbine would be 155GW according to ADEME, of which 33GW would be accessible taking into account the limits related to the competition of use.

In order to develop offshore wind energy, consultations were held with all stakeholders in the framework of the dialogues on maritime facades. Given the success of the consultation that was conducted there, the first calls for tenders will be launched in south of the North Atlantic West Channel , then in the Mediterranean,. The next wind energy tender will be launched in Normandy.

Box 8 : Cooperation group on energy in North sea

France is part of a cooperation group related to wind energy in North sea, whose objectives are to support the spread of wind projects between two countries and to share process and methods to accelerate wind energy in its countries . The group is constituted of France, Belgium, Netherlands, Danemark, Ireland, Germany, United Kingdom, Norway, Sweden and Luxembourg. France has used the information shared in this group to modify deeply the framework of offshore wind projects, giving a reinforced role to the government before the call for tenders (studies before and participation of the public, in particular to identify the zone of the call for tender with the National Commission for Public Debate). This group of cooperation follows also works to elaborate a common framework to assess the cumulative impacts of offshore wind. France will build on this knowledge. France committed itself to communicate to the cooperation group the future calendar for competition process, to give to the industrials, a consolidated vision of the calls for tenders to come.

Concerning the tidal sector, France, which has some of the strongest currents in the world, has an exploitable technical potential, without taking into account the constraints of use, of 2 to 3GW maximum. The deposit is located mainly off Raz-Blanchard in Normandy and in the Fromveur pass in Brittany.

Regarding wave energy, the sector is still in the demonstration stage. There is no reliable estimate of exploitable technical potential in this respect, given the maturity of the sector.

51 . The MAEP only mentioned the extra capacity (100MW). For the sake of homogeneity with other sectors, the capacity of the Rance plant has been added.

Regarding tidal energy, France is one of the current pioneers in this technology with the Rance plant, but its development is not envisaged in the short-term, especially in view of the important environmental issues presented by this technology on new sites.

Regarding the thermal energy of the seas, the potential deposit is mainly located in the overseas departments where temperature gradients between warm surface waters and deep cold waters are greater than in metropolitan France.

Socio-economic, industrial and environmental issues

Offshore wind power (fixed and floating)

With wind speeds that are more sustained and more consistent than onshore wind, a wind turbine at sea can produce on average twice as much energy as on land. The load factor is thus of the order of 40% (about 3500h / year). In addition, offshore wind farms have an average capacity of 500MW (compared to an average of 10MW for onshore wind farms).

The network manager is involved upstream of the calls for tenders to identify the capacity of the networks. They provide overall control and management of the connection of the fleets, and the engineering of the submarine connections and finance the costs for the fleets resulting from the procedures of call for competition.

Current and foreseeable costs

The costs of offshore wind turbines installed in Europe have been declining for several years and are currently reaching prices in the range of €60 to €80 / MWh excluding connection (in 2028). The connection adds a cost of between €10 and €20 / MWh depending on the site.

The four floating wind turbine pilot projects are supported by approximately €330M of assistance by the PIA on the one hand, and supplemented by a preferential purchase rate of the energy produced on the other hand, representing a total of almost €880 million in investments.

A sharp decrease in costs for commercial wind farms is expected with a tariff of about €150 / MWh for the first projects commissioned by 2028, and a convergence of the tariff between the fixed and floating wind turbines in the medium-term.

As regards tidal turbines, the studies and demonstrators carried out demonstrate that this sector is not mature and has very high production costs whose downward prospects are not sufficient to ensure the long-term competitiveness of the sector compared to other technologies, such as offshore wind.

Jobs

According to the ADEME study published in September 2017 on the "Study on the offshore wind energy sector: assessment, prospective, strategy”,[52] the structuring of the sector is crucial to generate a significant number of jobs during the following calls for tenders. All ongoing projects could eventually represent up to 15,000 direct and indirect jobs, including the several thousand that already exist. A development of offshore wind turbines without structuring 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 being more impacting than floating for this purpose), impacts mainly on bird life during the exploitation phase, and more or less significant landscape impacts depending on the distance of the fleets from the coast. There are also conflicts of use with professional fishing and recreational boaters.

52 . Study on the French wind energy sector: assessment, prospective and strategy, Ademe, September 2017, available at: http://www.ademe.fr/etude-filiere-eolienne-francaise-bilan-prospective-strategie

All of these issues are governed by the Environmental Code regulations relating to environmental authorisation. To better take into account these issues for future calls for tenders, the State will carry out studies and will refer to the National Commission of Public Debate upstream of the tenders to organise the public consultation on these fleets.

Renewable marine energies

In its *Medium-Term Renewable Energy Market* Report 2015, the International Energy [53]Agency indicates that the investment costs for a wave power device of 3MW would be in the order of €15400 /kW. The investment costs of a 10MW installation using marine currents would be around €12,500 / kW. For the thermal energy of the seas, the investment costs are higher and could reach €38,500 / kW. In all, for all renewable energy sectors at sea, 20 R&D projects are funded and receive total funding of more than €190 million.

Objective of increasing the installed capacity of offshore wind turbines and measures to achieve it

	2016	MAEP 2016 – Objectives 2018	2023	2028
Offshore wind objective (GW)		0.5	2.4	4.7-5.2

Measure: Launching the following bids corresponding to the minimum 500MW per year for offshore wind turbines with ceiling prices.

	2019	2020	2021	2022	2023	2024	>2025
Floating offshore wind 750MW			250 MW *Bretagne* (120 €/MWh)	250 MW *Méditerranée* (110 €/MWh)		250-500 MW selon les prix	1 projet de 500 MW par an, posé ou flottant selon les prix et le gisement
Fixed offshore wind 2.5 à 3 GW	500 MW *Dunkerque* (70 €/MWh)	1000 MW *Manche Est Mer du Nord* (65 €/MWh)			1000 – 1500 MW (60 €/MWh) MES 2028-29		

Calendar of calls for tender for offshore wind projects (the dates are the moment when the winner will be chosen, at the end of the competition process.

3.5.6. Geothermal electricity

State of play in the sector

Deep geothermal energy consists of exploiting a resource that has sufficient temperature to produce electricity, possibly supplemented by heat recovery by co-generation, or to directly produce heat for district heating purposes. The geothermal electricity sector in mainland 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 scientific experimentation in the mid-1980s, became an industrial site in 2017, with a gross electrical power of about 1.5MW, which represents 7800MWh / year supplied to the power grid.

53 . 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

Situation in 2016	MAEP Objective 2018	MAEP Objective 2023
1	8	20 à 40

Table 29 : The objectives set by the MAEP adopted in 2016 for the installed capacity of electricity generation from geothermal energy (MW)

Maximum supply potential

Deep geothermal energy only develops in certain regions, presenting 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 5000m.

In 2018, 15 exclusive research permits in metropolitan France cover an area of just over 10,000km². This exploration phase, which is a prospecting phase with a high financial risk, sometimes carried out for more than ten years, makes it possible to understand the geological context and reduce the geological hazard 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 Alsacian Upper Rhine Plain, in Auvergne and in particular in the Limagne basin, in the Rhodanian corridor, and the Aquitaine basin.

The thermoelectric conversion efficiency remains limited, at around 10%. One way to improve the performance of these units is to recover the waste heat produced by supplying heat networks in particular.

Socio-economic, industrial and environmental issues

This emerging sector mobilises a few industrial players in the metropolitan area.

Major investments through research permits and the long exploration phase required to qualify the resource and minimise geological hazards make it difficult to rapidly develop the sector. The establishment of the GeoDeep Guarantee Fund, which is being pre-notified to the European Commission, is a mechanism for covering geological hazards during the drilling phase, consisting of equal parts private and public funding.

A 30% flexibility in the context of the demand for modification of the installed capacity was accepted in order to consolidate the solidity and the visibility of the projects.

The legislative and regulatory framework has enabled a strong development of heat networks 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 the geological potential. This gain in competitiveness will also be made possible by the depreciation of boreholes and to a lesser extent the gains in efficiency and yield of units with a binary cycle.

In France, the cost of producing electricity from the Bouillante power station in Guadeloupe – the only volcanic-operated unit – is greater than €100 / MWh[54], which is higher than the international production price located between €38 and €62 / MWh for an installed capacity between 20 to 50MW. This is partly due to the island nature of the plant and because of its current small size (15MW). According to ADEME, for EGS geothermal energy, installations of the type that will be carried out in mainland France will have a production cost ranging from €173 to €336 / MWh.

54 Special report Court of Auditors, articles L. 1433 and R. 1431, of the Financial Jurisdictions Code, no. 71058, October 2014. L.

The decree of 13 December 2016 allows facilities using energy extracted from geothermal deposits to produce electricity to benefit from 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 [55]published in 2016, the deep geothermal sector – a sector in development – could represent about 1300 direct jobs, both in investment in production and maintenance. The total turnover of the deep geothermal sector was estimated at €177 million in 2014 (Source: ADEME). Of this turnover, 30% represents medium and high temperature activities.

Environmental challenges

The phases of life during which a deep geothermal site causes 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 in the same formation as the production. Aquifers exploited for their geothermal resources do not contain drinkable or drinking water. Exploitation of a geothermal site may produce induced micro-seismicity, but monitoring networks can be used to analyse the data. It is necessary for the projects to be well accepted by local actors 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 60g / kWh.

Measures

	2016	2023	2028
Objective (MW)	1	24	24

Given the cost of generating electricity by geothermal energy, in order to optimize the overall cost of achieving renewable energy targets, support for geothermal energy is focused on heat production. The support system is terminated via the additional remuneration in metropolitan France for the production of electricity from geothermal energy. Projects that have already been the subject of a request for additional remuneration that is eligible will be supported. Innovative projects may, if necessary, be supported under R & D schemes.

3.5.7. Self-consumption and local production of energy

Self-consumption is the act of consuming one's own electricity production. It is associated with the notion of self-production, which is the production of one's own consumption.

55 http://www.entreprises.gouv.fr/etudes-et-statistiques/filieres-industrielles-la-valorisation-energetique-du-sous-sol-profond

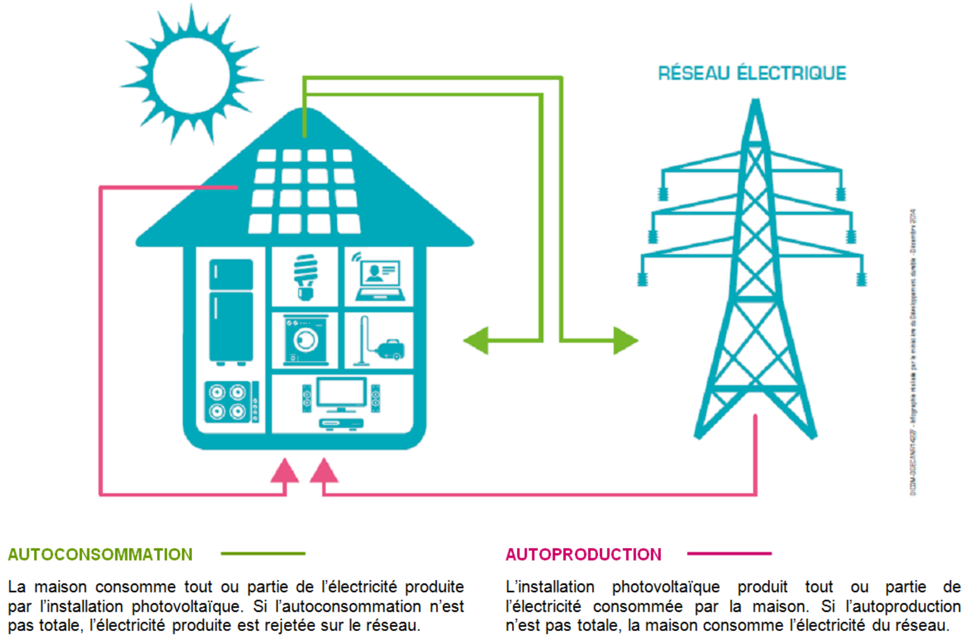


Figure 50 : Illustration of the concepts of self-consumption and self-production

In practice, in the majority of cases, consumption sites will need to use the traditional electricity grid for certain periods, either to provide electricity or to inject excess electricity generated by their local production facility. Thus, operating in self-consumption / self-production does not mean being energy self-sufficient.

The development of individual self-consumption is now a reality and has accelerated in recent years:

- In 2016, 36% of connection requests or declarations made to distribution system operators for photovoltaic projects concerned self-consumption[56] projects, i.e. about 8000 installations, including more than 2000 in total self-consumption;

- In 2017, total self-consumption would represent 18MW for 6500 installations, and 57MW for approximately 13,500 installations.

At the end of 2017, eight collective self-consumption operations were underway, starting by the end of the first half of 2018 and some 20 operations were in the process of being set up, for a start in the second half of 2018.

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 (only one meter required, remote reading, etc.).

Regulatory and support framework

The law defines the concept of collective self-consumption, which consists of associating several consumers and producers, who are related to each other within the same legal entity and who are located downstream from the same HV / LV transformer substation. Self-consumption and local energy production represent an opportunity for the energy transition by allowing for consumer ownership of this transition. They are intended to develop and take a more and more prominent place in the electrical mix in a context where:

- The production costs of renewable and particularly photovoltaic electricity installations are decreasing and electricity prices are rising;

56 . Applications for total self-consumption (self-consumption agreement) and partial self-consumption (surplus sale)

- Citizens and communities increasingly aspire to a model of "green" local economic development that meets 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 production, which limits the construction of new lines or the reinforcement of distribution networks.

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 they can generate on the electricity system.

The legislative and regulatory framework specific to self-consumption (individual and collective) came into effect in 2017. It includes provisions for network operators to facilitate self-consumption operations, in particular by equipping collective self-consumption operations with a Linky meter; specifies the responsibilities of the participants; and also charges the Energy Regulatory Commission with developing a tariff for the use of public electricity networks (TURPE) specific to self-consumption for installations of less than 100kW.

A specific support framework for developing self-consumption has been put in place:

- Small solar installations on buildings (<100kWc) for self-consumption benefit from a purchase contract for 20 years, in which an investment premium is paid for five years coupled with a purchase price for the surplus injected into the network;
- Power installations between 100 and 500kW, regardless of the renewable electricity generation technology, benefit from a call for tenders in the form of a bonus for electricity produced whether it is self-consumed or injected into the public network. This call for tenders is aimed in particular at consumers in the industrial, tertiary and agricultural sectors, economic actors for whom self-consumption can bring the most important benefits thanks to the combination of consumption and production. The support is built in such a way that it encourages maximising the rate of self-consumption.

Objectives and measures

- 65,000 to 100,000 solar production sites for self-consumption in 2023

The development of self-consumption notably involves a need for visibility for the players in their application context, and on the various factors that may have an influence on the level of profitability of self-consumption operations:

- Clarifying the framework applicable to the third-party investor model, in which the consumer does not own the installation but still benefits from production, in order to align it with the framework of individual self-consumption;
- Setting up support mechanisms for collective self-consumption projects;
- Increasing the maximum size of the installations eligible for the self-consumption call for tenders, for example up to 1MW;
- Extending the scope of self-consumption to allow for projects of collective self-consumption (large development projects / eco-neighbourhoods).

3.5.8. Nuclear energy

Description of the existing installations

The French nuclear installations currently consist of 58 nuclear power reactors distributed over 19 different power plants, with an installed capacity of 63.2 GWe and a production of 379.1 TWh in 2017, or 71.6% of the total electricity production. The installations are divided into three categories according to the reactor power capacity:

- 34 x 900MWe reactors;
- 20 x 1300MWe reactors;
- 4 x 1450MWe reactors.

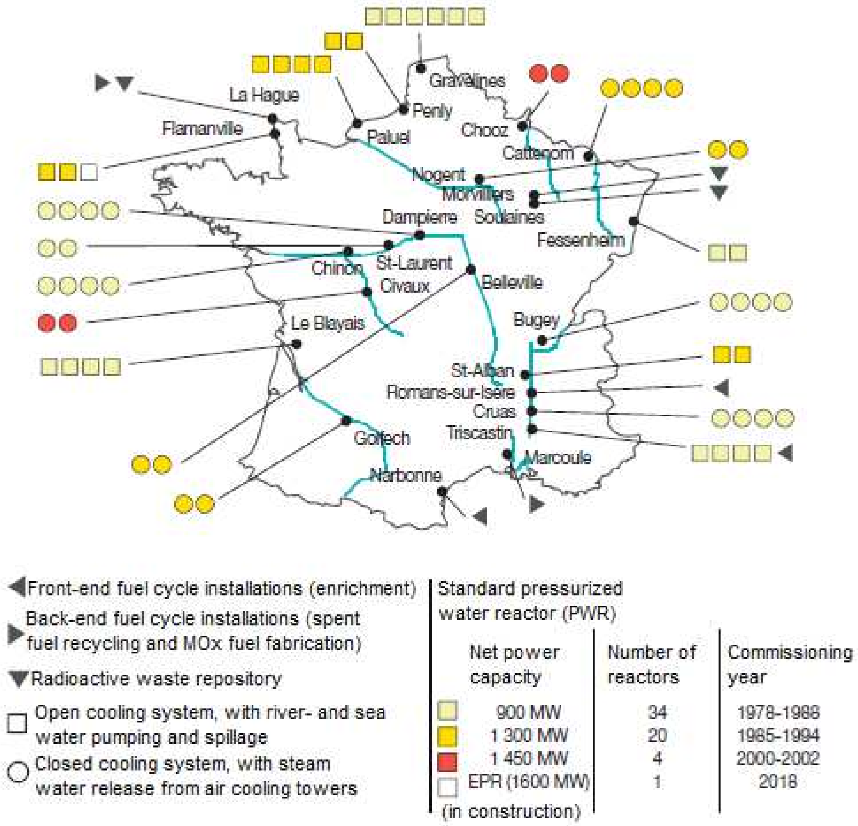


Figure 51: Nuclear sites in France (fromJanuary 1st 2017)

The Flamanville 1650 MWe EPR reactor is currently in the construction phase for commissioning expected by the end of 2019. The two reactors at the Fessenheim power plant will be shut down in Spring 2020.

The 900MWe reactors will reach 40 years of operation in the near future and will have their 4th decennal visit during the 2019-2025 period, while the 1300MWe reactors will have their visit between 2025 and 2035.

France relies on industrial activities covering the whole fuel cycle, including all reactor manufacturing and fuel supply operations, as well as spent fuel management from ore extraction to waste management.

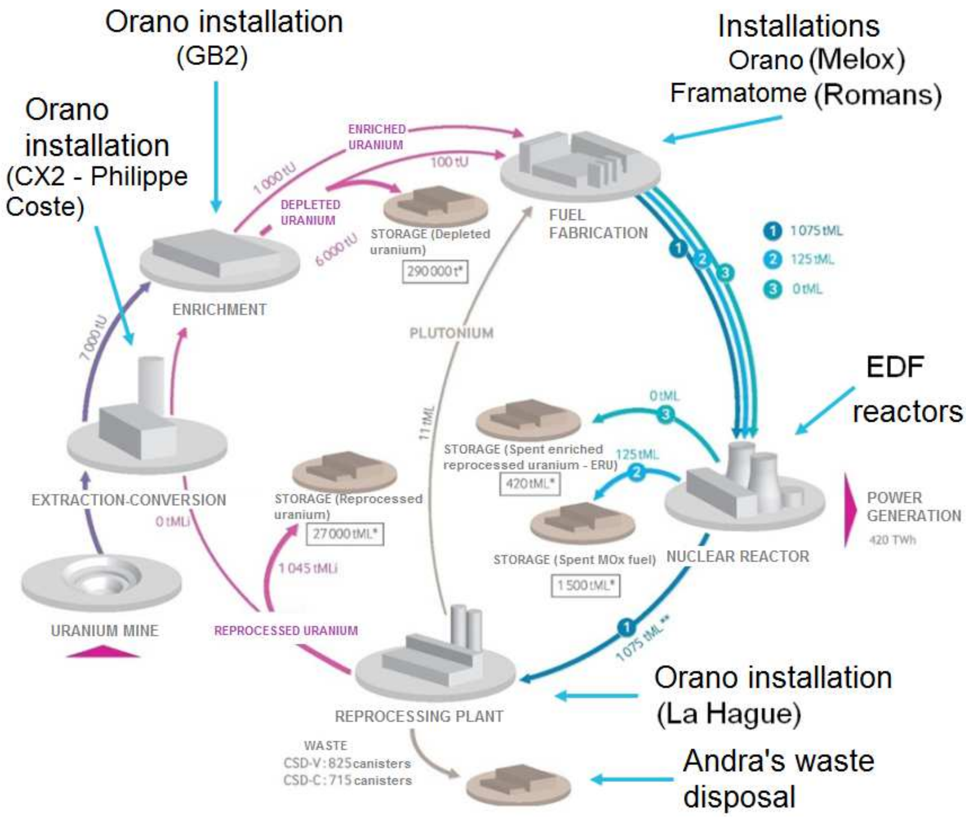


Figure 52: Fuel cycle in France

The French fuel cycle is currently based on "mono-recycling": spent fuel with enriched uranium is recycled once to extract plutonium and uranium used to produce recycled fuels: MOx (currently used in 22 of the 58 French nuclear reactors) and ERU (which will be used in the four authorised reactors in a near future). Spent MOx and ERU fuels are then stored while expecting later recovery.

The French cap of the installed nuclear capacity

In France, the installed nuclear capacity is capped at the current capacity of 63.2 GWe. This cap was implementedby the Energy Transition for Green Growth Act: "*The authorization to operate an electricity-generating facility cannot be issued when it would cause the increase of the total authorized capacity of nuclear power generation beyond 63.2 GWe*".

Energy yield

Nuclear power plants have an average yield of 33% and up to 37% on average for the EPR. The resort to nuclear co-generation could be envisioned, but would present specific challenges in terms of industrial deployment given the difficulties of modifying existing installations and the distance separating nuclear installations from the main areas of heat consumption, particularly urban ones.

Current and predictable costs

There is all but one single nuclear cost: marginal cost (it determines the order in which power production means are summoned), production cost yet to be committed (containing future operational and investment expenditures), economic value of nuclear reactors (which takes into account amortisation and return on capital). Furthermore, the consumer cost depends mainly on regulation, namely the mechanism of the regulated access to electricity production based on historical plant conditions.

The "cost" of nuclear energy thus consists of various components related to upkeep and maintenance investments operating expenditures (staff, fuel, etc.), decommissioning, waste management and investment costs for the reactor construction.

The marginal cost of nuclear plants is very low (< 10€/MWh). It means that nuclear electricity is summoned early among the electricity power production means both on the French and the European markets: shortly after unavoidable renewable energies (which have a marginal cost close to zero) but before carbon-emitting production means (lignite, coal, gas, fuel oil). It is one of the reasons why the French electricity mix is structurally exporter although it has no significant overcapacity.

Regarding the production cost of existing nuclear power plants, the average "cash" cost, which corresponds to the current and future investment and operating expenditures (staff, fuel, etc.), is estimated between €32 to €33/MWh. This cost is not very dependent on the uranium price evolution. Furthermore, it does not include the decommissioning costs and the cost of radioactive waste management covered by dedicated assets allocated by the nuclear operators.

The Court of Auditors had also estimated the production cost for the existing power plants at $€_{2012}$61.6/MWh by considering the full economic cost: the whole operating costs and the end-of-operation expenditures are taken into account, as well as the initial construction investments amortized over the complete reactor lifetime. Nevertheless, this cost was evaluated before the optimisation plan of “Grand Carenage” which enables to decrease the global amount of expected investments between 2014 and 2025 from $€_{2013}$ 55 billion to $€_{2015}$ 45 billion without taking into account EDF’s cost reduction plan on its operational costs whose downward impact is around 1€/MWh.

One can give the following costs (in order of magnitude):

- Grand Carenage (industrial program led by the power operator EDF including post-Fukushima investments, maintenance investments and upgrades of the existing reactors for the next ten-yearly visits): estimated cost in 2017 at €45.6 billion (in 2016 euro value) over the 2014-2025 period, this cost is taken into account in the evaluation of the cost yet to be committed (it represents around 10€/MWh on the basis of the nuclear reactor lifespan until the 5th;
- Decommissioning and waste management: gross costs estimated by the end of 2015 at €110 billion for all nuclear operators (EDF, CEA, Orano and Andra) and especially based on a 50-year operating lifetime for the 900MW reactors and on a 40-year operating lifetime for the other reactors from the commissioning date.

These costs must be considered carefully because they are regularly updated by the operating companies (in particular for the Grand Carénage), they are dependent on the market evolution (especially for fuel cycle activities) and they also spread over the whole reactor lifetime.

The characteristics of the nuclear industry in terms of employment

The nuclear industry employs around 220,000 employees, through direct and indirect jobs, i.e. 6.7% of the French industrial employment. It gathers 2600 companies with a turnover of €52 billion a year, €1.3 billion of which is devoted to research and development[57].

Small and intermediate companies represent 65% out of 2 600 companies compared to 3.5% for large groups and operators (EDF). Nevertheless, the latter ones represent most of the jobs in the sector, which is very specific due to its skilled jobs, the share of executive, clerical, technical and supervisory staff exceeding two thirds of the workforce. It is also important to notice the high level of specialization among the employees and the fact that small active companies in the sector are not very dedicated to the nuclear industry. EDF and large companies represent 75% of the total turnover:

- Nearly 72% of turnover are generated by the maintenance and the operation of nuclear reactors and 14% by fuel cycle activities;

57 . Figures from the 2016 mapping of the Strategic Committee of the Nuclear Sector

- Construction and component manufacturing activities account for 8% of the industrial activities. In particular, these are embodied by major projects, notably the Flamanville EPR, ITER (demonstrator for nuclear fusion) and the Jules Horowitz research reactor (RJH) in Cadarache;
- Radioactive waste management and sanitation account for around 2.5%.

Environmental challenges

The Intergovernmental Panel on Climate Change (IPCC) has published data[58] on the carbon impact of the nuclear industry. Nuclear energy emits on average 66gCO_2/kWh over its entire life cycle (ADEME carbon data).

The CEA has studied the breakdown of emissions for all activities in the sector:

- Extraction, conversion and enrichment of uranium: 49%
- Fabrication of UOx and MOx fuels: 1%
- Reprocessing and recycling of spent fuel: 7%
- Waste disposal: 2%
- Construction, operation and decommissioning of reactors: 40%

The environmental impacts of the nuclear industry are thus largely related to the management of materials (cycle front-end) and the operation of reactors including their decommissioning. The reprocessing strategy implemented by France accounts for only 7% of the sector's greenhouse gas emissions.

The radioactive materials and waste produced by the nuclear reactor fleet must be sustainably managed, in compliance with the protection of human health, safety and environment, on behalf of the legal rules enforced by the Environment Code. With this objective in mind, a safe and sustainable final destination for the radioactive waste must be sought and implemented in order to prevent or limit the burdens that will be borne by future generations.

Revised every three years, the National Plan for the Management of Radioactive Materials and Waste (PNGMDR) is the primary tool to implement these principles in the long-term, according to the legal framework set by the program law of 28 June 2006 on the sustainable management of radioactive materials and waste. Its main purpose is to draw up a regular review of the management policy for these radioactive substances, to evaluate new needs and to set the objectives to achieve in the future, particularly in terms of studies and research.

One of the strong environmental stakes addressed in the PNGMDR is the issue of very low-level waste (LWW), which will constitute the vast majority of the volume of waste resulting from the future decommissioning of the existing reactors (five times more than today according to Andra's estimates in the National Inventory of Radioactive Materials and Waste), no matter the scenario of evolution that will be considered, in particular in terms of footprint or recovery.

The post-operation management of closed nuclear power plants will also need special care.

Objectives and measures

Apart from the evolution of the nuclear fleet to reach 50% of power generation and possible new nuclear power (see 4.5. The electricity mix), the development objectives around the nuclear sector are given below.

Maintaining the jobs and skills of the nuclear industry in a period of energy transition

Facing major difficulties in recent years, the nuclear industry has dealt with a major reorganization, particularly in the reshaping of the Areva group (now Orano), to allow it to face the challenges ahead.

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58 . *https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_annex-iii.pdf*

In the long-term, the construction of the new energy model to which the Government is committed will involve a change in employment and skills in the nuclear sector as well as a transition for the local territories to be prepared. There is thus a strong challenge to lead this transition, which should be supported by appropriate tools: the ecological transition contracts and the programming plan for employment and skills will thus bring opportunities to the actors of the sector and allow them to be part of this transformation.

This transition will also be at the origin of major stakes to maintain a high level of skills across all activities of the sector, from fuel cycle to decommissioning, including reactor maintenance and integrating issues related to research and innovation as outlined in the National Energy Research Strategy (SNRE) adopted in December 2016. As part of the Strategic Committee of the nuclear sector (CSFN) currently being structured, the Government will ensure that the sector continues to invest on the most fundamental topics for its business model and its competitiveness: safety, lifetime extension of existing facilities and control of radioactive waste management.

Two subjects will be notably developed during the MEP period.

First, a lot of work remains to be done to develop a nuclear decommissioning sector with the ongoing projects (experimental facilities at CEA and others) and the future works (former and existing EDF reactors). As early as 2013, the CSFN recommended to "*strengthen the French decommissioning sector in order to meet the important needs to come in all the countries concerned.*" As part of the planned shutdown of the Fessenheim power plant and the decommissioning of the Chooz A reactor, the Grand-Est region could benefit from the expertise of the competitiveness clusters such as Nuclear Valley and the synergy between the region and the industrial actors of the Auvergne-Rhône-Alpes and Bourgogne-Franche Comté regions, where Nuclear Valley is located. The major operators, with EDF and CEA as frontrunners, have also committed to the development of such a sector, either by creating an engineering sector dedicated to decommissioning, or by technology transfer at the level of local clusters.

Second, some works on the development of small modular reactors (SMR), which consist of a new range of nuclear reactors, could be carried out. These reactors are characterized by their low power capacity (which means a simplified design compared to high capacity reactors) and a standardized modular construction, which makes them economically competitive despite the loss of scale gains. Their small size gives them the ability to resort to passive safety systems, thus limiting the accidental risks. Their power generation, which is more flexible than high capacity reactors, would enable a better integration in an electric grid supported by discontinuous renewable sources. Studies are ongoing on the market prospects and the competitiveness of a model developed by a French consortium gathering EDF, TechnicAtome, Naval Group and CEA.

Measures:

- Supporting the development of a decommissioning industry at both local and national levels.
- Providing that technical, economical and market studies on SMRs, expected in 2019, are conclusive, launching the completion of step-by-step conceptual design studies by the next MEP review, thus enabling a better assessment of the technology added value and the development of dedicated skills.

The transformation of the fuel cycle activities with regard to the evolution of the nuclear installations

In France, the current fuel cycle strategy is the mono-recycling strategy and is enshrined in a long-term objective of complete closure of the fuel cycle, which is meant to be achieved by the multirecycling of spent fuels in fast-breeder reactors (FBRs). . Today, France is one of the only countries in the world to master all the technologies needed for spent fuel reprocessing and recycling with the dedicated plants of La Hague in the Manche county and Melox in the Gard county. These plants provides work for more than 8 000 employees.

"Mono-recycling" reduces the use of natural uranium by 20 to 25% (MOx and ERU) by recovering radioactive materials (uranium and plutonium), reducing the number of stored spent fuels by 4, and ensuring a better containment for the final waste. This represents benefits for the energy system and is also an economic sector on which France can rely through a specific expertise. For these reasons, the spent fuel reprocessing and-recycling policy must be maintained.

In the very long-term, France will have to pursue the study of the technological options that might ensure the complete closure of the fuel cycle.

So far, research efforts have been focused on the deployment of Generation IV sodium-cooled fast-breeder reactors (SFBR). Within the framework of the 2006 law for radioactive materials and waste management, the design studies of a technological SFBR reactor, called ASTRID, have been launched since 2010. These studies are currently going on with a basic design phase on the 2016-2019 period.

However, since natural uranium resources are important and available at low cost, at least until the second half of the 21st century, the need for a demonstrator and the deployment of FBRs are not necessary before this horizon.

Meanwhile, in a shorter term, compared to monorecycling, multirecycling spent fuel in pressurized water reactors (PWR) might enable to stabilize plutonium stocks, as well as spent fuel stocks, Thus, the feasibility of this type of solution must be explored.

The recycling solutions for plutonium in PWRs require the fabrication of a new type of fuel ("MOX 2"). Using this type of fuel depends on a comprehensive R&D program and engineering studies. Moreover, multirecycling in PWRs would require the development of new cycle infrastructures (upgrade of La Hague's and Melox installations).

A financing development plan for multirecycling until its industrial deployment, including both reactor and cycle activities, will have to be issued and detailed by the operators for the next 5 years. This plan will be based on an R&D program that will enable to study the interest of various solutions in terms of reactor safety, operation conditions, manufacturing, transportation, etc… The testing of a fuel assembly in an existing reactor by 2025-2028 will be pursued, with a goal of potential industrial deployment by 2040.

Finally, the late prospect of a complete closure of the fuel cycle will imply a reshaped R&D program with a view to strengthening and maintaining skills around the physics of FBR and the related cycle processes. This program will rely on the development of numerical simulation capabilities and specific experiments. The detailed contents of this R&D program will be defined by mid-2019. Besides, an international strategy enhancing Generation IV reactor projects in the world will have to be implemented.

Measures:

- Defining and supporting an R&D program carried out by the industrial actors and leading to the long-term closure of the nuclear fuel cycle. This program will rely in the medium-term on the fuel multirecycling in pressurized water reactors, while preserving the ability for a potential industrial deployment of a fleet of fast-breeder reactors in the second half of the 21st century.

Management of radioactive waste with regard to the guidelines concerning the fuel cycle and the operation lifetime of the existing reactor fleet

Concerning the management of radioactive waste, long-term management solutions are already established for very low-level waste (VLLW) and low- and intermediate-level short-lived waste (L and IL-SLW), which represent most volumes of radioactive waste. The implementation of long-term management solutions should continue for low-level long-lived waste (LL-LLW) and high- and intermediate-level long-lived waste (H and IL-LLW) which have been managed so far by storage.

Today, the prospective waste inventories, and in particular those on which the design of the deep geological waste repository for H and IL-LLW relies, only take into account the waste of the existing reactor fleet with a predicted 50-year lifespan for the reactors. They assume the complete reprocessing of spent fuel produced by this fleet. Meanwhile, specific studies, called adaptability studies of Cigeo, aim at checking that underground disposal will also, while considering accessible facilities that may be engaged in due time, host spent fuel if necessary.

Apart from the assumption of spent fuel reprocessing, the inventories of waste generation, both in terms of the production of VLLW owing to the decommissioning of nuclear facilities or the production of H and IL-LLW in the context of reactor operation do not evolve very much and are independent from the reactor shutdown trajectories.

However,, according to the decision that will be made regarding the construction of new nuclear reactors, the question of an extension or new geological disposal capacities to receive the waste generated by the new fleet will arise.

Measure: Given the up-to-date measures regarding the evolution of the nuclear fleet and the complete closure of the fuel cycle, ensuring that the inventory assumptions considered for the radioactive waste management policy are consolidated and can be used for the preparation of the next national plan for the management of radioactive materials and waste.

3.5.9. Thermal installations

The thermal fleet is composed of nearly 1200 installations of very variable size (from a few hundred kW for the smallest to several hundred MW for the largest) with a total production capacity of 18.9GW. In 2017, these facilities generated 54.4TWh, or 10.3% of total electricity production.

In the French electricity mix, the main role of fossil fuel-fired power plants is to adjust production on demand, by operating in semi-base or as a complementary peak for nuclear energy and renewable energies. The relevance of the various types of production means and their contribution to the electricity mix depend on their technical and economic characteristics: base or semi-base for natural gas co-generation, semi-base for coal-fired power plants and combined cycle gas (CCG), points for oil-fired plants or combustion turbines (gas or oil). This corresponds to an operating time of between 3000 and 5000 hours per year.

Thermal power stations were characterised by low investment costs compared to the installed capacity, and high operating costs related in particular to the significant cost of fuel, which are detailed below by sector. In terms of the total cost of production (LCOE, which therefore integrates both investment and variable costs), the cost of production of a thermal power station strongly depends on the price of fuel but also on the applicable CO_2 price. It will therefore tend to increase over time.

The capacity mechanism[59] now makes it possible to recover the contribution of thermal power plants for the supply security of the production and erasure capacities that are necessary for covering the electricity peak in

59 . See Chapter 4. Supply, system and network security

winter. This mechanism will contribute, in the medium-term, to reaching the right level of capacity of production and erasure and should make it possible to improve the signals of investment.

Environmental and regulatory challenges

The Energy Transition for Green Growth Act aims to reduce fossil energy consumption by 30% in 2030 compared to 2012. In this development, it introduced the possibility of restricting the annual number of operating hours of a thermal power generation plant commissioned after 28 October 2016. A decree[60] has translated this provision by setting a greenhouse gas emission limit value at 2.2ktCO_2eq per year per MW of installed capacity. For co-generation installations, the emissions considered are those corresponding to the sole production of electricity.

The environmental impacts of the fossil fuel thermal fleet are framed by environmental standards. In particular, the 2010 directive on industrial emissions, the so-called IED Directive, which incorporates and reinforces the requirements of the previous Large Combustion Plants Directive and sets out the new constraints that have been applicable since 1 January 2016 for electricity production facilities. It toughens emission limits up for nitrogen oxides (NOx), sulphur dioxide (SO_2) and dust.

The IED Directive provides for derogations: installations that do not comply with the new emission limit values may operate for a maximum of 17,500 hours between 1 January 2016 and 31 December 2023. In this case, emissions must be lower than the limit values of the general (non-derogatory) case of the "GIC Directive" in force since 2008 for existing groups.

The MAEP adopted in 2016 aimed to increase the erasure capacity to ensure the electrical peak, so as to reduce the production of electricity from fossil fuels.

The coal thermal fleet

The fleet of high-power coal plants is composed of four power plants, operated by EDF and UNIPER, for a total installed capacity of nearly 3GW. In 2017, the production of coal power stations accounted for 9.7TWh of production, i.e. less than 2% of national electricity production, but 35% of GHG emissions from the electricity generation sector.

	Operator	Department	Power
Le Havre (sector 4)	EDF	Seine-Maritime	580 MW
Cordemais (sectors 4 & 5)	EDF	Loire-Atlantique	1160MW (2x580)
Emile Huchet 6, in Saint-Avold	UNIPER	Lorraine	595 MW
Provence 5, in Gardanne	UNIPER	Bouches-du-Rhône	595 MW

Table 21: Coal-based electricity generation facilities

Today, there are 670 direct and 740 indirect jobs in the four coal plants[61].

Air emissions from coal-fired plants, pollutants and greenhouse gases are their main drawback in the absence of a proven and economically competitive CO_2 capture and storage solution. The carbon base of ADEME reveals an emission factor of 1050kgCO_2 / MWh, nearly three times higher than that of gas-fired plants. The provisions of the IED Directive have already led to the shutdown of 15 of the most polluting coal plants since

60 . Article D. 311-7-1 of the Energy Code.
61 Source: EDF, UNIPER, INSEE

2013, for a total of 4GW, and contributed to the sharp reduction in CO_2 emissions from the electricity production sector.

A coal power station operates with an OPEX of €35 to €40 / MWh. The output of a coal plant is about 35%.

In accordance with the Climate Plan, the MAEP objective for coal-fired power plants is to stop the last coal-fired power plants by 2022 or to accompany their development towards less carbon-intensive solutions.

However, if the conversion of existing coal-fired plants to biomass or waste can technically be envisaged and could present an interesting potential for wood waste given the current saturation of the wood recycling market, it could not only on the very limited capacities of the fleet, prioritising the use of non-recyclable wood waste, particularly soiled or diseased. It should also take into account the energy efficiency requirements that will limit the benefits of any high-efficiency co-generation support system for co-combustion or biomass-fired generating installations by 2021-2022.

The closure of these power plants by 2022 requires the support of personnel and territories. The Government will be vigilant in setting up the accompanying vocational training measures for the employees concerned as well as jobs and redeveloping the sites into activities necessary to maintain the territorial dynamic, particularly through the conclusion of transition contracts with the territories concerned.

Measures

- Shutting down coal-fired power plants by 2022. In consistency with the priorisation of the use of biomass for heat generation, the government will not give any financial support for projects of electricity production with biomass;
- Supporting the employees and territories affected by these closures.

Fuel oil thermal fleet

In 2017, these oil-fired power plants produced 3.8TWh of electricity. At the end of 2017, the fuel oil thermal fleet represented 4.1GW of installed capacity. The application of the GIC and IED Directives governing the emission values of thermal power stations and promoting the use of the best available techniques has led to the shutdown of several GW of oil-fired power plants over the last ten years. During the first quarter of 2018, 3GW of additional power plants were shut down, corresponding to the closure of the four groups in Porcheville and a group of Cordemais, operated by EDF. There remains 1.1GW of installed capacity, composed exclusively of combustion turbines.

The main disadvantages of oil-fired plants are their atmospheric emissions and greenhouse gases. The carbon base of ADEME indicates emission factors ranging from 778gCO_2/ GWh for a fuel co-generation to 0.777tCO_2 / MWh for an oil-fired turbine.

The output of a fuel plant is about 35%.

Measure: Prohibiting the opening of new oil-fired power plants or oil-fired turbines (TAC).

Combined Cycle Gas / Natural gas co-generation

At the end of 2017, the installed capacity of Combined Cycle Gas (CCG) and Co-generation Gas was 11.9GW. In 2017, these facilities generated 40.9TWh, or 7.7% of total electricity production. The fleet is made up of:

- 6.2GW of combined cycle gas plants. An additional installation is currently being planned (Compagnie électrique de Bretagne in Landivisiau);
- 4.7GW of co-generation electrical capacity, distributed in nearly 900 installations[62];

62 These means are discussed in section 3.1.11. Co-generation with natural gas

- 1GW of combustion turbines.

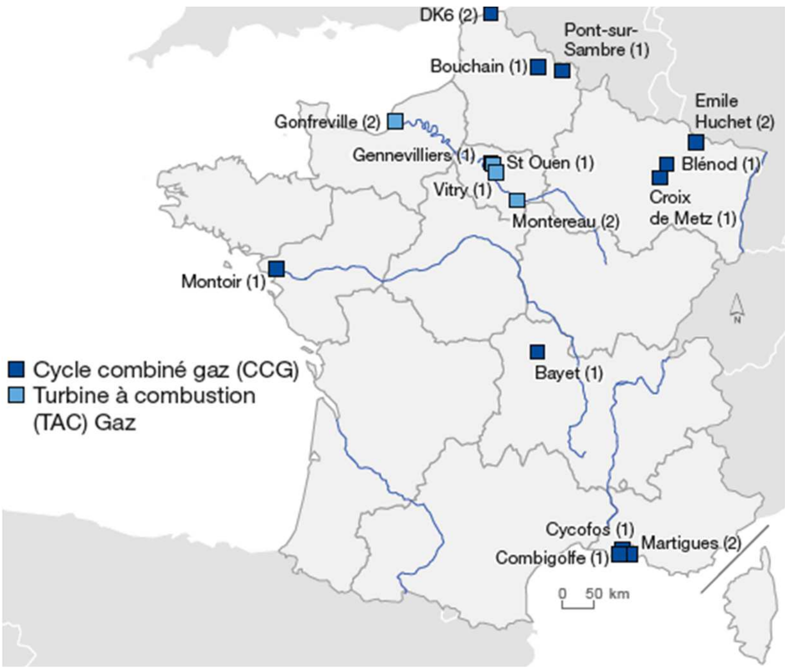


Figure 54 : On the left, gas-fired plants, situation as at 31 December 2016 (Source: RTE)

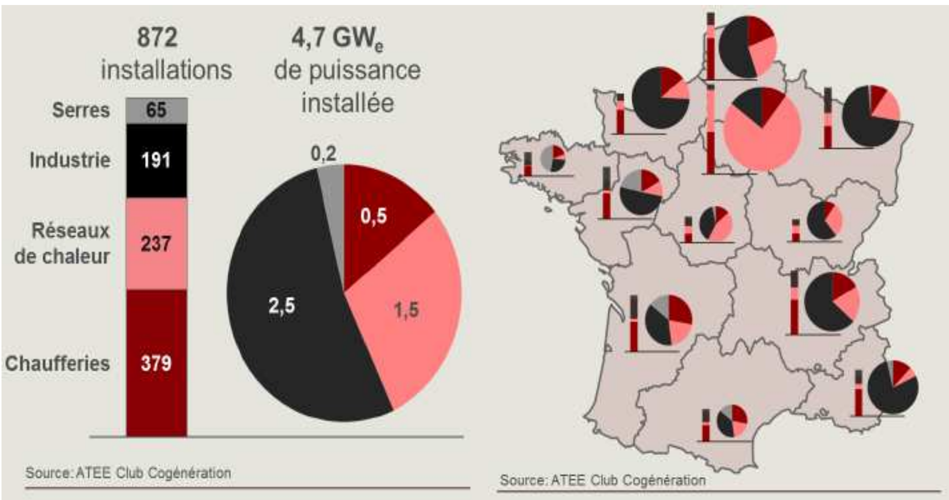


Figure 55: Co-generation fleet size by type of installation and its geographical distribution - Source: ATEE Club Cogénération

Combined cycle gas (CCG) plants, which constitute the bulk of the gas-fired generation fleet, combine a combustion turbine using gas and a turbine using steam produced by the heat generated by the combustion of the gas. The combination of these two turbines makes it possible to achieve efficiencies of the order of 60%. This improved performance reduces atmospheric emissions of CO_2, NOx and SO_2 compared to "conventional" gas plants (combustion only turbines).

The overall yield of Natural Gas Co-generation is greater than 75-80%. In other words, the efficiency of such an installation is more energy-efficient than conventional gas heating and a gas electric generator of the same power as the installation. Co-generation facilities produce electricity when heat needs are present, most of the time in winter. Co-generation thus makes it possible to provide additional seasonal electricity production. Following the MAEP adopted in 2016, a tariff decree was adopted for small natural gas co-generation plants.

Current and foreseeable costs

With regard to Combined Cycle Gas plants, their full production cost is between €45 and €70 / MWh. For a new unit designed to ensure only the peak, the full cost of production is between €120 and €175 / MWh. These ranges are, however, to be taken with caution since the evolution of the price of gas and the price of CO_2 has a significant impact on these values. Today, the variable cost of a combined cycle gas plant is between €45 and €55 / MWh.

The investment costs of the CCGs for new gas-fired combined cycle power plants are in the order of €900K / MW installed. For single combustion turbines, investment costs would be in the order of €500K to €600K / MW installed.

Concerning Natural Gas Co-generation, the costs of electricity production are around €100 / MWh. The investment costs are in the realm of €1M / MWe, which can be very variable depending on the nature of the installation, but are not likely to vary. Production costs are highly dependent on the price of gas and CO_2.

Environmental and regulatory challenges

Gas-fired plants also emit air pollutants and greenhouse gases and their development is not compatible with the GHG reduction targets set by the MAEP. The carbon base of ADEME retains the following emission values:

- 778gCO_2 / KWh for combustion turbines;
- 443gCO_2 / kWh for Gas Combined Cycle and Gas Co-generation.

MAEP objectives and measures to achieve them

Strong public support for new natural gas co-generation plants is no longer justified in view of France's climatic ambitions. No quantitative objectives for the development of new capacities are therefore set for this sector.

Measures:

- Prohibiting any new power station or CCG project (excluding Landivisiau);
- Removing support mechanisms for new gas co-generation installations.

4

Energy mix targets

4. Target energy mixes

4.1. The energy mix

Taken as a whole, the MAEP measures should change the French energy mix. The tables below present the mixes which should result from it 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	**Of which is renewable**	**Total**	**Of which is renewable**
Coal	2	0	0	0
Oil	539	33	434	35
Gas	320 (PCI) 358 (PCS)	5 (PCI) 6 (PCS)	285 (PCI) 320 (PCS)	From 13 to 20 (PCI) 14 to 22 (PCS)
Electricity	443	From 157 to 159	438	From 210 to 226
Heat (including biomass and biogas)	237	196	261	From 218 to 247
Total	1540	From 390 to 392	1418	From 486 to 540

Table 31: Final energy consumed in 2023 and 2028 by source (TWh)

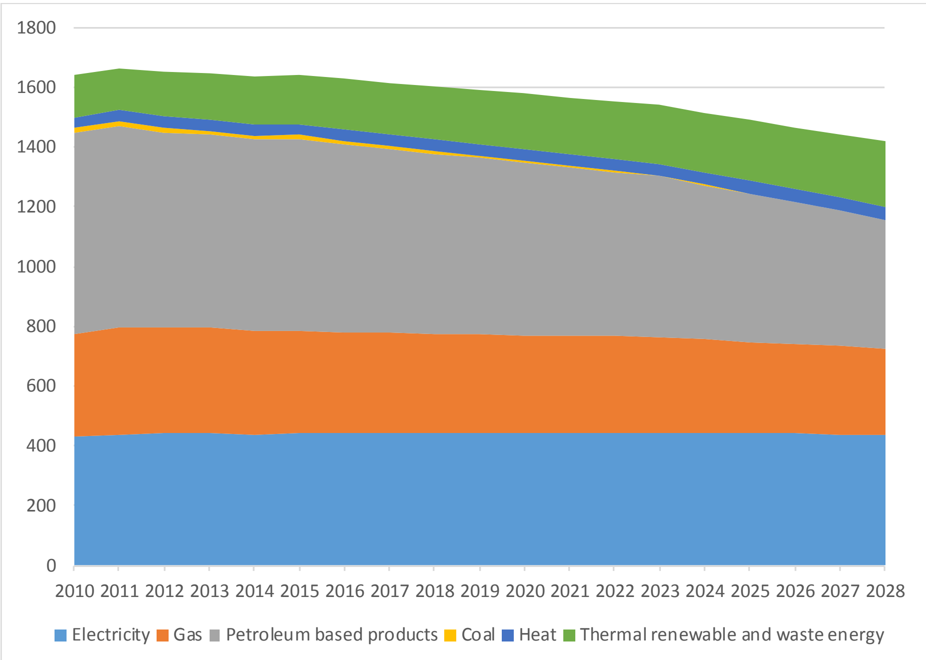


Figure 56: Progression of the real (2010-2016) and projected (2017-2028) energy mix by energy vector

	Coal	Refined petroleum products	Gas	Thermal and waste REn	Electricity	Heat sold	Total
Industry	1	19	124	24	116	13	298
Transport	0	412	5	35	21	0	474
Residential	0	56	124	111	150	19	460
Tertiary	0	19	64	22	148	9	261
Agriculture	0	33	4	2	9	0	48
Final energy consumption	2	539	321	196	443	41	1541

Table 32: Final energy consumed in 2023 by sector (TWh)

In 2023, final energy consumption should be in the region of 1543 TWh i.e. 6.6 % less than in 2012. Gross final energy consumption (including network loss and energy sector consumption in particular) should be in the region of 1651 TWh. Renewable energy will provide 390 to 392 TWh, covering 24% of final consumption.

	Coal	Refined petroleum products	Gas	Thermal and waste REn	Electricity	Heat sold	Total
Industry	0	13	114	30	115	12	284
Public	0	349	11	37	32	0	429
Residential	0	33	108	118	143	24	426
Tertiary	0	11	48	28	140	9	236
Agriculture	0	28	5	3	9	0	46
Final energy consumption	0	434	286	216	438	45	1420

Table 33: Final energy consumed in 2028 by sector (TWh)

In 2028, final energy consumption should be in the region of 1,420 TWh i.e. 13.9 % less than in 2012. Gross final energy consumption (including network loss and energy sector consumption in particular) should be in the region of 1,527 TWh. Renewable energy will supply 486 to 540 TWh, thus providing between 32% and 35% of gross final energy consumption.

The goal set by the Energy Transition for Green Growth Act (Loi relative à la Transition Énergétique pour la Croissance Verte, LTECV) for 2030 is that 32 % of final energy consumption should be provided by renewable energy.

4.2. The heat mix

The table below presents the energy sources that will ensure that heat needs are met for the MAEP timelines when the measures put forward in the present MAEP are adopted, and in particular the heat fund trajectory presented in part 6.

		2023	2028 Scenario A	2028 Scenario B
Fossil (heating 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	54
	Geothermal energy	3	4	5
	Solar thermal energy	2	2	3
Refuse-derived energy		4.4	7.6	9.9
Total heat production		690	635	635

Table 34: Heat mix resulting from the MAEP for 2023 and 2028

In 2023, the MAEP should enable heat needs to be met with 196 TWh of heat from renewable sources, i.e. 28 % of final heat consumption.

In 2028, the MAEP should enable heat needs to be met with between 218 and 247 TWh of heat from renewable sources, i.e. between 34.3% and 38.9% of final heat consumption. The goal set by the LTECV is that in 2030, 38 % of final heat consumption will be provided by renewable energy.

This progression will be achieved through an average rate of increase in renewables and refuse-derived energy of between 1.2% and 1.8% annually between 2020 and 2030, where the renewable energy directive requires a minimum growth of 1.3 % annually starting from 2020.

To be noted that if x % of biogas is injected into the network, x % of gas consumed to produce heat by means of the network is considered as renewable.

To be noted that electricity from renewable sources is not accounted for here because European methodology considers that since specific goals have been set for renewable electricity, it should not be accounted for twice. Only the goals that are not tracked by energy vector monitoring are followed up here. The table below shows the breakdown of the biogas sources.

	2023	2028 Scenario A	2028 Scenario B
Heat produced by injected bio methane	3.9	8.3	12.1
Heat produced by cogeneration	2.6	3	5.3
Direct heat or network heat	0.8	0.8	0.8

Table 35: Source of biogas in 2023 and 2028 (TWh)

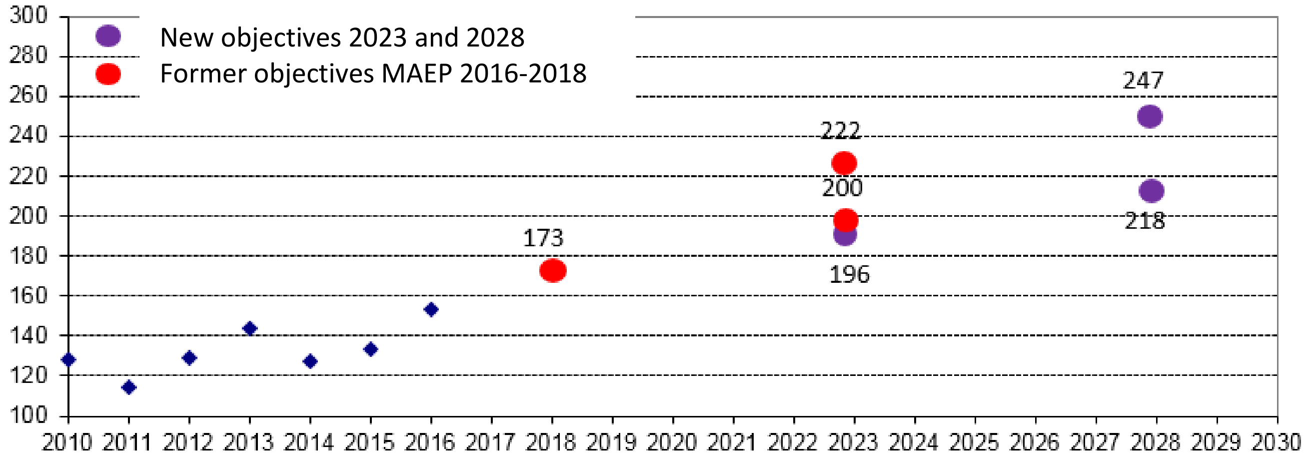


Figure 57: Final heat consumption from renewable sources

4.3. The liquid fuel mix

The table below presents the energy sources that will ensure that liquid fuel needs are met for the MAEP timelines when the measures put forward in the present MAEP are adopted.

		2023	2028
Petrol	Fossil	83	79
	1G renewable	6	6
	2G renewable	2	3
Diesel	Fossil	290	234
	1G renewable	22	18
	2G renewable	3	8
TOTAL		406	348

Table 36: The liquid fuel mix that the MAEP will enable in 2023 and 2028 (TWh)

In 2023, the MAEP should enable liquid fuel needs to be met with 33 TWh of fuels from renewable sources, i.e. 9 % of final fuel consumption.

In 2028, the MAEP should enable liquid fuel needs to be met with 35 TWh of fuels from renewable sources, i.e. 11 % of final fuel consumption.

The goal set by the LTECV for 2030 is that 15 % of final fuel consumption should be provided by renewable energy.

4.4. The gas mix

Gas consumption is characterized by a strong seasonality: the differential for gas consumption between the winter peak and the summer off-peak is a factor of somewhere around 10. In France, the gas spike is connected on the one hand with direct use for heat (about 100GW) and, on the other hand and to a lesser extent, with gas consumption for electricity production (less than 10GW).

In 2016 (the benchmark year for the chart), the seasonal variation for gas consumption between the spike and the minimum consumption 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.

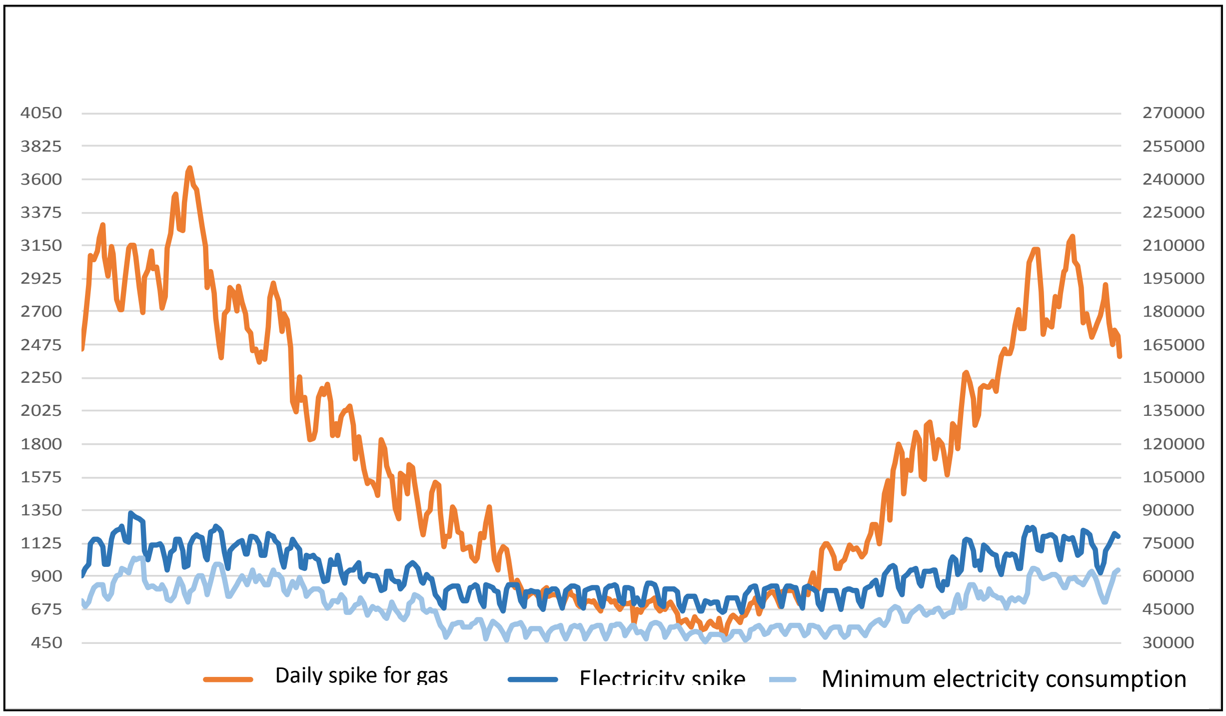


Figure 58: Daily spike (gas in GWh/day on the left and electricity in MW on the right)

The goals for reducing fossil fuels make a case for reviewing natural gas use by directing it towards 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 networks, 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 heat networks on the other.

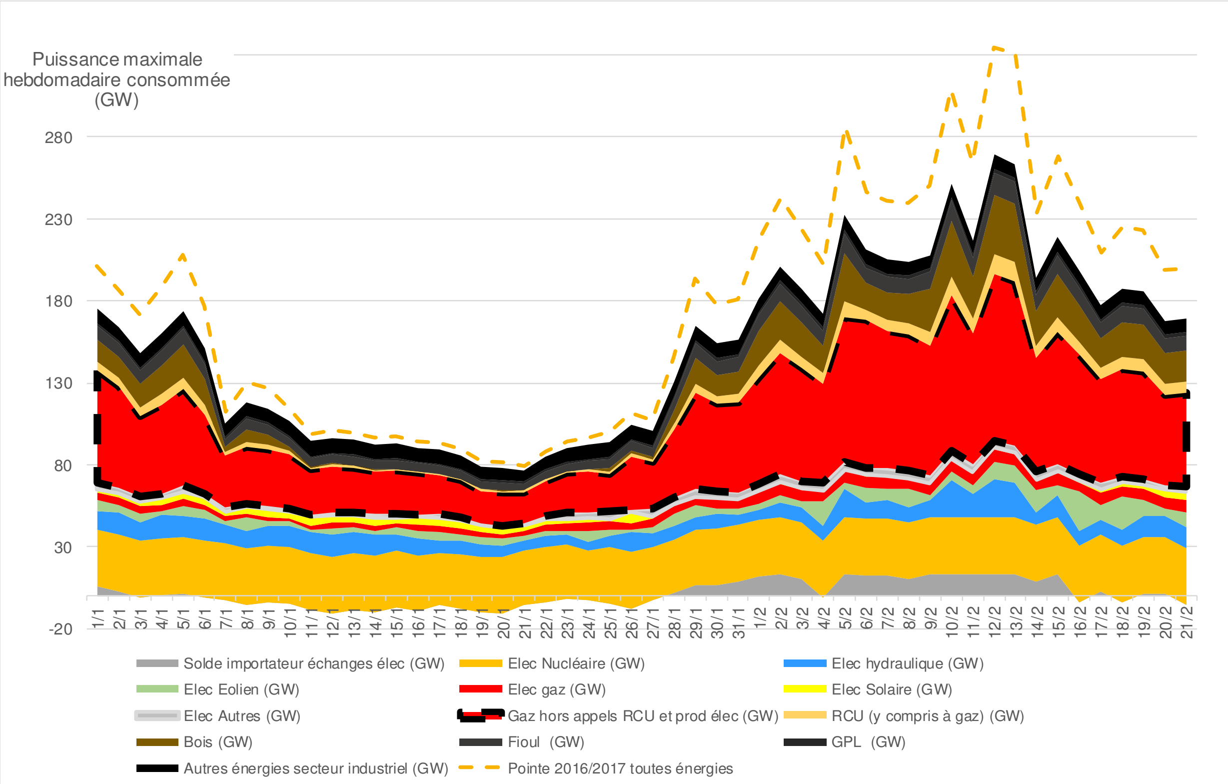


Figure 59: Demand curve for all energies in 2028

The table below presents the energy sources that will ensure that gas needs are met for the MAEP timelines when the measures put forward in the present MAEP are adopted.

	2023	2028 Scenario A	2028 Scenario B
Natural gas	315 (LHV) 352 (HHV)	272 (LHV) 306 (HHV)	265 (LHV) 298 (HHV)
Biogas (injected biomethan)	5 (LHV) 6 (HHV)	13 (LHV) 14 (HHV)	20 (LHV) 22 (HHV)
Biogas (other)	7 (LHV) 8 (HHV)	9 (LHV) 10 (HHV)	9 (LHV) 10 (HHV)

Table 37: Gas mix that the MAEP will enable for 2023 and 2028 (TWh)

In 2023, the MAEP should enable gas needs to be met with 14TWh of gas from renewable sources, i.e. 3% of final gas consumption.

In 2028, the MAEP should enable gas needs to be met with between 24 and 32TWh of gas from renewable sources, i.e. between 6 and 8% of final gas consumption.

The goal set by the LTECV for 2030 is that 10 % of final gas consumption should be provided by renewable energy.

4.5. The electricity mix

The table below presents the means of electricity production for the MAEP timelines when the measures put forward in the present MAEP will be adopted.

		2023	2028 Scenario A	2028 Scenario B
Nuclear		393	382	371
Fossil	**Coal**	0	0	0
	Oil Heating	34	32	32
	Gas			
Renewable	**Hydro**	62	62	62
	Terrestrial wind turbines	53-55	79	83
	Photovoltaics	24-25	43	53
	Bioenergy	9	9	10
	Offshore wind and renewable marine energies	9	17	17

Table 38: Electricity mix that the MAEP will enable for 2023 and 2028 (TWh)

In 2023, the MAEP should lead to a production made up of between 157 and 159 TWh of electricity from renewable sources, 34 TWh of electricity from thermal sources and 393 TWh from nuclear sources, i.e. 27% of electricity production from renewable sources and 67 % of electricity production from nuclear sources.

In 2028, the MAEP should lead to a production made up of between 210 and 226 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 production from renewable sources and between 59 and 61 % of electricity production from nuclear sources (upper range for REn goals).

Changes to the nuclear power station system with regards to achieving 50 % nuclear in electricity production

The goal to diversify the electricity mix

The Fessenheim nuclear power station should be shut down with effect from spring 2020, by applying a cap to the installed electronuclear power, established by the Energy Transition Act, and to enable the commissioning of the Flamanville EPR.

EDF has already indicated that the two reactors at the power station would not be used in any case beyond the deadlines for their 4th periodic safety re-examination in 2020 and 2022. If the start-up of the Flamanville EPR reactor goes according to the updated timeframe posted by EDF, the two Fessenheim Reactors will be shut down after winter 2019-2020, and it will be possible to plan for a halt to all electricity production from coal during this five-year presidency. If commissioning of the EPR were to be delayed, the two Fessenheim reactors will be shut down in spring 2020 in any case, but the timeframe for the staggered shutdown of coal production facilities would have to be revised in order to guarantee the security of supply.

Beyond this first stage, the government is pursuing a goal of diversifying the electricity mix to achieve a reduction to 50 % of the nuclear share in electricity production. This diversification policy is a response to several different issues:

- A more diversified electricity system, if it succeeds in incorporating an increased volume of renewable energies, can be more resilient to external impacts such as, for example, a drop in the production capacity of reactors following an incident or a generic failing leading to the non-availability of several reactors;

- The vast majority of the nuclear electricity power station system was built over a short period of time, about fifteen years. It is therefore not practicable to set a similar operational duration for all the reactors: such volumes of decommissioning over such a concentrated time period would risk security of supply problems. We should therefore plan for the early shutdown of certain reactors in the existing system to avoid a "cliff edge" effect which would be unacceptable both in terms of the social impact and for the sustainability of the electricity system. The progressive reduction of the nuclear power station system will smooth out the decommissioning and the investments in new production capacities without generating over capacities. From this point of view, EDF has confirmed the industrial value of shutting down part of the system before the end of its expected maximum service life (60 years);
- Several channels for electricity production from renewable sources have shown their ability to compete and will make up a significant part of the long-term electricity mix, at least towards the level where a massive storage of electricity need will appear, and more when the technical schemes of electricity storage will become competitive;
- Finally, diversification on this scale towards renewable energy should be smoothed out over the course of time because the new renewable capacity will be installed in a diffuse and decentralised way by means of small projects and channels, thus requiring a gradual stepping up in power.

The LTECV sets the goal of limiting the nuclear share to 50 % of the electricity produced in France by 2025.

In the notice from the Council of Ministers of 7 November 2017, the Government had taken note of the studies conducted by RTE in its provisional 2017 forecast of the electricity supply/demand balance which demonstrate that a 2025 deadline raises operational difficulties with regard to our climate commitments. Despite the Government’s future proactive development of renewable energies, and given the poor short-term maturity of storage solutions, France would be forced to build about twenty new gas facilities over the next seven years in order to guarantee security of supply during consumption spikes, leading to a major and durable increase in greenhouse gas emissions.

It seems impossible therefore to reach the goal of limiting the nuclear share to 50 % of the electricity produced in France by 2020, except by risking disruptions to France’s energy supply or by relaunching the construction of combustion power stations which would run contrary to our goals of combating climate change.

Thus, the government has set the goal for this progressive diversification of the electricity mix of achieving a 50% nuclear share in the mix by 2035. Such a progression is consistent with our climate commitments: it will be completed without building any new fossil fuel thermal power plants, it will not lead to an increase in greenhouse gas emissions from our electricity production and it is compatible with shutting down all our coal-fired power plants between now and 2022. It is also consistent with the requirements of the strategy for processing and recycling nuclear fuel and with the sustainability of the facilities in the cycle.

The government has chosen to set a clear plan for the changes to nuclear capacity, including beyond the term of the MAEP (2028), so as not to task our successors with designing the modalities for putting this diversification into action. Posting a legible and forward-thinking trajectory will enable the regions and employees to prepare better, undertake their reconversion well in advance and structure the dismantling channel. It will also provide a clear view of future developments for all players in the electricity system with regard to their investments.

After 2035, the diversification of electric mix still stands, in order to keep a robust and carbon free electric mix in long term, it will be based on complementary technologies.

The trajectory of evolution of the electro-nuclear system

To achieve this goal of 50 % of electricity production between now and 2035, the government sets the following guidelines:

1) 14 nuclear reactors will be shut down between now and 2035, including those at the Fessenheim plant;

2) The general principle will be to shut the reactors down (excluding Fessenheim) by the date of their 5th ten-year inspection, i.e. the shutdowns will occur between 2029 and 2035.

Shutdown at the 5th ten-year inspection is:

- An industrially consistent scenario: the 5th ten-year inspection is a well-defined date for which an extended shutdown and investments are mandatory, which will not be undertaken if a definite shutdown is planned at this date.
- To meet electricity demand in France as in Europe, investment in prolonging reactor use is less costly than investment in new capacity. As long as opportunities exist with no overcapacity leading to sharp falls in the market price, this is the most economically advantageous scenario for France.
- This set up enables the French and European electricity mix to derive benefit from an essentially carbon-free production, which enables a reduction in European CO_2 emissions when it substitutes a more carbon-rich electricity production.
- The government believes that these shutdowns are consistent with EDF's industrial strategy, which will amortise the 900 MW reactors in the accounts over a period of 50 years, and will therefore not give rise to compensation.

However, strict compliance with this principle of shutdown at the 5th ten-year inspection would lead to an average of 2 reactors being shut down per year between 2030 and 2035, raising the question of managing this programming socially, technically, and in terms of political capacity for the governments of this time. Depending on our neighbours' decisions with regard to the development of renewables or shutting down fossil fuel production capacity, the European electricity system could find itself in overcapacity by 2030 which justifies planning to shut down some reactors in advance.

However, research carried out in 2018 by RTE indicated that it will be difficult to shut down any reactors apart from the Fessenheim ones before 2024. It does however show that it is possible to close between 2 and 4 reactors (not including Fessenheim) between 2024 and 2028.

3) In order to smooth out reactor shutdowns so as to facilitate the implementation socially, technically and politically, the government requests that EDF make provisions for the closure of 2 reactors before their 5th ten-year inspections in 2027 and in 2028 in line with the energy policy. These reactors will be shut down except if:

- The Nuclear Safety Authority (Autorité de Sûreté Nucléaire, ASN) demands the closure of other reactors for safety reasons between now and then;
- Their closure leads to non-compliance with criteria for security of supply.

4) The government could theoretically also ask EDF for two additional reactor shutdowns, in 2025 - 2026, if the following conditions came together cumulatively, in addition to those cited above :

- The neighbouring countries to France undertake a rapid transition of their electricity production system, in particular by shutting down a large amount of coal-fired electricity production capacity, and massively develop renewable energy so that their security of supply does not rely on French production capacity: the French export balance would therefore be reduced and the closure of nuclear reactors would enable a limitation of overcapacity;
- There exists a significant margin in terms of security of supply across the nuclear capacity, making it possible to continue supply if the ASN ever decides to suspend the operation of several reactors for safety reasons;
- Market prices for electricity remain low because of core production overcapacity with a low variable cost (renewables and nuclear), thereby decreasing the profitability of prolonging the whole of the existing system, and enabling a capacity reduction without shifting the burden onto French consumers.

A report analysing these conditions will be the submitted by the Committee for Energy Regulation (Commission de régulation de l'énergie, CRE) to the government before 1st December 2022, based on RTE expertise.

5) The final version of the MAEP will identify the sites to close in priority. To implement this trajectory for the evolution of installed nuclear capacity, the government has asked EDF to submit a list of sites for closure, amongst the 900 MWe reactors in order to minimise both the economic and social impact and the impact on the electricity network, by prioritising reactor shutdowns that do not lead to the complete shutdown of any nuclear site. The first analysis of the government, on the basis of the age of sites, the date of the ten-year inspection, and the current industrial and economic situation described by EDF in its paper for public debate on MAEP, would conclude on the closure of 12 reactors, in priority on the sites of Tricastin, Bugey, Gravelines, Dampierre, Blayais, Cruas, Chinon, ans Saint-Laurent. Before the end of consultations on MAEP, EDF have to confirm or modify this.

6) The reactor closures will be confirmed 3 years before their implementation, based on data available at that time, to ensure that the above-mentioned criteria are complied with. They will be implemented after the shut down of coal plants, provided that the decrease of the carbon content of electricity production is the priority. This early action will furthermore allow us to support the regions affected by the closures, particularly by setting up ecological transition contracts that enable them to participate in the new development dynamics.

Coherence with the strategy for processing and recycling nuclear fuel

The reduction of nuclear capacity has consequences for the whole fuel cycle. The strategy for processing and recycling nuclear fuel is particularly important for reducing the volumes of radioactive waste produced. This strategy will therefore be retained over the MAEP period and beyond, by the 2040s, when a large portion of the facilities and workshops of the Hague plant will reach the end of their life. To this end, and to compensate for the closures of the MOX fuelled 900 MWe reactors over this period, the moxing of a sufficient number of 1,300 MW reactors will be undertaken in order to make management of the French cycle sustainable.

EDF confirmed the absence of any unacceptable technical obstacles to these operations, subject to the establishment of a balance sheet for safety margins that will happen in 2019. The moxing of some instalments could then occur by 2030 (with the objective of a first charge in 2028), taking operational deadlines and prior authorisations into account.

Beyond the 2040 timeline, the government, in association with the channel, should reflect on the strategic directions it desires for its fuel cycle policy, based on R&D efforts which will be pursued over the term of the MAEP in the domain of closing the fuel cycle, in particular for the multi-recycling of the nuclear fuel in the reactors of the current system, and to a longer term on the building of reactors from generation IV.

Measures

- The government has set a goal of achieving a maximum 50 % nuclear share in the electricity mix in 2035. The goal stipulated in the Energy Code will be modified as a result.
- To meet this goal, fourteen 900MWe nuclear reactors must close between now and 2035, including the two reactors at Fessenheim.
- The timeframe for closure of the power plants will comply with the dates of the 5th ten-year inspections for the reactors in question, except for 2 reactors which will shut in the second period of the MAEP in 2027 and in 2028.
- If certain conditions relating to the price of electricity and the evolution of the electricity markets at a European level are fulfilled, the closure of an additional 2 reactors could occur by 2025-2026, based on a decision taken in 2023.
- The government will identify sites prioritised for closure, based on the proposals submitted by EDF. The downsizing of the nuclear power plant system would not lead to any nuclear site stopping completely.
- The strategy for processing and recycling nuclear fuel will remain over the MAEP period and beyond, by the 2040s. To this end, the moxing of a certain number of 1300 MWe reactors will be undertaken and studies will be done on deploying multi-recycling of the fuel in the reactors in the existing nuclear power system.

The supply/demand balance over the long term: the place of nuclear

Technological options for electricity production to achieve carbon neutrality in the long-term

Achieving carbon neutrality by 2050 is a priority for France to meet climate challenges. It requires the long-term electricity mix to become completely carbon-free.

New nuclear capacity does not for any reason seem necessary to ensure a balance in electricity supply and demand before 2035. Beyond that, the question remains of how to build new means of carbon-free electricity production to ensure a balanced supply and demand in line with the decommissioning of the current nuclear system.

In the current state of technology, it is not possible to determine with certainty which technologies will be the most competitive to ensure our electricity mix on this horizon, between nuclear and renewable energy linked with storage and other flexibility solutions.

The deciding factors will be: the capacity of electricity networks to incorporate intermittent energy sources; the maturity of electricity storage technology, including inter-seasonal storage; and the economic performance of the different sectors calculated using the full cost. After 2030 and by 2050, these parameters should be combined to design France's new energy landscape and establish the respective shares for nuclear and renewable energy: several scenarios can be envisaged, going from a scenario of 100% renewables to a scenario where nuclear permanently remains an electricity production source incorporated into the electricity mix for reasons relating to managing production and competitiveness.

Because of the uncertainties, it is necessary to maintain the French knowledge to build new nuclear reactors based on domestic technology and industrial capabilities.

Preliminary conditions and the work required to make a decision

Where new nuclear is concerned, in order to allow a decision to be made on any potential launch of a programme to construct new reactors, the government will conduct a complete work plan with the sector between now and mid-2021 which will mainly cover the following items:

- demonstration by the French sector of its capacity to manage an industrial program for new reactors, by formalising the consolidated feedback on the commissioning of the first EPRs, in particular

Flamanville 3, and on the engineering phase and industrial mobilisation of Hinkley Point C, and by a program to remove risk from the new EPR 2 reactor model proposed by EDF;

- appraisal of future costs of the new EPR2 reactor model proposed by EDF and the technical economic comparison of nuclear power with other modes of low-carbon electricity production, taking into account all the direct and indirect costs (network development, total storage cost, management of nuclear waste, etc.);
- Impact analysis of the management of the waste generated by a new system, which will be incorporated as part of the development of the National Radioactive Waste and Materials Management Plan (Plan national de gestion des matières et déchets radioactifs, PNGMDR);
- analysis of the possible options for the portage arrangement and funding of a program of new reactors for the French electricity system, including the question of the model of economic regulation for these new reactors;
- the necessary actions to gain European Commission validation of the selected funding and portage provisions;
- the studies in order to decide on which sites the new reactors will be installed;
- the actions to be taken in terms of public consultation;
- the adaptations to the national legislative and regulatory framework which would be necessary for running a new reactor program.

It is also necessary to appraise, before the next MAEP, and on a regular basis, alternative options to ensure a free-carbon electric mix and ensuring the security of supply.

In terms of the alternative options, the State will invest in research on batteries, hydrogen storage (as part of the Hydrogen Plan) and power-to-gas in order to capitalise on French expertise in this field, to bring down costs and to offer a robust alternative to an electricity mix relying on uncontrollable renewable energies.

Measures

- Over the first MAEP period, the government will continue to examine the different options available to ensure a long-term balance of supply and demand in the electricity system, in particular the option of building new nuclear reactors. This option will thus be kept open in order preserve the government’s decision-making capacity.
- On this point in particular, by mid-2021, the government will conduct a work program with the sector to examine questions relating to the cost of new nuclear capacity and its advantages and disadvantages compared to other low-carbon means of production. It will also examine the potential funding models, the implementation conditions for the new reactor projects and public consultation, as well as questions relating to managing the waste generated by any new system of nuclear power stations;
- On the basis of this knowledge, and depending upon the evolution of the energy context, the government will decide upon the opportunity to launch a program to renew nuclear plants.

5

Security of supply, networks development, storage, flexibilities and local production

5. Supply security, development of networks, storage, flexibilities and local production

Supply security can be defined as the capacity of the energy system to continuously meet foreseeable market demand at a reasonable cost by balancing supply and demand.

5.1. Supply security of liquid fuels

5.1.1. National issues: refining and strategic stocks

In 2017, France extracted about 0.8Mt of crude oil from its subsoil, which currently represents 1% of national consumption. The majority of the deposits are located in the Paris basin with 60.8% of total extraction, followed by the Aquitaine basin (38.8%) and Alsace (0.4%).

In a context in which domestic hydrocarbon extraction only marginally contributes to national needs, France is almost totally dependent on petrol imports for domestic consumption. In order to secure its supply of petroleum products, France diversifies the regions from which it imports crude oil. In 2017, oil imports came from the Near East (25%) , Russia (11.4%), Kazakhstan (15%), Africa (23%) and Norway (9%).

France also imports refined products (diesel, jet fuel). In 2017, imports amounted to 41.2Mt while exports totalled 21.9Mt (including bunkering). The majority of French imports (53.4%) consist of diesel and heating oil. By contrast, heavy fuel oil is the main export (22.2% of French production was exported in 2017).

By 2023, petrol requirements should be 700TWh and by 2028 565TWh.

The oil logistics network in mainland France consists of:

- Import depots for petroleum products, located as close as possible to refineries or ports, providing the main storage capacities;
- Pipelines for the transportation of crude oil or finished products (pipelines or oil ducts);
- intermediate depots before final delivery to consumers through the service station network.

Each level of infrastructure is an indispensable link for supply security. The density of the network and, in particular, intermediate depots contribute to quality supply throughout the country. Declining petrol requirements will lead to changes in the profitability of the infrastructure. This must not be allowed to jeopardise the security of hydrocarbon supply.

France has had stable overall storage capacity for petroleum products since 2015, of around 46Mm³ – including 15.7Mm³ in refineries and 7.5Mm³ excluding refineries in a total of 23.2Mm³. More than 60% of these infrastructures are dedicated to the storage of finished products.

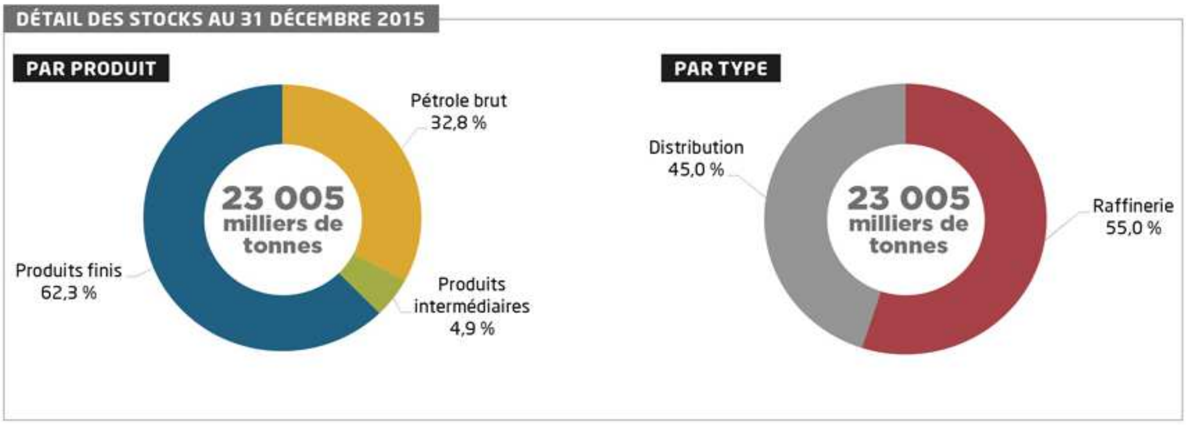


Figure 61: Detail of stocks at 31 December 2015 – Source: Professional Petroleum Committee (CPDP)

Diesel is still the main fuel (47%), super-fuels and jet fuel represent respectively 13% and 7% of capacity. The territory's network is deployed to the benefit of depots with larger capacities. Oil depots with a capacity greater than 400m^3 are slightly down (201 in 2015 against 207 in 2013).

The distribution of storage capacity in mainland France is influenced by the proximity of refining tools, import sites, but also by the infrastructure for mass transport of products (pipelines). The Normandy and Provence-Alpes-Côte d'Azur (PACA) regions together account for 48% of storage capacity. To a lesser extent, the regions of New Aquitaine and Hauts-de-France together represent 18% of capacity due to the presence of large import depots.

In mainland France, since 1 July 2012, the strategic stocks that operators must establish and retain represent 29.5% of the quantities of petroleum products distributed in year n-1, minus the quantities of crude oil produced on national soil (decree of 29 January 2016). The stocks thus constituted to meet the strategic storage obligation represent 88% of stocks in France. The plan for the location of strategic stocks, approved by the Minister of Energy, requires operators to locate their security stocks on a site linked to consumption and supply flows.

5.1.2. Local issues: Intermediate stocks and service stations

Today, hydrocarbons account for nearly 90% of the energy consumption of the transport sector. Consumption projections for petroleum products foresee a decrease of almost 25% in 2028 compared to current consumption. 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 decrease in consumption.

It is necessary to maintain a sufficient geographical network:

- To guarantee supply security. Indeed, excessive concentration of storage premises entails risks of shortage for the consumer if one of these sites is inaccessible and the others cannot support the activity of the missing site, or if extended travel time does not facilitate the guarantee of an adequate supply flow;
- To ensure proximity between storage and consumption sites in order to avoid an increase in the number of road 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 efficient service to the national territory. Fuel sales are increasingly concentrated in high throughput stations, in particular those owned by large and medium-sized supermarkets (GMS). 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 16km;
- 50% within 6 minutes and 3km;
- On average, a household takes 9 minutes 20 seconds to access a station;
- Under 2.5% of households have a service station more than 30km away.

The average time to get to a service station by department is used as an indicator to monitor the evolution of the network. 90% of individuals must be able to get to a service station in under 25 minutes. In 2018, less than 4,3% of families have more than 25mn of journey.

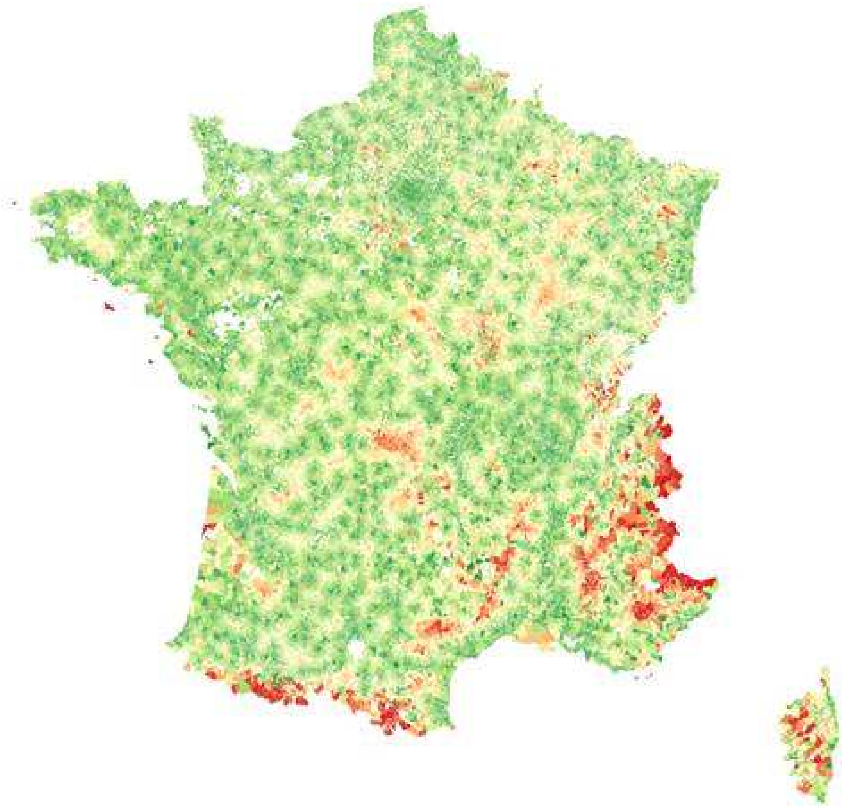


Figure 62: Home-service station journey time (IRS network), source: DGEC

Objectives and measures;

- Launch studies to have a future vision of the necessary network for oil storage and the minimum number required to guarantee security of supply;
- Monitor number and location of petrol stations to know the quality of service over the territory for all fuel consumers;
- Ask the opportunity to have tools to guarantee the continuity of service in the oil logistic in order to satisfy the essential needs of the country.

5.2. Supply security of gas products

In 2017, France consumed 493TWhHHV of natural gas. By 2023, France will be using 470TWhHHV of gas and 420TWhHHV in 2028.

5.2.1. Level and criterion of gas supply security

Natural gas supply security involves ensuring the continuity of the gas supply, given the various risks to which the gas system is vulnerable, in particular the climatic hazards and losses of supply sources, as well as continuity of routing of natural gas on the network, particularly given the risks of congestion.

The objective in terms of natural gas supply security represents the possibility of ensuring supply to natural gas consumers, except for consumers who have contractually agreed to a supply vulnerable to interruption, when:

- There is a cold winter, such as those occurring once every 50 years;
- Temperatures are extremely low for a period of three days, as occurs every 50 years.

The objective of developing interruptibility of natural gas consumption will lead to an increase in the number of consumers accepting a supply that might be interrupted and therefore mechanically to a lowering of the supply standard. The opportunity for further reduction in the supply standard will continue to be studied in relation to the reinforcement of the available means of action in the event of a crisis.

The level of supply security is stricter than the minimum level provided for by Regulation 2017/1938 of the European Parliament and of the Council. On the basis of the inspection report conducted on this matter, it is proposed not to modify the current criterion.

Measure Maintain the current criterion of supply security.

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.

5.2.2. 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 objective mentioned in 5.2.1.

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 in the French market is subject to ministerial authorisation. Justifications enabling confirmation of compliance with the continuity of supply obligations may be requested when the supply authorisation is updated annually.

Diversification obligations

Beyond a certain market share, a natural gas supplier is required to diversify the entry points of its supply in the national territory. The terms of this obligation are specified in Article R. 121-1 of the Energy Code. In order not to penalise new entrants, this measure does not apply below 5% of market share.

Obligations for continuity of delivery

Managers of natural gas transmission and distribution networks must size their infrastructures so that natural gas can be delivered at the level corresponding to the supply security objective.

Infrastructure operators are also required, under public service obligations, to provide advance notice of the dates when their facilities will be unavailable in order to allow suppliers to ensure continuity of supply.

5.2.3. Gas system sizing, storage

Over the past decade, the gas system has been significantly enhanced to facilitate natural gas flows.

The gas system now has seven main interconnection points (import capacity of around 2335GWh / day) and LNG terminals located on three seaboards (import capacity of around 1160GWh / day), providing access to diversified gas sources: the North Sea, Russia, the Netherlands, the Maghreb, but also more generally the international market for liquefied natural gas (LNG).

In mainland France, gas flows are ensured through a mesh of transmission and distribution networks that work in synergy with natural gas storage facilities. With the completion of the Val-de-Saône and Gascogne-Midi projects, the natural gas circulation capacities within the French gas system are considered sufficient to allow for the implementation of a single market, reality since 2018, November 1st.

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 sought.

This optimisation of the use of existing infrastructures relates particularly to underground gas storage infrastructures. Article L. 421-3-1 of the Energy Code therefore provides the definition, within the Multi-Year Energy Plan, of the storage facilities that guarantee medium- and long-term supply security.

Over the period covered by this Multi-Year Energy Plan, the natural gas import infrastructure is not expected to be disrupted. Uncertainty about the future use of the Fos-Tonkin terminal, in the event that the 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 provided in full by the single terminal of Fos-Cavaou.

The main expected change in the gas system relates to the gradual conversion from the low calorific gas (so-called L gas) network to the high calorific gas (called H gas) network. The roll-out of this conversion requires that all of Gournay's storage infrastructure be reserved for the storage of L gas until 2025, despite the gradual decline in consumers supplied with this quality of gas. The future of the two pipes that make up the Taisnières B interconnection point is uncertain at this moment, the options being conversion to H gas transmission and abandonment.

Focus on underground storage of natural gas

Over the period covered by the Multi-Year Energy Programme, natural gas underground storage infrastructures will continue to play a key role in ensuring continuity of delivery over the networks, 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 European Union Member States or to Switzerland.

The Multi-Year Energy Programme confirms the outlook for a fall in natural gas consumption, but there is uncertainty about the pace of this decline. In addition, 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 infrastructure 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 the demand.

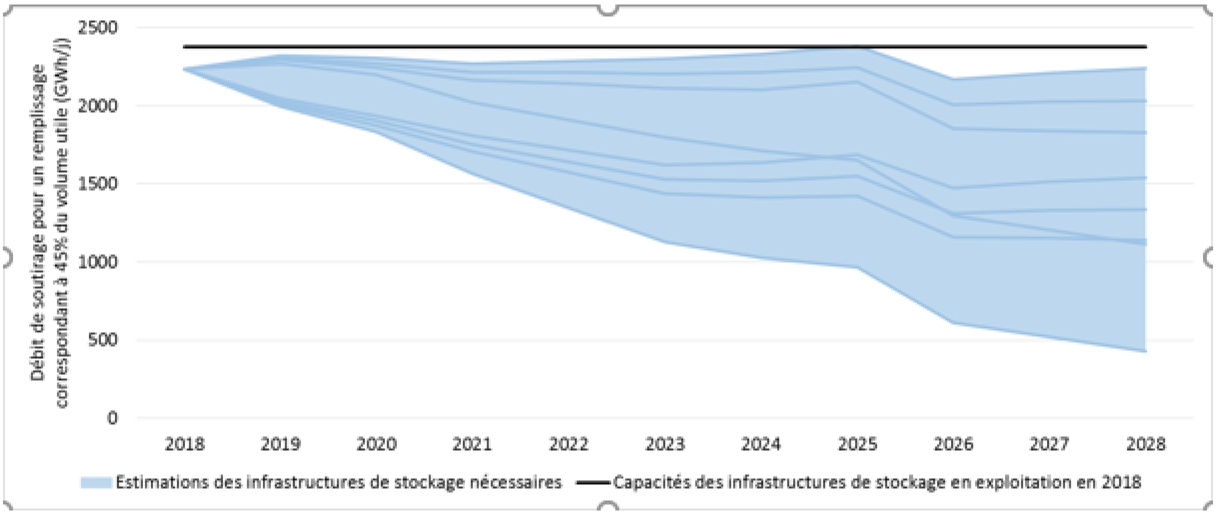


Figure 63: Estimation of the underground storage capacities needed to ensure the network's ability to meet demand, including L gas and back-up stocks.

Over the next ten 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 range of uncertainty as of 2023 involves keeping the underground storage infrastructures currently being used in operation for this timeframe.

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 138.5TWh and an extraction capacity of 2376GWh / day, which meets 45% of the usable volume needs:

Infrastructure	Operator	Year implemented	Type of storage
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

Table 39: 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 140GWh / 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 MAEP 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.

Measures:

- Keeping the 11 sites currently operational until 2023 (volume of 138.5TWh and extraction capacity of 2376GWh / day);
- Recommissioning the three mothballed sites (representing 7% of capacity) within the scope of the regulation;
- Not developing new storage sites within the scope of the regulation;
- In 2023, confirming the evaluation of the storage capacity necessary for post-2026 supply security and, in the next MAEP, identifying the underground natural gas storage facilities that would no longer be essential 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 140GWh / day (6%).

5.2.4. 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, reducing supply to certain consumers by the network operator to which they are connected;

- If these measures are not sufficient to maintain the supply to domestic consumers and essential social services, set up a call for European solidarity.

Interruptibility of natural gas consumption

The Energy Transition for Green Growth Act provides for the possibility of putting interruptibility schemes in place so that certain consumers can sign up with network operators to reduce their consumption if necessary. In order to achieve flexibility of approximately 5% of consumption in a cold snap, development of interruptibility of natural gas consumption of at least 200GWh / day is envisaged by 2023.

Load shedding and natural gas consumption

Insufficient gas at a point in the network can lead the manager of this network to reduce the supply to certain consumers. 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 contacts the natural gas consumer directly to ask them to reduce or suspend their natural gas consumption. The effectiveness of the load-shedding device therefore depends on whether or not the consumer in question complies with the load-shedding order. In order to reinforce the efficacy of the load-shedding procedure, clarification of the legislative and regulatory framework will be undertaken until 2023.

Calls for European solidarity

Regulation 2017/1938 of the European Parliament and of the Council provides for the setting up of a European solidarity mechanism in the event of a gas crisis. In extreme situations, if the demand of 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, Belgium, Germany, Italy or Spain could use this mechanism, which would lead to the loads being curtailed for industrial consumers, with the payment of compensation. The procedures involved in this European solidarity mechanism will be specified by 2023.

Measures:

- Developing the interruptibility of natural gas consumption by at least 200GWh / day by 2023;
- Clarifying the legislative and regulatory framework for natural gas consumption load shedding.

5.3. Security of electricity supply

The aim of the security of the electrical system is to avoid localised blackouts or blackouts on a larger scale. The security of the electrical system is based on two different building blocks:

- *Electrical system reliability* refers to the capacity of the electricity grid to convey electricity from producers to consumers, including maintaining infrastructures in working condition and performing short-term grid balancing operations. Events that result in large-scale power cuts, such as large storms or network imbalances due to an incident abroad, are relevant to electrical reliability. The associated issues will not be addressed in this document;
- *The security of electricity supply* is a balance between supply and demand: at every moment, the amount of electricity consumed must match the amount produced and injected into the grid, with the knowledge that production and consumption are vulnerable to hazards. This adequacy covers both operational management and the long-term. It involves management of two types of phenomena:
  - Surpassing consumption peaks which, because of the thermosensitivity of electricity consumption in France, require the availability of sufficient reliable and available production or curtailment capacity, during these periods;

- The management of rapid fluctuations in supply and demand, which requires that there be sufficient flexibility levers in the electricity system to compensate for them. These levers are demand management, storage, interconnections, and controllable production units.

The criterion of supply security responds to a probabilistic approach based on the development of the levers.

This section examines the different determinants of electricity supply security and how to ensure it satisfactorily.

5.3.1. The criterion of supply security

The RTE's annual electricity supply and demand balance forecast[63] is the benchmark used to assess the risks to the security of electricity supply in France. The most recently published assessment includes an in-depth study of the supply-demand balance over the next five years. This study quantifies the average disruption duration, analyses risk scenarios and evaluates the electricity generation or curtailment capacities needed to ensure the security of electricity supply.

Article D. 141-12-6 of the Energy Code sets the disruption criterion of the electricity system at "an average annual disruption duration of three hours due to imbalance between electricity supply and demand". However, the Energy Code does not explicitly define what is meant by the notion of "disruption". The definition used by RTE to build its models refers to situations in which the normal operation of the market no longer makes it possible to ensure a balance between supply and demand. The transmission system operator must then resort to exceptional contractual or non-contractual levers, as presented in the following figure:

Figure 46: Disruption situations – Source: RTE, 2018

63 . Electricity supply-demand balance forecast: https://www.rte-france.com/fr/article/bilan-previsionnel

The disruption expectation is calculated based on the definition provided by RTE by devising a range of scenarios that take particular account of temperatures, interconnections and the production risks faced in different sectors. In the models produced by RTE, a [64]disruption expectation of three hours per year represents a consumer cut-off expectation of less than two hours[65].

Box 9: Electricity supply security criteria used by other European countries

At the European level, other Member States use the supply security criteria reported in the table below.

Country	Criterion
Germany	No explicitly mentioned criteria. Strategic reserves and storage capacity with strict control.
Belgium	Disruption expectation of under 3h / year on average. Disruption expectation of less than 20h / year in the 5% of worst cases (for meteorological or other reasons).
Denmark	No criteria.
Spain	10% capacity margin in extreme peak demand situations.
France	Disruption expectation of under 3h / year on average.
Ireland	Disruption expectation of under 8h / year on average.
Italy	No criteria. Annual report to the State by the Transmission Grid Manager of a list of essential facilities.
Luxembourg	Criterion n+1: The loss of any element of the HV network must not lead to a loss of consumers.
Poland	Target capacity level.
United Kingdom	Disruption expectation of under 3h / year on average.
Switzerland	No criteria, one definition: "Ensure a sufficient grid capacity reserve".

Table 38: Disruption criteria – Source: CGEDD-CGE report, 2018

The European Commission, in the "Clean Energy for All Europeans" package of 30 November 2016, expressed its intention to start the harmonisation of security criteria, notably by using the value of undistributed energy. A cut-off is counted from the time at which the consumer is cut off. Not a general blackout but the use of rotating load shedding, the implementation of which is governed by the decree of 5 July 1990, setting the general guidelines for load shedding on electricity networks.

At the same time, discussions have started in France on a possible change to the criterion or a revision of its value. Thus, in April 2017, the General Council of the Economy (CGE) and the General Council of the Environment and Sustainable Development (CGEDD) were commissioned to conduct an audit of the difficulties encountered in the supply-demand balance and to propose changes to these criteria. In fact, the winter of 2016-2017 was characterised by lower availability of nuclear facilities and import capacities that were temporarily curtailed. However, load shedding or the use of exceptional means were not necessary as a result of less severe temperatures than announced.

64 . In the mathematical sense of the term.
65 . A cut-off is counted from the time at which the consumer is cut off. It does not refer to a general blackout.

The measures introduced by the MAEP make it possible to capitalise on the conclusions of this work, by proposing 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.

Measures:

Confirming the current supply security criterion and clarifying its content by specifying that:

- "Disruption" means the use of exceptional contractual and non-contractual means and that the duration of the disruption must not exceed three hours per year on average;
- That in these disruptions, the expectation of cuts in supply to end consumers, due to supply-demand imbalances, shall not exceed two hours per year.

Continuing the work for better consideration in these criteria of the number of customers cut and not only the duration of the cut.

Contributing to the harmonisation of the criteria used by the Member States in defining their objectives for the security of electricity supply.

5.3.2. Controlling and surpassing consumption peaks

In mainland France, the main risk to the security of electricity supply is that of peak winter consumption. Demand peaks occur during cold snaps that far exceed average power consumption: power demand then increases by about 2.4GW for every 1°C drop. To date, the maximum power demand at national level was 102.1GW, reached on 8 February 2012, during an exceptional cold snap.

The national production infrastructure and all means of flexibility 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 another, depending on the severity of the climate, as shown in the following figure.

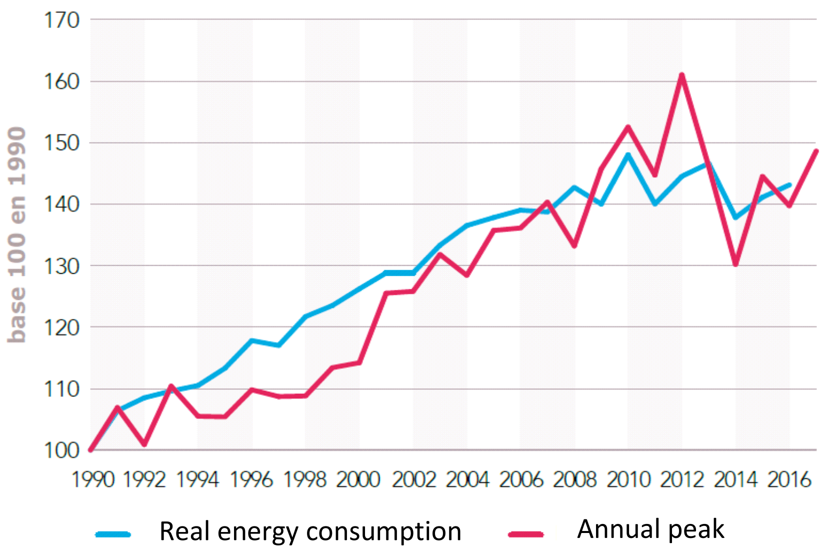


Figure 65: Evolution of annual electricity consumption and peak demand – Source: RTE, 2018

The long-term evolution in peak electricity demand depends essentially on the evolution of thermosensitive uses of electricity, foremost among which is electric heating. The implementation of the 2012 thermal regulations led to a decrease in the market share of electric heating in new collective housing as well as 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 evolution of electrical peak consumption will largely depend on the pace of energy retrofits of buildings, but also on the evolution of 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 detailed below.

Given these developments, in the coming years the evolution of peak consumption should reach that of total electricity consumption while remaining extremely thermosensitive.

Measure: Accelerating the decrease in peak electricity consumption:

- By encouraging heating means that do not contribute (or contribute less) to it;
- By developing flexibility of demand.

The capacity mechanism

In order to ensure compliance with the disruption criterion and ensure that demand peaks can be managed, through the NOME law, France set up a capacity obligation mechanism, as of 1 January 2017. The principle of this capacity mechanism is based on the obligation for each electricity supplier to provide evidence that the consumption of its customers can be covered in all situations in which the system seeks to cover itself, 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 results from calculations made by RTE, following a methodology consistent with the work carried out as part of the forecast. Capacity guarantees are released by RTE for production and curtailment capacities, during a certification process, throughout which a commitment is undertaken, in respect of these capacities, to their future availability during peak periods of the year in question. In order to meet their obligation, suppliers can therefore:

- Use the guarantees they hold based on their own means of production or curtailment; or,
- Obtain curtailment or production capacity guarantees from other operators.

Certificate swapping in a "capacity market" enables suppliers to cover their obligation at the best cost, by selecting the most competitive capacities, and it discloses the price of the capacity transparently.

The energy market ensures optimisation of the use of the production and curtailment capacities of the various players, but its free operation would not guarantee compliance with the supply security criterion. The addition of the capacity market to the energy market ensures this.

The implementation of the capacity mechanism on 1 January 2017 required approval by the European Commission, which considered that the capacity mechanism, like all capacity mechanisms implemented within the Union, was covered by European legislation on State aid. The approval of the scheme by the European Commission was conditional on France's commitment to:

- The introduction of an annual call to tender, to guarantee a fixed capacity price over seven years for new capacities, in order to promote – when economically advantageous – the market entry of new production or curtailment capacity. The calls to tender will be conducted in such a way as to ensure an economic benefit for consumers and to minimise the impact of these long-term contracts on the operation of the current system. They will be accompanied by stringent environmental conditions;

- Continuing the ongoing work on opening the French capacity mechanism to cross-border capacity, so that by 2019 the foreign contributions of the Member States it borders will be explicitly taken into account in the French system, rather than implicitly as before.

The development of these commitments will require agreements to be signed between the French electricity transmission grid manager (RTE) and its European counterparts, to implement the essential cooperation procedures for the coordination of different crisis management approaches. The review of this mechanism is also an opportunity for initial feedback, following its launch in early 2017.

Measure: Consolidation of the operation of the capacity mechanism by developing the commitments to the European Commission and by gathering initial feedback following the launch of the mechanism.

5.3.3. A European problem

The role of interconnections in supply security[66]

The construction of cross-border interconnections has historically been a response to a supply security rationale and the use for export of French electricity production surpluses, especially at night and in summer.

Interconnections offer the opportunity to import electricity from a neighbouring country in the event of a strain on the national supply, which is an economically efficient solution. Indeed, interconnections mean that France does not need to invest in additional capacity to ensure its supply security and this facilitates 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 10GW. In the medium-term, the planned developments will lead to an increase in import capacity from 11GW for winter 2016-2017 to 13GW for winter 2020-2021. Two of RTE's 2017 forecast scenarios assume a significant expansion of interconnections that will provide 27GW of import capacity and 33GW of export capacity by 2035.

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. Today, with an average import / export interconnection capacity of 15GW, France has 11.5% interconnection with its neighbours. By 2030, it is expected to exceed 26GW of interconnection, to reach at least 16.5%. The detailed issues relating to interconnections, as well as the list of ongoing projects, are outlined in section 5.6.4 on electricity grids.

European cooperation

European cooperation on supply security is taking shape in France through participation in the Pentalateral Energy Forum (or Pentaforum) – a regional initiative launched in 2005 to streamline electricity exchanges through 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 between its seven member countries (Austria, Belgium, France, Germany, Luxembourg, the Netherlands, Switzerland) through effective dialogue and good coordination between governments, networks 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);
- Carrying out an electricity crisis coordination exercise with all stakeholders in each Pentaforum country. This exercise is part of the sharing of best practices for the implementation of European regulations in force and in the process of development;

66 . See the chapter on “Electricity Grids”.

- The 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 production costs in the countries concerned, but also helps to improve supply security.

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.

Finally, Regulation 714/2009/CE provides for the development of network codes, which 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 will apply from December 2018. In particular, it will provide benefits through the harmonised technical management of electricity crises at European level. A second network code, established based on a guideline for the operation of the electrical system, provides for a harmonised approach both to the running of the transmission networks in normal operation as well as in a stressful situation (cold snaps, for example).

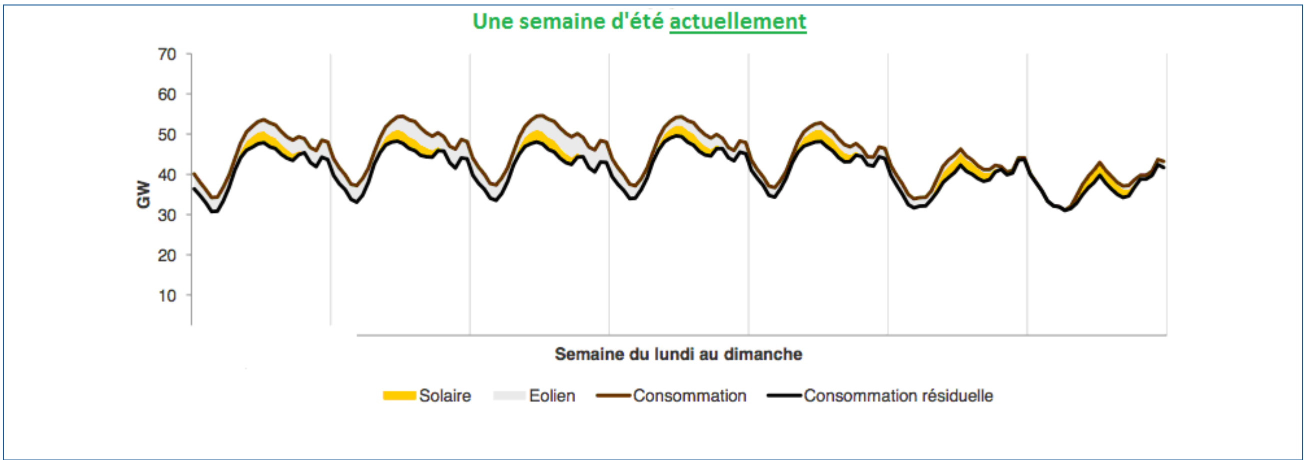
Measures:

- Continuing active regional cooperation in the area of supply security, particularly through participation in the Energy Pentalateral Forum and discussions with the Iberian peninsula;
- Implementing the network code on security and the restoration of the electrical system.

5.3.4. Impacts of changes in production infrastructure on supply security

The rise of renewable energies

The French electricity system is today sufficiently flexible in its current operation to be able to respond to short-term fluctuations in supply and demand, at hourly, daily or weekly levels. But in the long-term and beyond the timeframe of the MAEP, 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 forecast report on the balance of electricity supply and demand in 2015 were 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 photovoltaics create a need for hourly and daily flexibility.



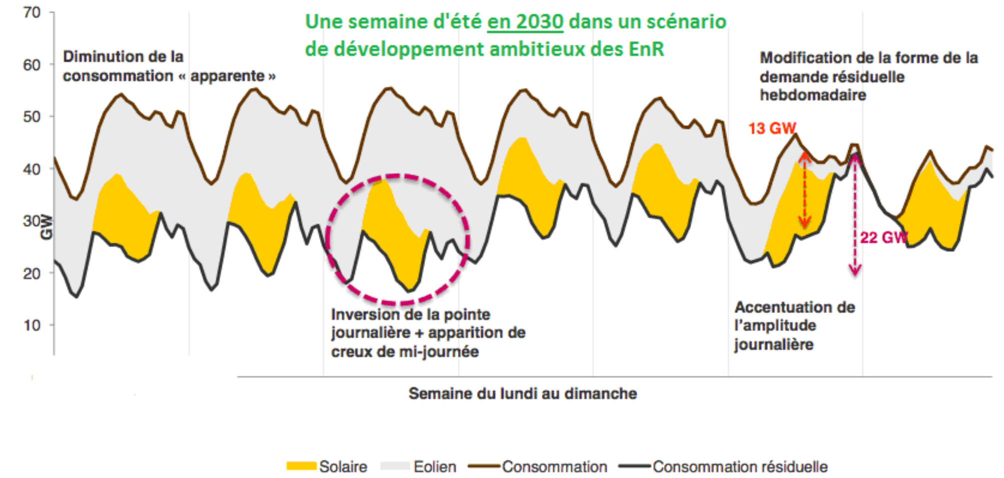


Figure 66: Illustration of electric demand variability and residual demand today and in a scenario of strong development of renewable energy in 2030 – Source: RTE, 2015

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 67GW of wind power (including 15GW of offshore wind) and 48GW of photovoltaics for the Ampere scenario; and 50GW (including 10GW of offshore wind) and 36GW respectively for the Volt scenario. These installed capacity levels for wind and photovoltaic power are of the same order of magnitude as the whole of the French electricity infrastructure in 2018, all sources combined, which is 101GW.

These massive developments of non-controllable capacities should change the pace of residual consumption, i.e. the net electricity consumption of so-called secondary renewable energy production. 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 residual demand at weekly level has changed.

In the two Ampere and Volt scenarios, the high levels of solar and wind power production in summer supplies exports, which reduces the need for the development of flexibility at national level. Occasional dumping, i.e. when production fails to find outlets in France or export, appear by 2035.

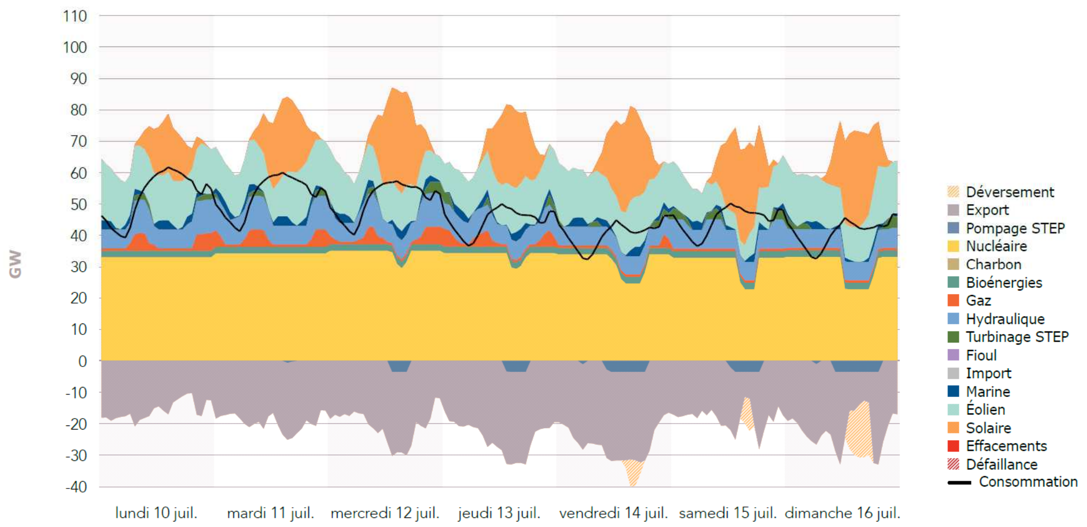


Figure 67: Illustration of production, consumption and exports in a summer week in 2035 (Ampere scenario) – Source: RTE, 2017

Other sources of renewable energy have characteristics that are generally beneficial for supply security. In addition to hydraulics with Pumped Energy Transfer Stations (STEPs) and hydraulics on lakes, which are already essential sources of flexibility for the electrical system, pondage production has a regular production profile with room for manoeuvre to vary production at intraday level. ROR production provides no flexibility, but does offer a regular production profile.

The production of electricity by cogeneration from solid biomass or biogas has a basic production profile (production that is substantially constant throughout the year) or a semi-basic production profile. Like hydraulics, they even offer a certain intra-day flexibility to help them achieve the supply-demand balance.

The analyses carried out by RTE in its forecast report conclude that the integration of significant renewable energy capacities (more than 100GW installed by 2035 in Ampere) will not require the development of new flexibilities to ensure balance between supply and demand. Nevertheless, this development of non-controllable electric renewable energies raises new challenges that can be addressed using all the existing flexibility levers, including flexibility of demand, storage and interconnections.

The scenario selected by the government in the context of the MAEP leads to wind energy levels of 34.1 to 35.6 GW, and photovoltaics of 35.6 to 44.5 GW in 2028. According RTE studies, levels do not require additional flexibility.

Other countries, including European countries, have much higher variable renewable energy penetration rates than in France, but without suffering disruptions due to supply-demand imbalances (see the example of Ireland below).

The closure of fossil thermal production plants[67]

In 2016, French electricity generation facilities still included 6.67GW of oil-fired electricity production capacity and 2.93GW 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. 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 at the end of 2017 by RTE and updated in 2018 confirmed the possibility of closing the last coal-fired power plants by 2022, while respecting supply security criteria both at national and local levels.

5.3.5. 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 needs of HVAC. Furthermore, the target of achieving carbon neutrality by 2050 is encouraging the transfer of certain uses of electricity in transport and in industry. The development of electric mobility could, in particular, 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 charge of electric vehicles (regulatory, economic, tariffs, etc.) in order to smooth consumption and limit impacts on the network and the electrical system.

67 See chapter 3.4.9. Fossil thermal facilities

Curtailment of consumption: A useful lever of flexibility for the electric system

The Energy Code defines electricity consumption curtailment as action targeting particular consumers for temporary reduction, upon request, of their level of extraction from electricity transmission or distribution networks, compared to a forecast schedule of consumption or estimated consumption.

Curtailments help to balance the whole electrical system in real-time, by using short mobilisation delays. Curtailments are intended to replace peak production means such as thermal power plants during peak winter consumption. It 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: the Energy Code therefore 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 or EJP or TEMPO rates. The abandonment of certain tariffs (blue EJP tariff since 1998 and blue business tempo from 2004), as well as the end of the yellow and green regulated sales tariffs on 1 January 2016, 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 progressive deployment of the Linky meter by 2021, which will enable energy suppliers to offer, based on the features offered by this meter, different deals based on times, days and seasons, including the incorporation of moving peaks. This possibility of offering differentiated deals is further reinforced by the integration in TURPE 5 of hourly / seasonal slots and even, for certain voltage levels, a mobile peak signal as is the case for business customers with medium voltage connections.

- *Alternatively, the consumer's supply is curtailed through the action of a curtailment operator* that offers a service that is separable from a supply offer.

Recent years have also been marked by a growth in the 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 price these curtailment capacities over the different time periods of the electricity markets; the aggregation allows for a proliferation of capacities and economic optimisation at the hands of the operators who 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 by interrupting a manufacturing process, shutting down refrigeration systems in tertiary warehouses, or using a local means of electricity production (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 the market mechanisms to curtailment, so that they can participate in the same way as the power generation facilities.

Industrial curtailments (since 2003) and diffuse curtailments (since 2007) can be part of the adjustment mechanism operated by RTE, which aims to ensure a real-time supply-demand balance and a secure grid operation. In 2017, about 27GWh of curtailment was activated on the adjustment mechanism, for an average capacity of 726MW deposited on the adjustment mechanism.

Curtailments can also be part of the various reserves procured by RTE for balancing the system[68]:

- Participation in system services (so-called "primary" and "secondary" reserves) for sites connected to the transmission network since the launch of an experiment on 1 July 2014. In 2017, the primary reserve had about 80MW of curtailment (almost 15% of this year's reserve);
- Participation in rapid and complementary reserves since 2011 with a gradual increase in opening, which made it possible to reach curtailment capacity participation of up to 500MW in rapid and complementary reserves in 2017 (50% of the rapid reserve).

Since 1 January 2014, curtailments can also be exchanged between market players in the energy market via the so-called "NEBEF" mechanism. Thus, for an electricity supplier, the purchase of 1MWh of electricity produced and 1MWh of curtailed electricity are strictly equivalent. In 2017, nearly 40GWh of curtailment was exchanged via this mechanism.

Finally, curtailments can participate in the capacity mechanism, which has been operational since 1st January 2017.

In addition to these market mechanisms, the Energy Transition for Green Growth Act has also provided for the possibility of calls to tender to develop France's current curtailment capacity, in order to meet the objectives set in the MAEP for the development of flexibilities. The implementation of this system required the prior validation of the scheme by the European Commission, under the State aid regime; an approval procedure during which the Commission wanted competitive criteria to be put in place to ensure the competitiveness of the calls to tender 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 made it possible to secure the completion of annual calls for tender, whose volume targets for each year are recalled below.

Objective trajectory (in MW)	Annual volume of curtailment	Including category >1MW	Including category <1MW
2018	2200	1900	300
2019	2500	2000	500
2020	2900	2100	800
2021	2000	1000	1000
2022	1800	500	1300
2023	2000	500	1500

Table 40: Target volumes for each call to tender

In total, for the year 2018, the volume of curtailment capacity available to ensure supply security during peak periods can be estimated at 2700MW. This corresponds to about 2000MW of certified curtailment capacity, plus about 700MW of curtailment performed by the suppliers.

Current curtailment pool and outlook for development of the sector

The figure of 2700MW of curtailment capacity existing in France is to be compared to the pool that it is technically possible to develop and economically important to establish. This achievable pool depends on

68 To ensure the success of its system balance tasks and to ensure 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 paid to make the capacities in question available (irrespective of any request).

several factors, including 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 MAEP exercise, several studies – published in 2017 – were conducted to assess curtailment development prospects in France:

- The ADEME[69] study which specifically addressed industrial and tertiary curtailments;
- The RTE study[70], which, continuing the first works on the smart grids in 2015, proposed to establish appropriate development targets for the different sectors of curtailment (diffuse, tertiary and industrial) up to 2030.

This work lead to the following observations:

- The value of the curtailments is largely capacity-related (according to ADEME 95% of the revenues of the sector are capacity-related);
- The continued diversification of the electricity mix will reinforce the development opportunities of the sector.

  In view of the results of the ADEME and RTE studies, the figure of 5GW of industrial and tertiary curtailment capacities (including interruptible capacity) represents a high threshold: this amount, according to ADEME, represents the upper range of the economically achievable pool with a remuneration of €60K / MW[71], and is confirmed by RTE's estimates for 2030[72]. Also based on the analyses of the transmission system operator, at present, the economically relevant pool would be close to 3GW. For diffuse curtailment, by 2030, the RTE study envisages a potential:

  - 300,000 households, large consumers, equipped with real-time consumption management devices;
  - Coordination of different uses – including heating – via communicating meters: with 7 million households for the 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 1.5GW by 2030 seems consistent. In total, this is therefore a target of 6.5GW of curtailment capacity – unchanged from the previous MAEP – by 2028.

It is proposed to adopt a smooth approach for the transition point for 2023 , lowering it at 4.5GW in order to have an increase trajectory of the sector to this objective by 2028.

This re-phasing in reaching the target envisaged for 2028 – which does not call into question the role that the sector will need to play in the long-term – can be explained by:

- An initially optimistic view of the need for new capacities by 2023, which, although not materialised, did not justify the economic development of curtailment at the pace anticipated in the first MAEP;
- An issue of technical consolidation and enhancement of the reliability of the sector, which has led to the elimination of a certain amount of capacity formerly offered by curtailment operators, on the basis that they did not meet legitimately expected reliability standards[73];
- An issue of changing the support framework for curtailment, in order to best meet the expectations of the industry.

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69 . Electrical curtailment in France – Evaluation of curtailment potential by process modulation in industry and tertiary in metropolitan France, ADEME, 2017.

70 . Smart grids: Economic, environmental and overall deployment value, RTE, June 2017.

71 . Pool for the "high" scenario, with remuneration of €60K / MW.

72 . See the conclusions of the above-mentioned RTE study on the development outlook, for 2030, for industrial and tertiary curtailment capacities.

73 . Presentation on consumption curtailments during the CURTE market access commission, organised on 27 January

The framework in which the curtailment call to tender is made is the result of negotiations with the EC competition authorities; they imposed 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 may be envisaged to take account of the results of the first two calls to tender (2018 and 2019), which will require the mobilisation of the various stakeholders (State services, ADEME, and CRE, RTE and ENEDIS, the curtailment players, etc.).

These adjustments must be compatible with European Community law on State aid, which for some may require exchanges with the services of the Commission.

The current MAEP exercise confirms the objective of 6.5GW by 2028, by making a smooth transition point in 2023 credible by reducing it to 4.5GW.

Measures:

- Promoting the use of such flexibilities in industry and tertiary;
- Targeting support for curtailments achieved by postponing or foregoing consumption by abolishing support for curtailments made from generator groups from 2020;
- Changing the estimation of curtailments, including the methods used to control curtailments, to take account of the variety of curtailments;
- Improving and simplifying the support framework for curtailments to best meet the needs of the sector, in compliance with European Community law on State aid;
- With ENEDIS and ADEeF, increasing the options for use of demand modulation to manage local problems with the operation of distribution networks;
- Encouraging suppliers to develop deals promoting flexibility, by taking advantage of the new potential offered by communicating meters.

5.3.6. Electricity storage

Electricity storage provides a response to the issues raised by the variability of production and consumption. Storage makes it possible to flatten production peaks and transfer energy to consumption peaks at different timescales (ranging from a few seconds / 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 production (e.g. smoothing, load monitoring, displacement of production, market arbitrage);
- Electricity transmission and distribution: participation in system services according to network codes, arbitrage with the construction of new lines, optimisation of network management, voltage control and distribution security;
- Consumption: decrease in peak consumption, continuity of supply, self-consumption or even energy autonomy in isolated sites.

At present, the law does not set any target for electricity storage.

State of the art in technologies

At present, there is a large number of electricity storage technologies, each with various costs, maturity levels, and technical characteristics of power, energy, response time, charge-discharge interval times and different energy densities targeting centralised, distributed or diffused storage markets. By providing responses to different services, technologies thus offer a certain complementarity with each other. Energy storage solutions fall into three main categories:

- *“Mechanical” storage:*
  - Facilities using potential mechanical energy such as Pumped Energy Transfer Stations (STEPs), hydroelectric dams, 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 / minutes) or short-term storage (a day, for example);
  - The hydrogen produced by electrolysis is considered a means of inter-seasonal storage via 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: Evolution of price of batteries Li-ion between 2004 and 2016 and perspective towards 2025

Source: BNEF, DGEC

State of the art of storage in France

Pumped Energy Transfer Stations (STEPs) and hydroelectric dams are currently the major large-scale storage solutions in France (4.3GW STEPs and 13GW hydro with reservoir). It is estimated that there is still a potential of around 2GW in mainland France for this technology. STEPs today are still the only “economically competitive” means of storage, while under current market conditions it is not possible to achieve a return on a new investment without short-term aid. There is a further 13 to 20TWh of thermal storage in hot water tanks.

The development outlook

In electrical 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 supercapacitors, are useful to compensate for a possible drop in frequency, and even faster so that the system will have less inertia with increased development of photovoltaic or wind power;
- Short-term (day-to-day) means such as batteries or STEPs, enable the evening peak to be managed, 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" storage means to which STEPs can respond, as can other storage technologies such as hydrogen, compressed air energy storage and certain forms of thermal storage.

The needs in each of these types of storage are intrinsically linked to the planned electricity mix for mainland France, but also to that of our European neighbours.

By 2028, within the timeframe of the MAEP, with the expected penetration of renewable energies, there will be no additional storage needs to ensure the supply-demand balance. The mainland electrical system, which is integrated in 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 forecast:

- In the Volt scenario (40% renewable energy and 56% nuclear in 2035, i.e. 55GW), the flexibilities on consumption are sufficient to meet the flexibility needs of the electricity system. The characteristics of the system as envisaged by RTE do not predict a possibility of making a return on investments in storage.
- In the Ampere scenario (50% renewables and 46% nuclear power in 2035, i.e. 48.5GW), the need for new flexibilities is also low by 2035 and can likewise be provided by curtailment. Storage remains a less competitive solution for this timeframe.

RTE's analyses indicate, however, that this lack of 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 and reach 38.5GW in 2035, additional flexibility is needed. RTE is considering the following flexibilities: +3.5GW of curtailment, +2GW of new STEPs and +2GW 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 require new flexibility requirements beyond the MAEP to meet the supply-demand balance of the electricity system. Given the time needed to launch certain investments or to develop certain sectors, it is necessary to implement actions during the MAEP.

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 ten years) and insofar as these decisions must be incorporated into the concession award procedures. A development potential of 1.5GW 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 it in view of the expected daily and weekly needs of the electric system from 2030 to 2035.

Moreover, in addition to hydrogen (partly addressed in 3.3.3), several uses already suggest the development of battery storage by 2028, in connection with the rapidly observed decline 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 reaction times). However, the accessible market potential remains limited (competition with means of production and curtailment, total reserves of less than 2GW);
- Development of batteries can also be expected with 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 battery of the vehicle is used as a means of flexibility (charging or discharging) when the vehicle is connected to the charging terminal;
- Finally, storage could also avoid or defer investments for network reinforcement in order to avoid local congestion when renewable energies are producing at the same time in grid-constrained areas, thus avoiding the need to cap them.

Box 11: Virtual line experiment

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 tested batteries have a capacity of 12MW for 24MWh at each site. The experiment 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, production / consumption adjustment, congestion resolution, etc. The use of batteries, instead of grid reinforcement, might therefore find an economic space during the period covered by the MAEP.

Measures:

- Launching, during the first period of the MAEP, the procedures for the development of the STEPs for a potential of 1.5GW identified for the commissioning of the installations between 2030 and 2035;
- During the first MAEP period, setting up the framework for rolling out the development of virtual lines using battery storage facilities, to avoid grid reinforcements and capping of renewable energies, by 2028;
- Continuing upstream R&D or demonstration efforts (e.g. a programme of future investments for demonstrators, a single inter-ministerial 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 enable the share of renewable energy in the electric mix to continue increasing.
- Linked with sectors committees, envisage the possibilities to develop a French production sector of batteries and give an ambitious plan with all parameters of storage by mid-2019;
- Given the existing possibilities, studying the interest of the reuse of saline cavities for the storage of hydrogen.

5.3.7. Supply security issues in 2028

RTE's forecasts on the supply-demand balance

In its 2017 forecast report, RTE undertook a major forecasting exercise, by presenting five electricity system scenarios with assumptions relating to production, consumption, flexibility and interconnection means, by 2035, with milestones at 2025 and 2030.

All scenarios show stagnation or decline in annual electricity consumption, even in the case of a significant development of electric mobility. Indeed, in all scenarios, the downward effects of energy efficiency equal or exceed the upward effects associated with transfers of use. This decrease makes it possible to release long-term margins for manoeuvre in terms of supply security. The scenarios also show that it is possible to achieve renewable electricity production in excess of 40% without jeopardising the electrical system in 2035.

The recent closure of oil-fired power plants and the prospect of the closure of coal-fired power plants by 2022 with a gradual increase in renewable energies make the 2018-2020 period the tightest period in terms of supply security.

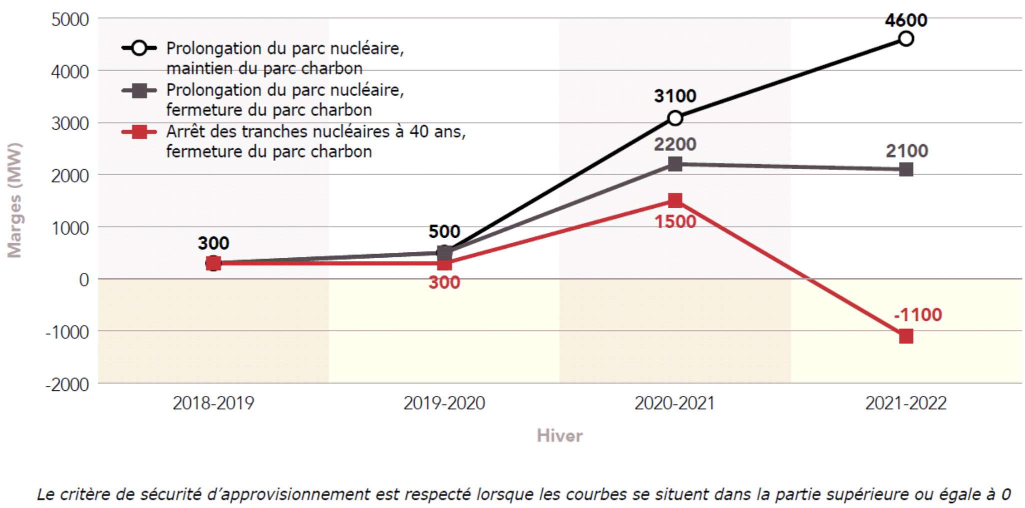

Figure 68: Evaluation of the impact of closing nuclear plants and coal facilities on supply security (Source: RTE)

From 2020, the simultaneous closure of coal-fired power plants and nuclear plants within 40 years would lead to failure to meet the criteria, unless there is massive development of new means of production in a very short time. The development of thermal means would generate greenhouse gas emissions and the long-term profitability of these means is not guaranteed due to the development of renewable energies in France and in Europe, which will continue beyond 2025.

More long-term, the nature of the risks to supply security changes with the development of renewable energies: episodes of strain can be less long-lasting and may involve smaller volumes of energy, but can happen more often and especially outside winter periods. These forecasts confirm the need for the development of flexibilities and interconnections to ensure long-term supply security, benefitting from the proliferation of renewable energies at European level.

The scenario of the government take into account all the constraints and propose a calendar for coal power plants and nuclear reactors closures in order to guarantee the security of supply.

The participation of nuclear in supply security

Around the world, nuclear reactors operate most often 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 respect of the fuel when a reactor is shut down, unlike fossil fuels.

Conversely, in France, nuclear plants were designed to operate in load monitoring mode and to thus continuously adjust the production of electricity for consumption. Today, the average load factor of the French system is therefore relatively low when compared to other international references: it is in the order 72% in France while the facilities of the Exelon operator in the United States United has, for example, 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 to such an operation.

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 enhanced benefit from the flexible capacities of our European neighbours for our own supply security.

Interactions between the supply security of electricity and gas

The electrical and gas systems are interdependent:

- During cold snaps, gas and electric heating are 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 PACA where the electricity network is limited, making the operation of some gas plants necessary. Today, gas supply to power plants can be interrupted under the interruptibility clauses of their supply contracts

The existing coordination between GRTgaz / Téréga (formerly TIGF) and RTE needs to be deepened to examine, more specifically, 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 in the day than gas demand, and that load shedding can be more easily implemented, locally and rotating, for electricity.

Measure: Enhancing cooperation between the operators of the gas and electricity transmission networks on the risks to the electrical system in times of stress on the gas system, and setting up procedures for managing these common disruption modes.

5.4. Uranium security of supply

Regarding the needs for nuclear-based power generation, the French nuclear system uses various types of uranium-based nuclear fuels (UOx, MOx or ERU). EDF, which operates the entire French nuclear reactor fleet, is responsible for the uranium security of supply..

The needs for uranium mainly depend on:

- The evolution of the nuclear installations and their operating methods;

- The spent fuel recycling strategy, particularly with the use of "MOx" fuel, which enables to reduce the supply of natural uranium.

EDF's consumption for the French nuclear industry represents around 8 000 tons of natural uranium per year, about 13% of the world's consumption of around 62,000 tonnes (2016 data).

Global conventional resources are estimated at 7.6 Mt and represent a resource-to-production ratio of more than 120 years at constant consumption. These resources are well distributed geographically throughout the world, notably between Australia (1.8 MtU), Africa (1.6 MtU), Central Asia (1.4 MtU), North America (1.1 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 €22 per pound.

To bolster its supply security, EDF uses several levers:

- The 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) from six different suppliers;
- Long-term contractual certainty for EDF: EDF's needs for each cycle stageare generally covered for about ten 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 reactors of the French nuclear fleet over several years, thus responding to the risk of supply disruption.

However, the supply of uranium is not the only issue for supply security: the robustness of industrial processes for fuel fabrication and the storage capacities associated with these activities can also be critical. Indeed, a long disruption of some plants in the cycle, or the saturation of spent fuel storage capacities could lead to a forced temporary shutdown of some nuclear reactors in the whole country.

Measure: Ensuring the legal obligation of EDF to build a uranium stockpile for the operation of its nuclear power plants, as well as optimal operational conditions for the fuel cycle facilities and the availability of suitable storage capacities.

Box 12: The "resource" issues of the Multi Annual Energy Plan and the energy transition

Climate change and resources: A double link

Using fewer natural resources and using them better and for longer helps to reduce greenhouse gas emissions and therefore combats climate change. The International Resource Panel (IRP) has developed scenarios for reducing natural resource consumption based on a change scenario taking account of current trends. The "Efficiency +" scenario combines ambitious policies for the efficient use of resources and for combating climate change in order to keep the temperature rise within 2°C. In this scenario, the annual economic benefits amount to more than $2 trillion by 2050 compared to the trend scenario. The deployment of infrastructures for wind and solar generation, for storage and distribution and greater use of biomass, the development of electric mobility, as well as improved energy efficiency (insulation of buildings, increased use of digital, roll-out of LEDs, etc.) are leading to a change in the structure of our material needs: fewer fossil fuel resources (gas, petrol, coal), more biomass and mineral resources. This development is part of a context of strong worldwide growth in the demand for natural resources. Thus, in its "Efficiency +" scenario, the IRP estimates that in 2050, 50 billion more tonnes of materials will be extracted worldwide than in 2015 (including 45 billion tonnes of non-metallic minerals, mainly construction minerals, +4 billion tonnes of metals, +7 billion tonnes of biomass and -6 billion tonnes of fossil fuel resources), i.e. 50 billion tonnes less than in the reference scenario.

Supply difficulties vary based on the resources:

- *Aggregates and cement for concrete* are present in the national territory. These resources are available in such sufficient quantity that there is no fear of supply difficulties, provided that the sites that can produce them are accessible.
- *Metals* come from international markets. Their supply is subject to global competition. Competition is more or less acute depending on the materials in question. "Critical" metals (cobalt, gallium, indium, scandium for example) may be subject to short- / medium-term risks. The uses and technologies associated with these metals change rapidly, which makes it difficult to anticipate their consumption.
- *Copper in particular* could become a critical raw material in the medium- / long-term.

In any case, it is important to put in place end-of-life resource reuse loops to mitigate pressure on resources. This is why the government in 2018 adopted a Circular Economy Roadmap to improve recycling and support emerging sectors.

Increasing environmental costs, particularly for metals, more or less controlled depending on the mineral resources

When produced locally, the environmental impacts of the extraction and production of aggregates and cement can be anticipated and controlled.

For imported minerals and metals, environmental impacts are "relocated", particularly to emerging countries where environmental (and social) regulations are not as stringent as in Western countries.

As deposits become increasingly difficult to mobilise or have lower substantial content, the economic and environmental costs of their extraction and production are expected to increase.

Issues associated with additional biomass requirements

To cover the additional biomass requirements resulting from the energy transition, different biomass resources – and therefore several sectors – must be mobilised (wood, crop and livestock residues, perennial crops, intermediate energy crops, wood, waste).

The National Biomass Mobilisation Strategy assesses the additional biomass resources needed to meet the demand for biomass for particular energy purposes by 2018 and 2023, as envisaged in the Multi-Year Energy Programme (see 5.5.).

5.5. Security of biomass supply

The 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 area. The National Low-Carbon Strategy envisages a five-fold increase in non-food uses of biomass (wood-construction, green chemistry, biomaterials, bio-energies, etc.). In this context, the implementation of strategies (nationally and regionally) for biomass mobilisation makes perfect sense.

Energy recovery from biomass takes 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 bio-fertilisers, 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.

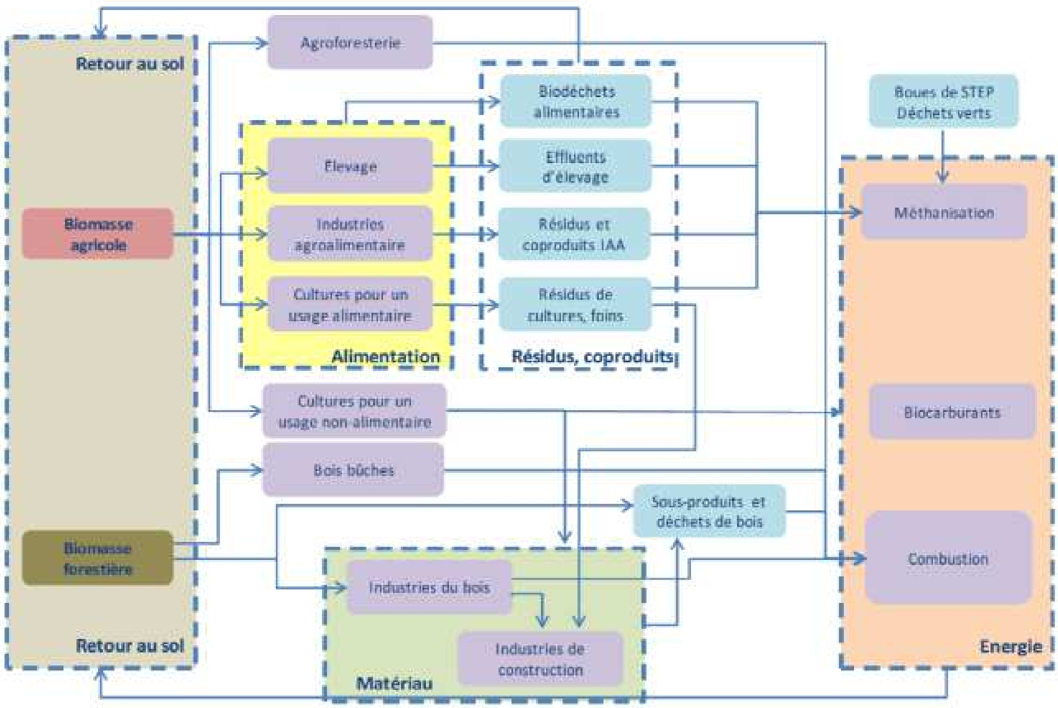

Figure 69: Diagram of the main uses of biomass. Source: Diagram taken from the National Biomass Mobilisation Strategy.

5.5.1. Identification of resources

The National Biomass Mobilisation Strategy (NBMS) assesses additional non-methanised biomass supply for non-food uses combined, by 2028, to be around 72TWh (compared to 2014), of which 36TWh is from forestry, 28TWh from agricultural resources and 7.8TWh from waste.

			2023	2028
Non-methanised biomass	**Forest biomass**		20.8	35.7
	Agricultural biomass	**Crops (perennial and Intermediate Crops for Energy Purposes)**	0.23	0.35
		Crop residues	22.9	25.4
		Agroforestry	1.5	2.6
	Waste and other residues	**Waste (including end-of-life wood), by-products, pruning, cutting**	3.4	4.3
		Composting refuse	2.1	3.5

Table 41: Additional biomass supply (TWh) Non-methanised biomass is in primary energy

The total supply of solid biomass, which cannot be used for methanisation, by 2028 is estimated at 251TWh, of which 120TWh will be forest biomass.

			2016	2023	2028
Non-methanised biomass	**Forest biomass**		84	106	120
	Agricultural biomass	**Crops (perennial and**	63[74]	86	89
		Crop residues			
		Agroforestry	27[75]	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

Table 42: Total biomass supply (TWh) Non-methanised biomass is in primary energy

Regarding methanisable biomass, the National Biomass Mobilisation Strategy evaluates the additional supply of methanisable biomass without destabilisation of other existing sectors at 30TWh, making total resources of 40TWh.

74 . For 2016, the figure of 63TWh includes crops (primary, perennial and intermediates for energy purposes).

75 DGEC estimate based on Agreste data on forest harvesting for energy purposes.

			2023	2028
Methanised biomass	**Agricultural biomass**	**Crops (perennial and Intermediate** [illegible]	2.3	2.4
		Crop residues	6.7	11.3
	Waste and other by-products	**Green waste**	1.2	1.9
		Sludge from STEPs	0.2	0.4
		Waste and agri-food by-products	0.2	0.5
	Effluents		7.8	13.3

Table 40b: Additional biomass supply in end-use energy (TWh)

Recoverable wood resources that can be recovered as energy are estimated to be 2Mt of which 1.1Mt are already recovered. This means an additional energy resource of about 2TWh. Measures to increase the mobilisation of biomass resources in accordance with sustainable management practices, in order to coordinate the uses of biomass, 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 underway within the framework of the Strategic Committee for the Timber Industry.

The aim of the waste recovery policy is to re-use wood waste in material form, instead of incinerating it. The circular economy action plan above all encourages cascading wood use, with several re-use and recycling cycles.

Support systems for energy recovery should thus provide for the eligibility of recyclable wood waste for only a minority of the supply of the installations, and only when it is demonstrated that the waste cannot 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. The cost impact of upstream processing of this waste or processing via energy recovery at the necessary support level is still to be studied.

If the potential resource is abundant, mobilising it in good economic and environmental conditions will require a progressive approach (e.g. the National Biomass Mobilisation Strategy – SNMB). The evaluation of additional biomass supply available shows that by 2023, a large proportion of the additional needs should be met from agricultural biomass, mainly through the use of crop residues, intermediate crops for energy purposes (CIVE), via 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 only a small proportion 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 a some transitional use of biomass imports. In the case of the upper trajectory, the need for non-methanised solid biomass could even be only half covered by domestic biomass, which would then require major transitional use of imports.

Box 13: National Biomass Mobilisation Strategy

The 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 area. The achievement of carbon neutrality requires a major increase in non-food uses of biomass (wood-construction, green chemistry, biomaterials, bio-energies, etc.).

The National Biomass Mobilisation Strategy (SNMB) aims to develop positive externalities related to the mobilisation and de facto use of biomass, especially for the mitigation of 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, in good synergy with other existing policies. It has been designed in close connection with the National Low-Carbon Strategy and the Multi-Year Energy Programme, which includes demand targets for biomass for energy purposes. The SNMB is also supported by the National Forest and Wood Programme. 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 2019 and then every five years.

The SNMB identifies different categories of biomass that may 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 the material uses of high added value (progressive concentration of biomass energy use on end-of-life bio-sourced products that are not recyclable), restoring sustainable forest management (close combination of bio-economy, adaptation to climate change and increased preservation of biodiversity), focusing on strengthening the quality of soils, especially agricultural soils, etc.

On the basis of studies of the potential available at national level, the SNMB sets targets for the mobilisation of additional forestry, agricultural and bio-waste resources by 2023;

- Additional non-methanised biomass (possible use in bio-sourced materials, green chemistry, biofuels or heat-cogeneration) is estimated at 52TWh in primary energy equivalent.
- Additional biogas production is estimated at 18TWh.

By this medium-term target date, agricultural biomass would contribute about 80% of available biomass.

The SNMB is followed up annually, with a presentation to the Information and Orientation Committee, whose indicative membership is attached to the strategy and then made public. This follow-up is complementary to the monitoring of the sector plans with which the SNMB is coordinated (National Forestry and Wood Plan, agroforestry plan, MAEP, prevention and waste management plan, National Low-Carbon Strategy, etc.).

Another change factor to be considered for this strategy is the forthcoming compilation of regional biomass schemes (SRB) being devised in the regions. The first revision of the strategy in 2019 will be an opportunity to ensure consistency with the SRB.

5.5.2. Strategic orientation of these resources

Biomass is a scarce resource and will remain scarce until 2050. For this reason, the Multi-Year Energy Programme gives clear guidelines on prioritising it for the uses where it is most effective:

- For wood, its use in heat in a heat network or for the production of industrial heat will be prioritised. Cogeneration should only take place in special cases and high efficiency cogeneration should be preferred in this case;
- For biogas, biomethane injection must be prioritised. Cogeneration shall only take place in specific cases, in particular for production facilities remote from gas networks;
- For biofuels, the goal is not to increase 1st generation fuels but to increase 2nd generation fuels.

Objective of developing resource mobilisation and measures to achieve it

In 2028, mobilise 52TWh of solid biomass (including for the production of 2G biofuels) and 36TWh of biomass for biogas.

Measures:

- Continuing the mobilisation of waste and residues;
- Establishing sustainability criteria with information on biomass sources in accordance with the REDII Directive;
- Encouraging professionals to define a best practices charter for importing biomass;
- Undertaking work to improve the coordination of biomass supply and demand.

5.6. Energy infrastructures and networks

5.6.1. Heating and cooling networks

The heating networks play a key role for the development of renewable energies and the use of recovery energies, because they enable the mass mobilisation of biomass, geothermal energy, solar power, or the recovery of waste heat from industry, waste recovery units etc. The Energy Transition for Green Growth Act has set the objective of a five-fold increase in the amount of renewable and recovered heat and cold delivered by the networks by 2030 (baseline 2012), which represents a target of 39.5TWh.

Baseline situation 2012	The situation in 2016	MAEP Objective 2018	Lower MAEP Objective 2023	Higher MAEP Objective 2023
7.9TWh	13TWh	15.7TWh	22TWh	26.7TWh

Table 41: Targets set by the MAEP adopted in 2016 for renewable or recovery heat consumption by heating networks

To reach the 2023 upper range, the pace of projects must be increased by 2.8.

State of play in the sector

In 2016[76], there were approximately 750 heating networks in France covering more than 5000km and producing 24.6TWh of heat. 22 cold networks cover 200km of networks and deliver 0.9TWh of cold. Heat networks supply 2.32 million household equivalents[77]. While fossil fuels continue to play an important role in supply (39% of which is gas), the share of renewable and recovered energies (R&R energy) is continuing to increase, reaching 53% in 2016 compared to 27% in 2005 and 40% in 2013. The share of biomass has increased

76 . The data come from the annual survey on heat networks conducted on behalf of the statistics department of the Ministry of Ecological and Solidarity Transition. 669 network operators responded.

77 . Each household consumes about 12MWh.

most significantly (+25% between 2005 and 2016). The market share, or connection rate of buildings to an R&R energy heat network in France, remains low (around 6% against 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%).

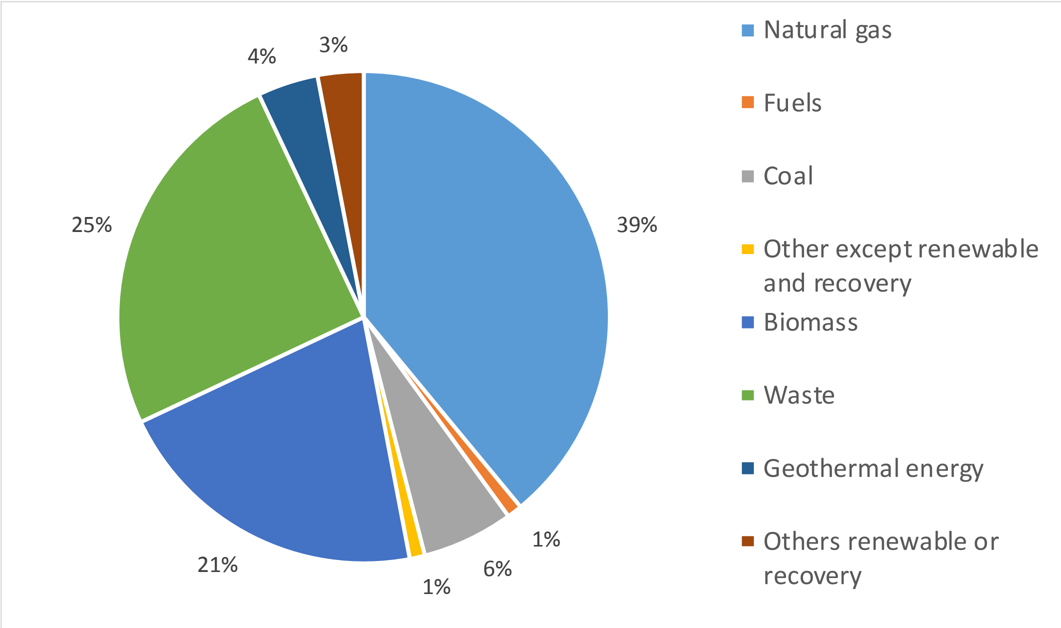

Figure 70: Energy mix of heat networks in 2016

Resources

Heat networks are effective in dense areas. Taking account of a minimum density of 4.5MWh delivered per linear metre for the network to be profitable, the SNCU evaluates the potential of the heating networks for delivering 11 times more than that in 2012. By combining this data with renewable and recovered energy resources, ADEME estimates that the maximum potential would be around 67TWh (i.e. 8.5 times more than in 2012).

An analysis of the Regional Climate Air Energy Schemes of the previous exercise shows that only three regions have developed a quantitative objective for heating networks. Future SRADDET exercises will need to define useful objectives in each region (or at PCET scale). This can be achieved by using the national mapping of the development potential of heat networks[78] or the SNCU study, which published maps of regional potential[79].

Socio-economic, industrial and environmental issues

Yields

Heating networks can be used for the use of renewable and recovered energies with good energy efficiency. The average yield of all the networks participating in the annual heat network survey is about 85%. The new networks are built, when plans permit, with a low level of water flow temperature, which allows a two-fold reduction in the losses compared to a high temperature system. 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 heat network come largely from the civil engineering related to the length of buried pipes. The energy density indicator (or linear thermal density), which is expressed in MWh of energy delivered per metre

78 . http://reseaux-chaleur.cerema.fr/carte-nationale-de-chaleur-france

79 . **Mapping of the development potential of heat networks in France (SNCU/FEDENE/SETEC ENVIRONNEMENT):** http://www.observatoire-des-reseaux.fr/le-potentiel-de-developpement/

of track (MWh / ml) per year, is one of the characteristics of the viability of an R&R energy heat network. The costs are very variable and depend on the type of network financed. Based on the data from the Heat Fund that supports the creation, densification and extension of the network, it is estimated that the investment cost is around €1000 / linear metre[80].

R&R energy heat networks enable the supply of competitive energy for users over the long-term. The stability of the selling prices of the heat delivered is higher as the share of renewable energies in the grid rises and the energy mix is varied.

The characteristics of the sector in terms of employment

The heating networks generate an annual investment of around €280 million and employ around 1800 FTEs. Local employment is promoted during the construction, supply, and day-to-day management of the network (civil engineering, maintenance operation, mobilisation of engineers, technicians, workers, and salespeople). French engineering skills are widely recognised and sought for export.

Densification, creation, extension and greening issues

To reach factor 5 set by law, it is necessary to continue the densification / extension / greening of existing networks, but also to create new heating networks. The heating network is often efficient. If it does not emerge, it is also due to the inertia of the systems in place. This is why conducting a feasibility study should enable cities to become aware of the importance of heating networks and to take action. Cities are the territorial units responsible for the creation and operation of heat networks.

In addition to the creation / densification / extension of networks, the mobilisation of renewable and recovery energies must be accelerated. The average R&R energy rate on all the networks is currently 53% (variable from one year to another according to weather conditions). Biomass must continue to increase as well as the recovery of waste energies, in particular heat recovery from waste heat treatment units must continue (a specific initiative will be carried out on the ten units still not connected to a heat network, when compatible with the regional waste plan). Solar thermal mobilisation is also available to complement the energy mix of virtuous heat networks.

The existing regulatory tool aims to impose the submission of a cost / benefit analysis in order to study the possible recovery of waste heat in a network[81] that has been in force since 1 January 2015. This analysis is mandatory for any new installation of more than of 20MW or for any substantial change[82]. Two cases are involved: an industrial installation that must study the possibility of recovering its waste heat in an existing network or in a network being created, but also an installation of energy production in a network that must first study the possibility of recovering the waste heat from existing industrial facilities nearby, before sizing its power. It is necessary to reap the fruits of this regulation.

Furthermore, it is necessary to maximise the R&R energy ratio of planned and existing heat networks without jeopardising competitiveness for the end user. The Renewable Energy Directive currently being reviewed provides for the option of increasing the average network R&R energy rate by at least one point per year from 2020 for all Member States where the rate is yet to reach 60%. Over the last ten years, the average network R&R energy rate 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 to set an indicative target rate of 60% of R&R energy in networks in 2023 (national average), then 65% by 2030, combined with the objective in terms of housing equivalent connections.

Ensuring the integration of R&R energy in territorial policies and plans

The integration of R&R energy should also take place as close as possible to the projects and could be adapted to the scale of the Local Development Plan. In addition, at local level, specific action could be taken to promote

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80 Markets and jobs related to energy efficacy and renewables – ADEME – April 2016.
81 . https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000029920606&categorieLien=id
82 . Change leasing to a cost of at least 50% of the cost of a new unit.

network ranking[83], for example based on the winners of eco-network labels. This label is based on three criteria: a minimum R&R energy of 50%, competitiveness, and the establishment of a consultation. The production of "all energies" master plans is also to be developed / systematised.

To encourage local acceptance of projects and inform users, the creation of consultation committees between councils, operators, subscribers and users must be encouraged. Social landlords should also be encouraged to develop R&R energy and anti-fuel poverty targets.

Renewable and recovery cold networks

There are several network cold production technologies:

- Cold compression units with caloric evacuation by aerothermics (this technology can be considered to be the benchmark solution and is not counted in the networks' R&R energy objective);
- Surface aquifer or surface water heat pumps;
- Free cooling and geo-cooling (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;
- 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 2016, cold deliveries from cold networks amounted to 900GWh[84]. The production of cold networks is 94% based on cold compression units. Some networks operate on "free cooling" and some water loop projects funded by the Heat Fund's "New Emerging Technologies" call for projects are being put into operation. Some technologies are already eligible for renewable energy under the European Directive 2009/28 / EC: free cooling. The ongoing revision of this Directive provides for the definition of criteria to identify other renewable technologies for the production of cold.

At French level, the Energy Transition for Green Growth Act sets the goal of a five-fold increase in the amount of renewable and recovered heat and cold in the grids by 2030. That is why from 2018, the Heat Fund is supporting technologies considered as renewable and recovery technologies at national level, without waiting for the definition at European level. It is for this reason that this MAEP sets an indicative target for the delivery of renewable and recovery cold (see below). Aquifer heat storage technology could also be developed (see chapter on low and medium geothermal energy) and be supported in research programmes and via the Heat Fund's New Emerging Technologies call for projects. The challenge for cold networks is to develop a co-production of heat in winter and cold in summer by using the thermal storage aquifer.

Environmental challenges

Heat networks 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 benefit from better energy and environmental performance. This is especially true for the use of solid biomass. In environmental terms, heat networks supplied mainly by renewable and recovered energies allow very low levels of CO_2 emissions (50 to 100gCO_2 / kWh for a biomass network) compared to individual fossil solutions or networks powered by fossil fuels (greater than 200gCO_2 / kWh).

Cooling networks have a positive impact on the environment as a means of replacing individual cold groups[85]. They enable the amount of coolants to be reduced, and water vector technologies (aquifers, surface water, free cooling) also offer an alternative to the challenge of heat islands in urban areas. Cold networks have a very low environmental impact (around 16gCO_2 / kWh)

83 . The ranking of a heating or cooling network is a procedure that enables a community to make it mandatory to connect to the existing or planned network in certain areas for new building installations.
84 Source: Heat networks survey, 2016
85 Energy and environmental efficiency is five to ten times more efficient than conventional electric air conditioning – Source: RAEE and IEE Work Package, 2006.

Development objectives of the sector and measures

The targets are an average rate of 60% in network R&R energy in 2023 and 65% in 2030. Renewable and recovery cooling network deliveries should be multiplied by three by 2030, i.e. around 5M in equivalent homes connected in 2030.

	2016	2023	2028 Scénario A	2028 Scénario B
Delivery of renewable and recovered heat (TWh)	13	24.4	31	36
Delivery of renewable and recovery cold by networks (TWh)	0.14	0.27	0.37	0.49

Main measures complementary to renewable and recovery heat supply measures:

- Accelerating the mobilisation of renewable energies (especially biomass) and recovery energies in networks by maximising the R&R energy ratio of Heat Fund projects;
- Asking cities with more than 10,000 inhabitants to carry out feasibility studies into heating and cooling networks, in order to further densify and extend existing networks and speed up the creation of new networks;
- Keeping VAT at 5.5% for heat deliveries from networks more than 50% supplied by R&R energy (and incorporate solar thermal energy to eligible R&R energies);
- Supporting the development of the most efficient renewable and recovery cooling networks through the Heat Fund;
- Establishing a recognised definition of renewable cold when delivered by network, at European level;
- Encouraging social landlords to develop R&R energy and anti-fuel poverty targets.
- Ensuring the integration of R&R energy in territorial policies and plans and planning documents;
- Promoting strategies for ranking networks when the master plans are submitted by the end of 2018.

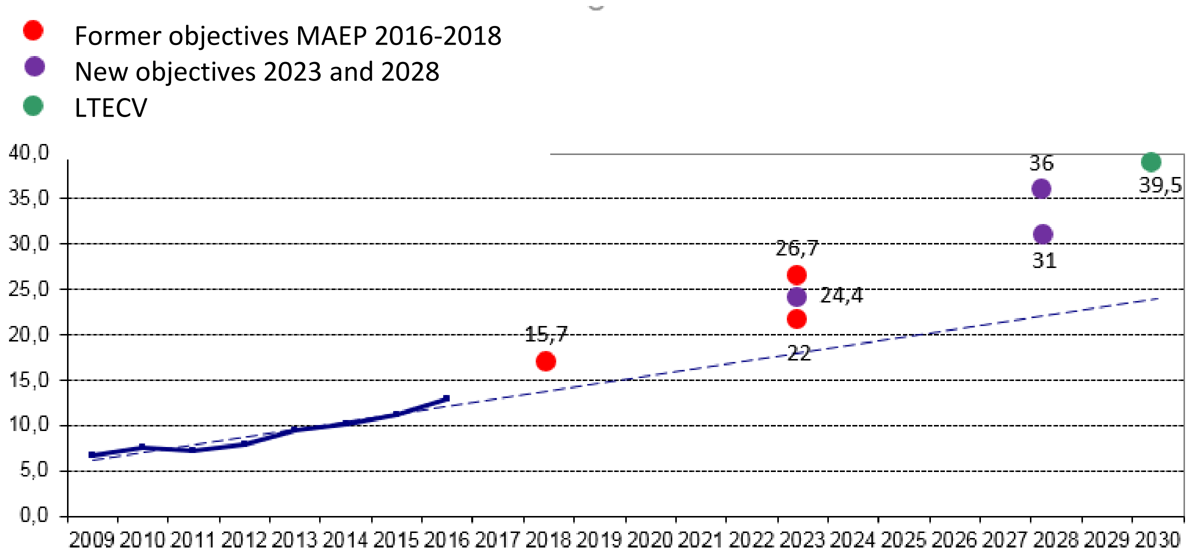


Figure 71: R&R energy heat delivery by networks

5.6.2. The liquid fuels network

The logistics network consists of depots of imported petroleum products, located as close as possible to refineries or ports, crude oil or finished products transport pipelines, intermediate depots before final delivery to consumers through the network of service stations. Each level of infrastructure is an indispensable link for ensuring that the territory 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. The amounts of crude oil transported in the two main pipelines are rising (3.5%). Conversely, the transportation of finished goods declined slightly to 34.2Mt (-0.7%).

Pipeline systems are the predominant means of transportation for moving products out of refineries and import depots as they allow for mass, safe transportation.

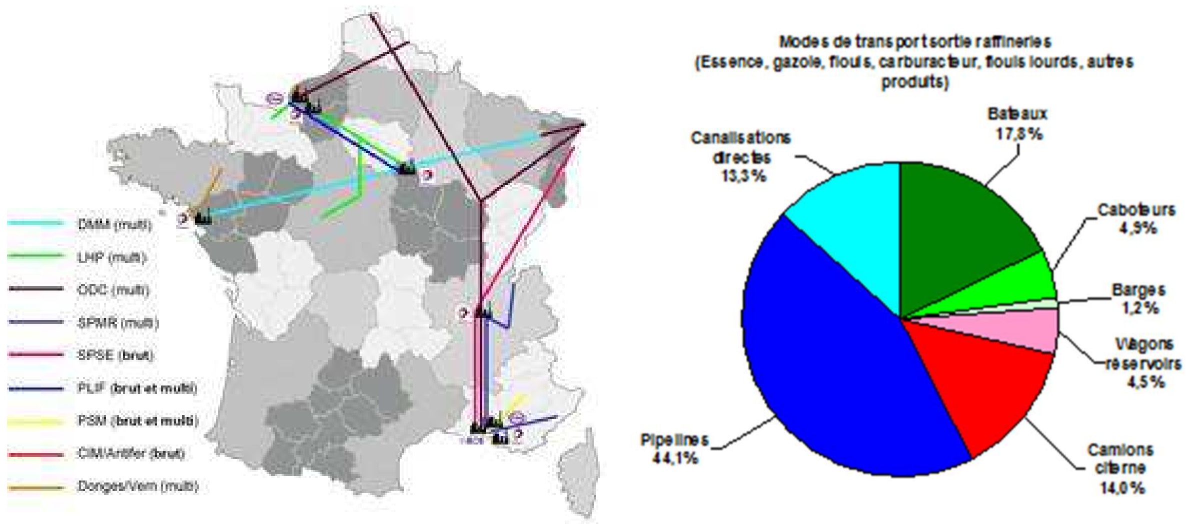


Figure 72: Pipeline and transport modes from refineries

The main installations for conveying crude oil are the following:

- The Southern European pipeline (PSE) – 760km: Supplies the refineries of Feyzin and Cressier (Switzerland) from the great seaport of Marseille.
- The Île-de-France pipeline (PLIF) – 260km: Supplies the Grandpuits refinery (south-east of Paris) from the port of Le Havre; can be used as a backup for the supply of the Normandy refinery.
- The Antifer-Le Havre pipeline – 26.5km: 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 on the Lower Seine.

Transportation of finished products:

- The Le Havre-Paris pipeline (LHP) – 1380km: 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) – 765km: Supplies the Lyon region, the Côte-d'Azur and Switzerland (Geneva) from Fos-sur-Mer.
- The Common Defense Pipeline (ODC) – 2260km in France: Represents the French part of the Central Europe Pipeline System (CEPS) of the North Atlantic Treaty Organization (NATO).
- The Donges-Melun-Metz (DMM) pipeline – 627km: 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. Any change in these points of carriage and delivery compromises the performance and optimisation of the system with a certain impact on supply security in the event of a crisis.

5.6.3. The gas network

The natural gas network transports natural gas from import points, LNG terminals and biomethane production facilities to consumers and export points. It includes transmission pipelines, compressors, distribution networks, all operating in synergy with underground natural gas storage infrastructures.

The natural gas transmission system

The French natural gas transmission network is used to move gas from import points at the borders (terrestrial interconnections with other European countries, gas pipeline from the Norwegian Sea and LNG terminals) to delivery points distributed in the national territory (distribution networks 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 consisting of CNP Assurances, CDC Infrastructures and Caisse des Dépôts et Consignations) operating 7498km of primary network and 24,916km of regional network.
- Terέga: Owned by the Italian operator Snam (40.5%), the State Fund of Singapore GIC (31.5%), EDF (18%) and Predica (10%), it operates 1155km of primary network and 3985km of regional network.

The gas transmission networks are regulated by the Energy Regulatory Commission (CRE). The most recent rate for the use of transmission networks, "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 network has been upgraded to facilitate the movement of natural gas within it, to limit the risks of congestion, to streamline trade between the South and the North of France, that allowed, the 2018, November 1st, to merge the markets. The upgrades include:

- The creation of the Arc de Dierrey by GRTgaz (DN 1200, 308km), which benefitted from the status of project of common interest (PIC) with the 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, 190km) benefit of the status of PIC, with the investment of €744M, consists of a doubling of the Burgundy Artery between Etrez (Ain) and Voisines (Haute-Marne). Commissioning is scheduled for 1 November 2018.
- The Gascony-Midi project sponsored by Teréga (DN 900, 60km): This project, which has the status of a PIC, involves a partial doubling of the Gascony artery between Lussagnet (Landes) and Barran (Gers), that began 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 progressively upgraded, enabling the firm capacities from France to Spain to be increased from 70 to 165GWh / day. At the same time, 225GWh / day in firm capacity has been created in the South-North direction;
- The 2001 commissioning of the Oltingue Interconnection point led to the supply of 220GWh / day of firm capacity from France to Switzerland and Italy;
- Upgrades to the Obergailbach interconnection led to an increase in 2009 in the firm capacity between Germany and France from 400 to 570GWh / day;
- The new Alveringem interconnection point enabled the creation of 270GWh / 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 for the creation of 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.

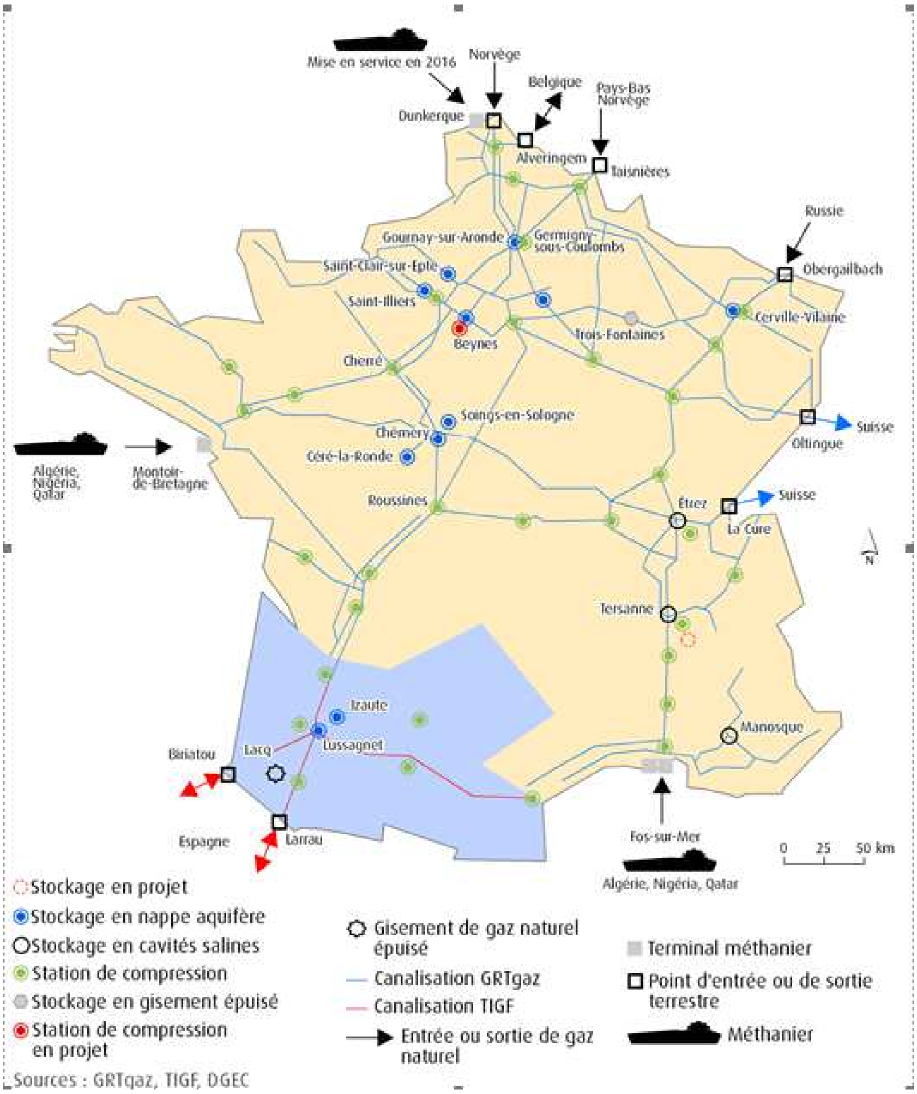


Figure 73: Gas infrastructures

Natural gas distribution networks

The natural gas service to domestic, tertiary or small industrial consumers, downstream of the transmission network, is provided via distribution networks.

Natural gas distribution networks are owned by local authorities. They are operated through concession contracts linking operators to 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), as well as a few other licensed companies.

They serve more than 9500 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 provides 77% of the French population with access to natural gas.

The 27,000 municipalities not supplied with gas today have several options for accessing this type of energy:

- The extension of the existing natural gas network with the development of a distribution network 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 facing good management of the distribution networks require progress on:

- Good 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 brakes on the capacity limits of the networks.

The development of biomethane injection projects may need to increase the flexibility of the distribution networks. Indeed, the amount of biomethane that can be injected into a distribution network is limited by the gas consumption on the network. Upgrades to gas networks, particularly to allow the implementation of backward flows from the distribution network to the transmission network, may be necessary to prevent biomethane production projects located near an existing network being blocked due to lack of capacities.

Natural gas smart meters

Article L. 453-7 of the Energy Code sets a goal of rolling out smart meters for natural gas consumers. Historically, this type of meter was deployed only on sites with high consumption, including industrial sites.

By a decision dated 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 network. A technical-economic study showed that the present net value of the project was positive at the level of the local authority, after taking account of the earnings outlook for natural gas consumers associated with management of 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 affects 11 million meters, is scheduled through to 2022. At the end of october 2018, around 2.2 million Gazpar meters were installed, in line with the objectives.

The Gazpar meter enables the natural gas consumer to be billed based on actual consumption, thanks to a technique of remote transmission of the indexes. The procedures for changing supplies are simplified as a result. Consumers can use information made available to them about their consumption so that they can act to manage the energy they consume.

The widespread deployment of smart meters is being studied by other managers of public natural gas distribution networks.

LNG terminals

Four LNG terminals are currently in service in France:

- Fos-Tonkin (3Gm3 / year) and Montoir-de-Bretagne (10 Gm3 / year), owned by Elengy, a 100% subsidiary of GRTgaz.
- Fos-Cavaou (8.2Gm3 / year), owned by Fosmax LNG, a subsidiary of Elengy (>70%) and Total, managed by Elengy.
- Dunkerque LNG (13G m3 / year), owned by consortiums composed by Fluxys, Belgian transmission system operator, Axa Investment Manager, Crédit Agricole Assurances and Korean companies IPM and Samsung Asset Management.

In 2016, liquefied natural gas (LNG) arrived in France from Algeria (69%), Nigeria (20%) and Qatar (11%).

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 Dunkirk, Fos-Cavaou and Montoir-de-Bretagne LNG terminals benefit from capacity subscription agreements extending beyond the period covered by the Multi-Year Energy Programme, which secures their operation for this period.

Uncertainty weighs on the future use of the Fos-Tonkin terminal. In the absence of any new capacity subscription by natural gas suppliers, the 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, the entire LNG import capacities on the Mediterranean sea-board will be managed by the Fos-Cavaou terminal alone. Emission capacities would remain unchanged, but at the price of a more constricted 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 indeed likely to raise questions of technical compatibility and safety for the networks (material compatibility, gas burner settings, measurement of quantities delivered, etc.).

Measures:

- In a context of declining natural gas consumption, studying infrastructure investment projects in light of the risks of stranded costs;
- Asking gas infrastructure operators to evaluate the potential for the network incorporation of hydrogen, whether mixed with methane or on its own;
- Taking into account the existing possibilities, study the interest of the reuse of saline cavities for the storage of hydrogen.

5.6.4. The power grid

Power grids are a key link in the 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 underway is leading to a paradigm shift, with a significant change in electricity flows in grids. The electrical system is evolving from production that, historically, was very largely centralised, consisting of large power plants connected to the transmission grid, and "descending" towards consumers via the distribution network, to production that is increasingly diffuse and closer to consumption: for several years, most new energy production facilities have been renewable and connected to the distribution network.

At the end of the first quarter of 2018, 382,000 production sites were connected to the distribution network managed by Enedis. The vast majority of these sites are low power photovoltaics. For its part, wind power, although provided by a limited number of sites (around 1500), makes a predominant power contribution, 11.9GW compared to 6.9GW solar photovoltaics, in a total of 21.4GW of connected renewable energies.

The different types of renewable electric energy have very different characteristics, which have variable impacts on the distribution and transmission networks. In addition to differences in plant size, differences in energy sources include production profiles (seasonal, daily, hourly production variability), predictability, or the possibility of modulating production[86]. Finally, the wave qualities or the voltage profile of these productions must be taken into account for effective grid operation.

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 networks.

Organisation of power grids

The operation of electricity transmission and distribution networks are regulated public services.

The public electricity transmission grid, which can be compared to "electricity highways", consists of all the lines operated at a voltage greater than 50,000V in mainland metropolitan France. It comprises 106,000km of high and very high voltage power lines (HVB) and 2700 substations. RTE, a public limited company, is the sole operator and owner.

More than 90% of current French electricity production is injected into the transmission grid, but it only serves a few hundred end consumers directly, most of which are large industrial consumers.

These are public electricity distribution grids, consisting of medium voltage structures (HVA, between 1000V and 50,000V) and low voltage structures (LV, less than 1000V) connected to the transmission grid.

The public distribution of electricity takes place through local concessions. The authorities responsible for electricity distribution (AODE), also called licensing 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 the metropolitan area, today holds more than 600 concessions. Enedis operates 1.35 million kilometres of lines, 778,500 distribution points (HVA / LV) and 2700 source stations (HVB / HVA, providing the interface between the transmission and distribution grids). It serves 36 million consumers. 5% of the metropolitan area is served by 150 local distribution companies (LDCs) depending on the local authorities.

The main tasks of the public electricity grid operators are grid operation (troubleshooting, running and control of the network, connection of new consumers or producers), calculating the energy quantities injected or extracted, and upgrading infrastructures to ensure they are maintained in operational conditions.

RTE, the transmission system operator, is also a major player in the management of the electricity system, particularly through the management of real-time supply and demand balancing mechanisms.

Public power grid use tariffs (TURPE)

Both electricity transmission and distribution are public services whose tariffs are regulated and set by the Energy Regulatory Commission in four-year periods. These tariffs for the use of public power grids (TURPE), which, on average, represent a little less than one third of consumers bills (incl. taxes), cover the investment and operating costs of the grid operators RTE and Enedis. In particular, the tariff levels are set based on the

86 . See the chapter on electricity supply security for further details.

investment forecasts of the network operators, so as to systematically guarantee them sufficient resources to maintain or improve the infrastructures for which they are responsible. The tariffs are accompanied by incentive regulation mechanisms, in particular to encourage grid operators to control their costs or improve the quality of their supply.

For local distribution companies (LDC) and for network operators in non-interconnected zones (NIZ), revenues are adjusted to actual costs incurred through the Electricity Equalisation Fund.

The TURPE is set based on the tariff equalisation principle (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 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 the revision of tariffs in 2020 for better consideration of the specifics of self-consumption and other new uses.

Since November 2017, small renewable energy generation facilities have benefitted from the TURPE covering part of the cost of connection to public electricity distribution grids. 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 grid

Investment planning tools

Power grids are long-lived infrastructures; they require massive investments that need to be planned well in advance. This is especially true for the transmission grid, which has an investment timescale of around ten years. Planning is all the more complex as it relies on several documents, drawn up both at national and European level.

The 3rd Internal Market Package, adopted by the Member States of the European Union in 2009, introduced a coordinated approach to planning transmission grid investments: every two years, the Association of European Network Operators (ENTSO-E) has to publish every a European ten-year plan for the development of the European electricity transmission grid (TYNDP[87]). Nationally, each transmission grid operator draws up its ten-year grid development scheme (SDDR), which must be consistent with the plan established 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 mentions the main transmission infrastructures to be constructed or significantly modified over the ten-year period, lists the investments already decided as well as the new investments to be made within three years, with a timetable of all the investment projects. Each year, the ten-year plan is updated and submitted for consideration by the Energy Regulatory Commission, which may require changes.

Major investment guidelines

The transmission grid currently faces a number of trends. The consumption stabilisation observed at national level masks significant disparities between regions, notably related to demographic change; the development of renewable energies is also highly variable locally, in particular in respect of weather patterns. The development of more diffuse generation facilities, connected to the distribution grids, is globally leading to fewer extractions from the transmission network; but the transmission network plays an increasing role in back-up and solidarity between the territories, in particular through an expected reinforcement of flows on very high voltage lines, up to 400,000V. The transmission network must also deal with the hazards resulting from the multiplication of more volatile instantaneous power fluctuations, in France and in Europe, which can be linked to consumption (in particular in cold weather) but also to production.

87 Ten-Year Network Development Plan; see http://tyndp.entsoe.eu/

To respond to these developments, in the coming decade, network investments are estimated at an average of €1.5 billion per year, of which €1 billion will go to the development of the grid and €400 million to grid equipment upgrades, according to RTE.

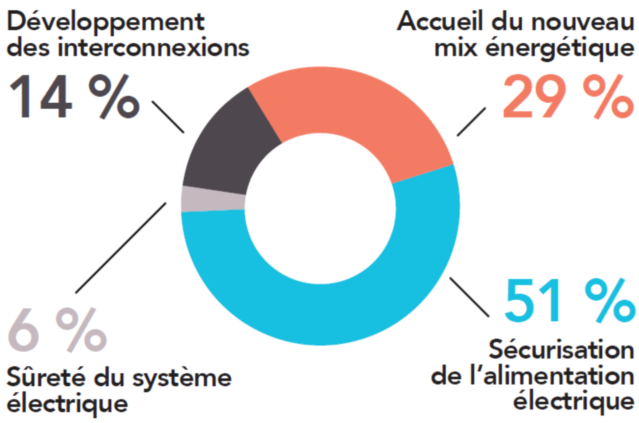


Figure 74: Distribution of investments in the transmission grid, by purpose (2017-2020). (Source: RTE)

RTE, in its latest ten-year plan, anticipates the need to create and upgrade about 2000km of structures for the coming decade. These investments will include the creation of 4GW of additional offshore wind generation capacity and 10GW of additional interconnection capacity.

RTE also contributes to the development of solutions that make it possible to limit infrastructure investments wherever possible, through improvements in 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 the behavioural change incentive.

Continuing the development of interconnections

The French public power transmission grid 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

In 2017, France's total interconnection capacity was 17.4GW in exports and 12.5GW in imports, representing an interconnection rate of around 11.4%. The capacities actually used on average are lower (around 8 to 10GW), because of the characteristics of the interconnection lines, their availability and the internal constraints on the power grids of each country.

The construction of cross-border interconnections has historically been a response to a supply security rationale and the use for export of French electricity production 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 peak consumption.

Interconnections lead to a proliferation of geographical hazards between countries, but which can be addressed more efficiently as the specifics of each country reduce the correlations of hazards and mitigate the consequences of the occurrence of national tensions. The dominant hazard in France today is, and will remain over the MAEP period, the thermo-sensitivity of demand; the risk associated with the intermittency of renewable energies is today dominant in countries with the greatest penetration rate of these renewable energies (Denmark, Germany); the hazard associated with hydropower production is dominant in countries where it has a major generation role (Norway, Switzerland, Portugal). Interconnections prevent France from investing in additional capacity to ensure its supply security.

Cross-border exchanges make it possible to have capacities available abroad. Following the commissioning of the interconnection between Baixas and Santa Llogaia (Spain), a new interconnection with Italy (Savoie-Piedmont line) will be commissioned in 2019/2020. Other projects are under construction with England or being studied with Germany, Belgium, Ireland and Switzerland (see list below).

Country – Project (nominal capacity)		**Contracting authority**	**Progress**	**Commissioning**
Germany	Vigy Uchtelfangen	RTE & Amprion	Study phase – Increase of existing capacity	By 2021 then 2030
	Muhlbach Eichstetten	RTE & Amprion	Study phase – Increase of existing capacity	By 2025
Belgium	Lonny Gramme	RTE & Elia	Study phase – Increase of existing capacity	By 2025
	Avelin Mastaing–Horta	RTE & Elia	Study phase – Increase of existing capacity	By 2022
Spain	Gascogne (2GW)	RTE	Consultation phase	By 2025
Ireland	Celtic (0.7GW)	RTE	Start of procedure	By 2025
Italy	Savoie-Piémont (1GW)	RTE	Work in progress	2019-2020
Switzerland	Genissiat Verbois	RTE & Swissgrid	Study phase – Increase of existing capacity	By 2023
	Cornier Chavalon	RTE & Swissgrid	Study phase – Increase of existing capacity	By 2025

Country – Project (nominal capacity)		Contracting authority	Progress	Commissioning
United Kingdom	IFA2 (1GW)	RTE & National Grid	Work in progress	2020
	Eleclink (1GW)	Eleclink	Work in progress	2021
	FAB (1.4GW)	RTE & Fablink	Procedure currently suspended	By 2022
	Aquind (2GW)	Aquind Ltd	Start of procedure	By 2022
	Eleclink (1.4GW)	Elan Energy Ltd	Start of procedure	By 2022

Table 45: Electricity interconnection projects with France DGEC, 2018

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 production mix.

The ten-year development plan for the power transmission grid drawn up by RTE in 2016 estimates that the increase in interconnection capacity being studied or planned for commissioning by 2030 will be about 10GW. These figures are consistent with the scenarios of the 2017 RTE forecast report: two of them assume an import capacity of 27GW and an export capacity of 33GW to ensure the system's balance 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 ten-year grid development plan, and to study the opportunity for developing new interconnections in light of a cost-benefit and project acceptability analysis.

Public power distribution grids

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 grids be rethought.

Distribution grids were initially designed exclusively as top-down structures, i.e. to route electricity to the consumption areas. Nowadays, they accommodate most new renewable energy installations, which involved the need for modernisation procedures to facilitate the two-way operation of the grids.

Moreover, the development of decentralised production, especially in low consumption areas, may require the creation or enhancement of network 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 investments depend in particular on the nature of the installed terminals (fast or slow recharging), which create more or less constraints on the grid.

After a period of lower investment in the renewal of networks, resulting in particular in an overall ageing of the infrastructure and degradation of the average cut-off time, several years ago Enedis entered a new investment cycle. Projected investment amounts under the Enedis TURPE 5 (not including the deployment of the Linky meter, under a separate investment framework) for 2018 are €3.255 billion, up 2.5% on 2017 (€3.175Bn).

Local authorities, licensing authorities and grid owners also invest between €800 and €900 million each year in distribution grids, thanks in particular to the resources provided by the TCCFE (end-use electricity consumption tax) and the local authority rural electrification support fund (CAS Facé).

Over the 2018-2023 period, investment needs in electricity distribution grids will continue to grow, to continue the upgrading of existing networks and to adapt to new sources of production and consumption presented 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 the renewal of dilapidated underground cables in metropolitan areas. Investments, which have historically focused on medium voltage (MV), which constitutes the "backbone" of the distribution network, must also be developed on the electrical equipment of distribution stations and the low voltage (LV) network located in France. downstream of these stations, which serves the bulk of consumers, in order to stop ageing.

Investment planning and governance at national level

In view of this growth in investments in the distribution grid and the strategic nature of the latter for the integration of renewable energies and the development of new electrical uses, effective coordination and clear governance are essential in the coming years for good investment management.

Indeed, while investments in distribution grids are still driven by the particularities of local situations (the emergence of grid constraints due to the development of consumption or production, cable ageing, etc.), governance at national level must make it possible to ensure that investments are consistent and must guarantee territorial balance.

The NOME law in 2010 established the Departmental Conferences, annual meetings under the aegis of the prefects to present the investment programmes of the different public power distribution grid stakeholders, distribution grid operators and organising authorities in each department.

The "Public Electricity Distribution System Committee" (EPCED), created by the Energy Transition for Green Growth Act, started operations in 2017. It is responsible for reviewing the investment policy of Enedis and those of the authorities organising electricity distribution (AODE) and local electricity distribution companies, relying in particular on the summaries of the work of the Departmental Conferences to ensure coordination between national policies and investments, 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.

Developing the electrical system to integrate a growing share of renewable energies

Changes being implemented at European level

The 3rd Internal Market Package, adopted by the EU Member States in 2009, set up a number of tools to facilitate the construction of Electric Europe. It provides for the development of "network 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 will be integrated into the French regulatory framework. Three of these network codes are intended to harmonise the technical requirements for the connection, respectively, of production and consumption facilities and very high voltage direct current lines. These elements also aim for improved integration of renewable energies into the operation of the electricity system through a connection adapted to electricity grids.

The construction of the electrical system of tomorrow

At national level, the evolution of the means of production in the electrical system will not lead to new technical constraints over the life of the MAEP. In the longer-term, many questions will arise 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 of thermal means controllable at French and European level to be replaced by renewable energies, including wind and photovoltaics. These renewable energies in the long-term will constitute a significant part of the electricity mix, supplemented by hydraulic means and possibly by nuclear generation. The challenges posed by the penetration of renewable energies essentially relate to:

- The decentralisation of the electrical system, with, in particular, more and more installations connected in HVA or LV, which will change flow management practices and will raise important planning issues for the accommodation of new production capacities;
- Management of variability and maintaining quality of supply;
- Interfacing this production, particularly via power electronics, to ensure the security of the electrical system.

Providing system services with renewable energy

System services, in voltage and in frequency (adjustment, balancing, etc.) are currently provided mainly by traditional production means. Renewable energies can already provide some of these services today. New production facilities will also be required to have the capacity to fulfil these services, under the network codes that will soon be applicable throughout the European Union. On the other hand, the question is still open for other services provided for this grid, that currently appear not to be able to be provided due to interfacing with power electronics.

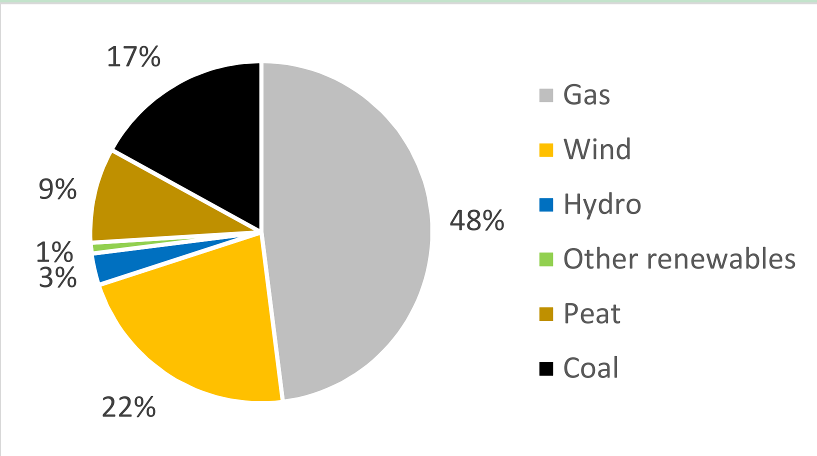
Work will be undertaken with the grid operators and the IEA to study in detail the services that can be provided by renewable energies interfaced by power electronics and possible changes in the management of the electrical system to guarantee the same level of security and quality of supply in a system with a high 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 establishment of new services, as the Irish case shows for example.

Box 14: Integration of renewable energies into the Irish electricity mix

In 2016, Ireland produced 30TWh of electricity, of which 26% came from renewable energies. Its installed facilities represent a little more than 7GW.

With variable wind power generation accounting for 22% of national production and aiming to reach 42.5% of renewable energy by 2020, Ireland must continually adapt the operation of its grid to the integration of a growing share of intermittent renewable energy. Indeed, Ireland has very limited interconnections and therefore needs flexibility to ensure the supply-demand balance at all times.



Irish electric mix 2016: 30TWh

In 2010, Eirgrid and SONI (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. Indeed, the first problems that the grid operator has to address result from the high rate of frequency change due to low synchronous inertia and lack of production stability.

In order to gradually increase this 50% limit, Eirgrid and SONI have set up the "Delivering a Secure Sustainable Electricity System (DS3)" programme. This programme gradually implements services that respond to potential problems in the system (e.g. variability of production, lower inertia, difficulty in maintaining frequency), identified through technical studies. These services include, for example:

- The establishment of technical requirements on the facilities, for example a requirement for wind farms to provide "synthetic" inertia (aimed at recreating, thanks to the wind turbine blades, part of the inertia provided by rotating machinery);
- The development of new balancing products, such as the supply of dynamic reactive power or the ramping margin, which – for a given production unit – involves defining a margin of production that can be guaranteed for a certain period of time and that evolves over time depending on the degree of certainty of production.

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%. Eirgird aims to reach 70% in 2019 before 75% in 2020.

Measure: Launching studies with the IEA and RTE on the integration of renewables into the electricity system and identifying the services they provide to the grid.

Smart grids

The term "smart grids" encompasses all technical solutions often based on new information and communication technologies, which 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 to all stakeholders of the electrical system.

They foster the reinforcement of consumer role by enabling them to be part of the optimal system functioning, particularly with self-consumption development, of curtailment of consumption or “smart charging”.

They enable system operators to optimise their operation: in particular via a better knowledge of the constraints and the possibility to operate remotely a lot of elements of the network. They could make the network more hazard resilient (for example with auto-backup) and avoid expensive investments. Flow optimization enables also to mitigate grid losses which accounts currently for 8 % of the whole power consumption.

Smart grids solutions also foster generating fleet optimisation in order to prevent from investing in new power-generation capacity emitting GHG, by enabling to pilot renewable energy production, if possible, and to promote new sources of flexibility through power storage.

Economic relevance

In-depth studies on the longer-term socio-economic significance of the different smart grid solutions have been conducted by the grid operators with ADEME. These studies concluded that all smart grid solutions identified by grid operators by 2030 are economically relevant[88], with net benefits expected to be around €400 million per year for the community, with a particularly positive impact resulting from the development of storage and from curtailment of industrial and "large tertiary" actors.

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 translation of the services actually rendered to the electricity system.

Considerable technical challenges

The main technical issues in the field of smart grids are:

- 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 needs of balancing, intra-day storage intended to smooth a consumption or production load curve, or longer-term storage of up to a few months to adapt to differences in production and consumption patterns on a seasonal scale. Multiple technologies are available (batteries, hydrogen, flywheels, pump stations, etc.) and the developments must continue to find the technical / economic optimums.
- The management of electric vehicle charging represents a major challenge in reducing the impact on grids and management of the supply-demand balance; Vehicle-to-Grid (VtG) solutions will be used to inject electricity stored in vehicle batteries into the grid.
- Many smart grid components rely on the development of software and telecommunications solutions to obtain real-time information on the state of the grid and its constraints, for efficient processing of the data produced and remote action on the different parts of the grid, in an economically efficient way and so as to avoid cybersecurity vulnerabilities.

Smart grid solutions require the involvement of many types of actors: technical equipment suppliers for the grid or for metering, energy solution integrators, software solution or aggregation service providers, telecom operators, car manufacturers, etc. Raising the awareness of each actor's category to the operations and constraints of others – to enable the optimal development of these solutions – is a major challenge.

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. This plan aims to consolidate the French electricity and IT sectors in new high-growth and job-creating markets. Public support played a critical role to enable innovation and development of the smart grids solutions.

Many experiments have been launched in France for several years. As part of the future investment programme operated by ADEME, more than €120M in funds since 2011 have led to the to about 20 demonstrators being implemented. These demonstrators promote the grouping of actors with complementary expertise (grid 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 in real-life conditions involved the inclusion of renewable energies in grids, the development of technological components for the modernisation of grid operation and energy demand management.

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 power transmission grids, including high-voltage direct current (HVDC). SuperGrid receives public financial support (State and local authorities) of more than €80 million.

All of these provisions aim to promote the development of the sector in order to benefit as quickly as possible from smart grid technologies, in France but also internationally.

88 See in particular,"Socio-economic benefit of smart grids", ADEef, Ademe, Enedis, RTE, July 2017, which can be downloaded from http://www.enedis.fr/la-valorisation-economique-des-smart-grids

Indeed, 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 COP 21 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 state of the grid, on consumption and production, at increasingly fine-grained geographical scales and time intervals. These data open up new possibilities for the energy transition at the level of local governance of grids, especially in its multi-fluid planning dimension (electricity but also gas and heat networks).

- 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 refine knowledge about constraints on the grid and thus 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 charging infrastructures; they constitute a real breakthrough.

Moreover, more and more data on annual consumption with a fine-grained geographical grid – maintaining 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 lead to data governance that is satisfactory for everyone and at the service of the energy transition. This means that there is need for clarity about data ownership and possible uses of data.

The smart meter: A major asset

The deployment of smart meters began on 1 December 2015 and will continue until 2021. More than 10 million meters have already been installed.

The investment of about €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 of 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.

The smart meter offers two key innovations over existing meters:

- A much more fine-grained measure of consumption and information on the quality of the electricity supplied;
- Two-way communication: it can send information and receive instructions using powerline communication technology.

The smart meter plays a fundamental role in grid modernisation by making it possible for grid operators to significantly increase the observability of the low-voltage grid, in particular by more fine-grained monitoring of the level of voltage on the low voltage network, as well as faster detection of consumption faults and anomalies.

The meter promotes the emergence of consumer control services, which it will support. It also supports the deployment of new pricing mechanisms, for greater transparency on the costs of the electricity system and encouragement of the right incentives, either 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 participate in the optimisation of the power grid and the means of production.

Measures:

- Refining the economic evaluation of smart grid solutions according to the beneficiaries (grid operators, producers, consumers), to target the most effective State support;
- Making best use of the services offered by smart meters, in particular by communicating more about their functionality;
- Encouraging the emergence of smart charging management solutions to facilitate the integration of electric vehicles.

5.6.5. Recharging infrastructures for alternative fuels

The development of alternative fuels, namely Natural Gas Vehicles, LPG-C, electricity, hydrogen, etc., represents an important lever for the transition of the transport sector, in particular for road and river transport. Indeed, these fuels can be used to limit the sector's dependence on petrol while diversifying energy sources. They also help 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 State and local authorities. Companies must be guaranteed visibility to facilitate investments in cleaner carburising vehicle technology.

Box 15: Alternative fuels

Alternative fuels are defined by Directive 2014/94 / EU on the deployment of an alternative fuels infrastructure, such as:

"Fuels or energy sources that serve, at least partially, as a substitute for fossil fuels in the transport energy supply and can contribute to the decarbonisation of these and improve the environmental performance of the transport sector. They include:

- Electricity;
- Hydrogen;
- Biofuels within the meaning of Article 2 (i) of Directive 2009/28 / EC;
- Synthetic fuels and paraffinic fuels;
- Natural gas, including biomethane, in gaseous form (compressed natural gas (CNG) and in liquefied form (liquefied natural gas (LNG)); and
- Liquefied petroleum gas (LPG)."

EU Directive 2014/94 of 22 October 2014 on the deployment of an alternative fuels infrastructure asked Member States to reflect on the evolution of these energy sources in the transport sector by drafting a framework for a national action plan. In 2017, France published its action framework, which laid the foundations for the development of these fuels.

The establishment and maintenance of a charging and refueling network infrastructure is a major challenge for the development of alternative fuels. The design of the distribution grid is adapted to each fuel: electric charging is structured between recharging at the homes of private individuals and public recharging, hydrogen recharging stations are structured above all through identified captive fleets, maritime LNG requires a specific development linked to use as a marine fuel and the NGV distribution grid is developing within general moves on European mobility. The LPG distribution grid is already structured and used.

Electric charging networks

The electric vehicle charging network must be developed while ensuring that vehicles are properly integrated into the energy distribution network. The public electric vehicle charging network is currently sufficient for the number of vehicles in circulation. Nevertheless, it could be undersized if EV sales evolve in line with targets. It is therefore necessary to continue the efforts made in public charging stations.

In order to scope needs, European Directive 2014/94 / EU of 22 October 2014 sets an indicative ratio of one public terminal per ten electric vehicles, i.e. a total of 100,000 public charging stations in 2022 if the sector achieves its objectives. However, this ratio must be adapted in response to the context. The form in Appendix 3 aims to put forward an assessment of the demand for 7kW/low power and 22kW charging terminals based on their geographical location; in particular, this approach helps to identify zones in which demand will be highest. The results of this simulation show that 2.2 million charging terminals will eventually be required to cover the needs of all vehicles (excluding moderate power charge), a ratio of 6.5 per 100 vehicles, one terminal for every 15 vehicles. This includes 0.8 terminals per 100 vehicles for charging at 22kW / high power. However, this distribution is not uniform across the whole country. Public charging requirements are higher in dense urban areas, where the number of private parking spaces is reduced. These urban areas are also of relevance for electric vehicles. It is therefore necessary to provide a dense public charging network. In rural areas, the dispersion of housing facilitates the installation of home terminals and the need for public charging essentially seeks to ensure geographical coverage. Finally, a network of charging terminals with 22kW / high power capacity will need to be developed along major routes, at regular intervals, to enable electric vehicles to travel long distances. This network must be large enough to absorb seasonal peaks. Particular attention must also be paid to the development, production and recycling of batteries.

Gas distribution networks

Natural gas vehicles

France has the largest network of CNG stations for trucks in Europe. The development of CNG stations is linked to biomethane development to ensure European mobility. The lack of natural gas refuelling stations is currently the main obstacle to the adoption of this mode of propulsion by road hauliers. The number of stations should be scoped to provide coverage of major road routes, as well as 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, but today it is about forming a more ambitious vision.

The form in Appendix 4 aims to scope the network of CNG stations in line with the SDMP timescales, to provide an effective network in the country to meet energy demand without unreasonable wait times at the stations while respecting a break-even point for the station. In order to meet the energy objectives of this SDMP, it is estimated that 138 and 326 are the minimum numbers of stations required in 2023 and 2028 respectively. Furthermore, the maximum number of profitable stations is estimated at 367 and 845 in 2023 and 2028 respectively.

Liquefied petroleum gas

LPG consumption in the world and in Europe is growing strongly. France is reporting very stable consumption. There is a dense European network. France is one of the only European countries where the network has decreased slightly in the last ten 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. The network is ready to accept bio-LPG: It is important to take advantage of the current situation.

Hydrogen

The development of hydrogen charging stations will continue based on the so-called "captive fleet" method, which involves helping to deploy stations near to those who choose hydrogen. Thus, the plan for the deployment of hydrogen is based on the roll-out of regional mobility ecosystems, in particular via fleets of commercial vehicles:

- 5000 light commercial vehicles and 200 heavy vehicles (buses, trucks, 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 2000 heavy vehicles and from 400 to 1000 stations by 2028.

Objectives and measures for developing charging infrastructures for alternative fuels

Sector	State of play (January 2018)	Objectives – 2023	Objectives – 2028
Electricity	22,308 public charging points	100,000 public charging points	
GPL-c	1750 stations	Vehicle fleet development only: The current infrastructure can ensure a 500% increase in fleet	
Hydrogen	Approximately 20 stations	100 stations	400 to 1000 stations
NGV (LNG and CNG)	82 refuelling stations (February 2018)	140 à 360 stations	330 à 840 stations
Maritime LNG	Le Havre (electricity) Marseille (3 stations)	Development in all major ports	
Quayside electricity	Marseille (3 stations)	On a case-by-case basis, using LNG at the quayside to supply electricity to all boats (more flexibility, higher power)	

Main measures:

- Revise the legislative and regulatory framework for NGV and hydrogen refueling facilities in order to facilitate the deployment and the control of electric charging stations by 2020;
- Encourage the development of electrical terminals thanks to a decrease in the TURPE, CITE and mobilisation of ESCs.
- Increase to 75% the maximum level of coverage, through the tariffs for the use of public electricity networks, of the cost of connecting public charging infrastructures to the public;
- Make mandatory the pre-installation of electric charging stations in all car parks with more than ten places of new or renovated buildings, and the equipment of all car parks with more than 20 spaces of non-residential buildings by 2025.
- Simplify the "right to take" for natural or legal persons using indoor or outdoor parking in condominiums.

6

Research and innovation to promote new energy technologies

6. Research and innovation for the development of new energy technologies

Challenges

The transition towards a low-carbon economy (low in material and energy consumption, very circular and carbon-free) makes the expansion of research and innovation activities in the energy field absolutely necessary, in order to develop technologies and patterns of behaviour which will contribute to reducing emissions, and to position France competitively on future markets for low-carbon goods and services.

Many needs specific to research and innovation have been identified:

- in the energy sectors, on energy decarbonisation, energy efficiency, energy storage, intelligent management of transport and distribution networks, as well as solutions to capture, store and reuse carbon;
- in the non-energy sectors, to improve processes aimed at “carbon” and environmental efficiency, and resource optimisation, recycling and reuse;
- on the health impact of the energy transition and new technologies, social innovations (change in behaviour, conduct and assimilation of the changes, etc.) and organisational innovations (public policies, etc.).

These needs, in terms of meeting the low-carbon transition challenge, will mobilise all the players involved in low-carbon research and innovation actions nationally, but also across Europe and internationally.

Existing plans and strategies

At international level, France is involved in the Mission Innovation initiative launched during the COP21 in November 2015 by presidents Hollande, Obama and Modi in the presence of around 20 heads of State. This is based on the recognition that innovation will be essential for long-term compliance with the commitments of the Paris Agreement and that acceleration is needed. It focuses on three objectives:

- double public financing of R&D into carbon-free energies between 2015 and 2021;
- strengthening cooperation between member states on these R&D actions;
- mobilising private investors to bring new solutions to the market.

As part of this initiative, eight thematic challenges (innovation challenges) have been launched on the following themes: smart grids, off-grid energy access, carbon capture/storage/recovery, advanced biofuels, conversion of solar energy into fuel, advanced materials, decarbonised heat and cold for buildings and hydrogen. France is involved in all of these challenges and is jointly leading the challenge relating to off-grid energy access.

At European level, the strategic energy technology plan (SET Plan) aims to introduce a European cooperation policy to accelerate the development and deployment of low-carbon technologies.

At national level, the French National Research Strategy (*Stratégie Nationale de Recherche*) is built around 10 great challenges for society, including three dedicated to the energy transition: “Careful resource management and adaptation to climate change”, “Clean, safe and efficient energy” and “Sustainable transport and urban systems”. The National Energy Research Strategy represents the energy section of the strategy. It comprises four guidelines:

1. *Target the key themes for the energy transition:*

This guideline reflects the governmental objectives (diversification of energy mix and development of renewable energies, strengthening of energy efficiency in all areas, reduction in use of fossil resources, etc.) by listing the associated scientific and technological challenges (flexibility of systems for the integration of renewables, multi-scale decentralisation and governance of energy systems, increased role of consumers, continued improvement of nuclear, etc.). In this respect, the following are proposed:

- expanding the interdisciplinary nature of the R&D (link between energy transition and digital revolution, environmental challenges and inclusion in the circular economy, health impacts of the energy transition and new technologies, economic and social challenges to involve consumers and support the decentralisation of systems);
- carrying out comparative analyses, in a systematic approach, of different flexible solutions in development (curtailments, managing production, storage, coupling networks and vectors, etc.) in order to gain a consolidated view of the technological options in the short, medium and long term. This research will support numerous short-term efforts on the different innovative means of production (e.g. marine energy) or demand management (e.g. materials and processes required for the energy renewal of buildings).

2. *Develop Research & Development & Innovation (R&D&I) in connection with the regions and industrial fabric, particularly for small and medium-sized businesses and "mid-caps" companies:*

Guideline 2 highlights the economic challenges of maintaining and improving the most competitive mature sectors and the development of new sectors, which are part of an international framework, beyond the needs of the energy transition in France. In order to accelerate the transfer of technologies from R&D centres onto the market, a collaborative approach between the public and private sectors and an experimentation phase are required. In particular, the following are proposed:

- scaling up the support approach to demonstrating new technologies and solutions, in particular in overseas territories in connection with the authorities (e.g. through the action of the next PIA3) and using all financial instruments (State aid or equity);
- supporting the development of SMEs/ETIs, not only with financial support (e.g. with AAPs such as the innovation contests, together with competitiveness centres) but also with market positioning support (establishing links with manufacturers);
- structuring French sectors by supporting the existing initiatives on a national level (cf. New Industrial France plans, strategic sector committees) by carrying out regular analyses of the positioning of French actors on the international stage and mobilising these actors to participate in global and European initiatives.

3. *Develop skills and knowledge for and by the R&D&I:*

Guideline 3 relates to developing skills for both the consolidation of an energy research community and for the information and training of different interested communities (professionals, civil society, decision-makers). A strong emphasis is placed on the multidisciplinary nature and constitution of a community of basic sciences for energy, including human and social sciences. The following are therefore proposed:

- strengthening international collaboration and the global visibility of actors in French R&D in the energy sector;
- developing thematic networks of researchers in order to build critical masses around existing laboratories of excellence, as well as focusing on major research infrastructures;
- developing modelling and foresight capacity in order to develop scenarios integrating the different dimensions of energy systems and to characterise and guide energy mix choices;
- developing new training programmes for energy transition professions, with the support of higher education establishments or institutes such as the Institutes for Energy Transition;
- involving civil society in demonstration projects in the territories and in feedback on these demonstrations in order to facilitate debate and choice of society and the adoption of technologies providing the best services.

4. *Create light-touch, effective governance to provide dynamic operational management of the National Energy Research Strategy.*

This final guideline highlights the need to coordinate the implementation of the National Energy Research Strategy (SNRE) with the existing initiatives at different geographic scales, from local (in particular at regional level) to international (in particular at European level with the Horizon 2020 programme and the SET Plan) and to consolidate governance for an efficient implementation across the strategy's development phase.

Support and funding

The annual total of public research funding from the French State in the domain of new energy technologies (renewable energies, energy efficiency, carbon capture and use, storage and networks) has been €440 million/year in the last few years, using the International Energy Agency's nomenclature. This is a little more than 40% of French research spending in the energy domain.

In parallel to funding public research organisations, the State supports R&D actions operated by ADEME (the demonstrator component in particular), BPI France, the *Caisse des dépôts et consignations* (CDC) and the National Research Agency (Institutes for Energy Transition, calls for generic projects). The state also funds innovation with short-term marketing potential via the Single Inter-Ministry Fund (*Fonds Unique Interministériel).*

Between 2010 and 2017, ADEME operated the first two components of the PIA: "Demonstrators of the ecological and energy transition" and "Vehicles and transport of the future", thus covering multiple themes divided into four main components:

- production of renewable energy, storing energy, and smart grids;
- energy efficiency in building, industry and agriculture, and biobased chemicals;
- circular economy and waste;
- all components of transport and mobility;

Different financing tools were implemented, calls for projects for demonstrators, SME initiative and equity interventions, making it possible to finance – through 85 calls for projects – 745 projects for a global amount of aid of €2.5 billion (overall project budget: €7.22 billion).

In line with PIA 1&2, ADEME operates several actions as part of the third component of the PIA (started in 2017), for a total amount of €1 billion:

- "highly ambitious territorial and innovative demonstrators", with €400 million of equity and €300 million of State aid (the CDC is also an operator with separate credits for the territorial component). For Ademe, this action constitutes the continuation of the PIA1&2 actions supporting "demonstrators of the ecological and energy transition";
- "innovation contests" for SMEs, with €150 million of State aid (the BPI is also an operator with €150 million, which must also cover the territorial component);
- support for "innovative ecosystems" in the sustainable mobility domain, with €150 million of State aid.

Incentives intended to stimulate research and innovation connected to renewable energy - Institutes for Energy Transition

The Institutes for Energy Transition (ITE) are public-private platforms that aim to constitute campuses of excellence bringing together academic research, large groups and SMEs on the specific themes of the energy transition to foster innovation by converging public R&D efforts and industrial strategies. Therefore, ITEs target the industrial development of an entire sector, from technological innovation to the demonstrator and industrial prototype.

Within the scope of the future investments programme (PIA), the National Research Agency (ANR) monitors the ten or so structures in the following domains:

- green chemicals and agrobased materials;
- renewable marine energy;

- solar energy;
- geothermal energy;
- smart grids;
- energy efficiency;
- sustainable building;
- decarbonised vehicles and mobility.

This programme is allocated a budget of one billion euros, financing up to half of all of the ITE's activities.

Box 16: An improved bilateral cooperation between France and Germany to foster the development of innovative solutions

In 2018, the French Ministry for Higher Education, Research and Innovation, via the National Research Agency (ANR), and the German Ministry for Education and Research (BMBF) launched a call for bilateral projects for energy storage and distribution (expected to be competed January 2019).

This call for projects aims to support the development of innovative, efficient and sustainable solutions for the storage and distribution of energy.

This is part of an improved cooperation between France and Germany in the energy domain. This partnership aims to stimulate innovation in France and Germany to contribute to the implementation of a sustainable energy system in Europe by 2050.

The call will support collaborative projects bringing together French and German partners whose upstream research (technical readiness level - TRL between 1 and 5) is aimed at developing economically, ecologically and socially efficient solutions for the distribution and storage of energy in France, Germany and the rest of Europe. It is addressed to both research organisations and businesses.

The expected projects should focus on one of the two main themes: 1. Conversion and storage of energy from renewable sources, 2. Smart energy (transport and distribution) networks. The themes addressed in this scope may contribute to achieving the objectives shown in the SET Plan batteries and storage action plan.

Analysis of practices and lifestyles to better involve "consumers" in the ecological and energy transition

Beyond simply technological progress, the question of behavioural changes, and more generally, the evolution of our lifestyles, is a key challenge for the ecological and energy transition. Emerging new technical solutions require new organisations that must be accepted by all stakeholders and fit into social dynamics that are not necessarily convergent.

As a result, there is now a consensus on the need to develop practices on an individual and collective scale. However, the actions to be implemented to achieve the set objectives remain complex to define.

Indeed, faced with the multitude of tools available (information, communication and education, support for change, financial incentives, regulatory and legal requirements, services and products), it is necessary to identify the most effective levers, particularly in terms of practices and social categories.

It is also a question of better understanding the obstacles to the change and the diffusion of the technologies and at the same time characterising the economic, political, institutional and legal stakes that condition the emergence of the factors of success and social acceptability.

Finally, the rise of digital technology allows access to data that is incommensurate with previous practices that should be used to best support the energy transition. However, this technology is not always accepted.

Therefore, there is still a need to further knowledge and understanding of behaviours within the individual and collective spheres with a view to devising methods and tools to support the evolution of these behaviours.

For this reason, these issues are considered as decisive for the success of the French ecological and energy transition and are at the heart of the national energy research strategy and are the subject of numerous joint actions led by research actors in the domains of energy and social sciences.

At national level, research units focus on the social and political issues of energy and the environment. In addition, the Energy Unit of the CNRS has put in place a thematic group "GT9 - Sociology and economic foresight" with the objective of identifying sociological issues in matters relating to energy, pooling knowledge and approaches, and contributing to reconciliation between engineering and human sciences. In concrete terms, the calls for projects of the non-thematic energy unit encourage the submission of projects on the socio-economic aspects of energy and select at least two projects each year on this theme.

In addition, the National Alliance for Coordination of Energy Research (ANCRE) leads joint actions with its counterpart the National Alliance for Human and Social Sciences (ATHENA) through its programmatic group "Foresight and energy economy". In this way, the SHS dimension has been integrated into the different energy scenarios established by ANCRE.

At European level, the national energy and human and social science contact points of the Horizon 2020 research framework programme are engaged in a regular dialogue in order to promote the integration of French partners in transversal projects.

Objectives and measures:

- Continue and expand support for R&D and innovation for the energy transition, in particular by means of the Future Investments Program, in coherence with the main guidelines formulated by the Innovation Council, implemented in 2018;
- Confirm the commitments taken on as part of the Mission Innovation and in particular increase public funding of R&D in order to speed up the development of technologies serving the energy transition;
- Consolidate French participation in large international research programs and particularly in the upcoming Horizon Europe framework program;
- Develop new training for energy transition professions, with the support of higher education establishments or institutes such as the Institutes for Energy Transition.

Box 17: Examples of R&D actions encouraging the deployment of renewable energy and reduction in energy consumption

Competitiveness of green hydrogen production:

Hydrogen is of major interest as an energy source for the energy transition – a role which currently remains underdeveloped. It can be used to produce electricity for the national grid or for transport, and is also an energy storage solution, notably for electricity, which will be one of the major challenges for the energy systems of the 21st century. Hydrogen as an energy vector therefore represents a significant scientific, environmental and economic issue.

Electrolysis technologies facilitating the production of hydrogen from renewable energies are now reaching maturity, as evidenced in particular by the decrease in costs observed in recent years (-75% since 2010). However, in order for green hydrogen production to reach costs comparable to those obtained by conventional methods (steam reforming) by 2030, support for R&D and innovation remains essential.

Put the digital revolution at the service of the energy renewal of buildings:

In France, the building sector accounts for almost 45% of end-use energy consumption and 27% of greenhouse gas emissions. Its contribution to the transformation of our development model for energy efficiency is therefore imperative and involves reducing the energy needs of buildings, the use of efficient systems to limit energy consumption and finally the deployment of renewable energies. To do this, the ability to modernise the entire building sector by supporting innovations and their dissemination to a maximum including artisans, is a major issue.

Digital technology is an unprecedented opportunity to develop innovations in the building industry. As an example, the digital model (BIM: Building Information Modelling), already common in the new construction sector, and developing in the field of renovation, will provide better knowledge of the building. On the one hand, this will make it possible to optimise work and subsequent renovations (fewer errors in the work or renovations, less waste, fewer greenhouse gas emissions), but also to better target the works, in particular to reduce greenhouse gas emissions. More generally, the data revolution in building must make it possible to have better knowledge, better understand, better diagnose and ultimately better deal with the energy issue. Connected objects and the smart management of buildings or blocks of buildings, but also artificial intelligence offer the prospect of radical progress for the identification of priority renovations and relevant work or for the control of uses and changes in behaviour.

Make grids smarter to allow for massive integration of renewables and the development of electric mobility:

Over a half of new electricity generation facilities currently constructed in Europe are renewable energy facilities, with different constraints on the grids than fossil fuels. In the medium term, this new situation will require profound changes in the structure of transport and distribution grids and their operation.

Increasing the penetration rate of variable renewables will lead to more decentralisation and flexibility of supply, requiring optimised grid management. From this new perspective, innovation will be essential, especially to develop multi-form storage capacities, integrate electric mobility, enhance interactions between different energy vectors, share maintenance information concerning individual devices on the high-voltage central grid, and share and optimise the data distributed by the network.

7

To maintain the purchasing power of final consumers and the price competitiveness of the energies, assessment of the needs in new skills

7. Protection of consumer purchasing power and competitive energy prices, assessment of professional skills requirements

7.1. Macro economic issues and socio-economic impacts of the MAEP

The Three-me Model was used to assess the macroeconomic impact of the scenario put forward in the National Low Carbon Strategy (Stratégie Nationale Bas Carbone, SNBC). The SNBC energy consumption scenario is the same as that of the MAEP up to 2028. It should be noted that the SNBC measures covering reductions in greenhouse gas emissions other than those associated with energy combustion in agriculture or forestry in particular, do not feature in the MAEP but form part of the scenario whose macro-economic impact was modelled. For ease of expression, this scenario will be referred to as the "MAEP Scenario" in what follows in this paragraph because it corresponds to the MAEP timeline and because the MAEP measures have an over arching impact on all of it.

Box 18: the Three-ME model, a "hybrid" macro-economic approach

The Three-ME model has been in development since 2008 by the French Economic Policy Observatory (Observatoire français de conjoncture économique, OFCE) and the French Environment and Energy Management Agency (Agence de l'Environnement et de la Maîtrise de l'Énergie, ADEME) and is used to assess the MAEP. It is a calculable Keynesian general equilibrium model in the sense that price dynamics and money supply account for short-term imbalances on markets, particularly the labour market, and that the interest rate on the financial market is set by the Central Bank. It is also hybrid in that it reconciles a classic top-down approach with a bottom-up approach which consists of providing a microeconomic basis for household decisions regarding energy consumption, heat efficiency renovations and house and vehicle purchases. In this hybrid block, the vehicle and housing stocks are also modelled, broken down by efficiency class, allowing for very detailed measurements of the economy's CO_2 emissions.

The Three-ME model is multi-sectoral: it considers 24 economic sectors (agriculture, iron and steel, energy production, rail transport, non-market services, etc.), making it possible to analyse the effects of activity transfers from one sector to another (in terms of employment, investment, imports, etc.). Finally, the Three-ME model considers four production factors (capital, work, intermediate consumption and energy) and 17 types of energy (oil, biofuel, nuclear, gas, geothermal, wind, etc.) that are more or less able to be substituted.

Featuring 14,000 equations and 70,000 parameters, the model is characterized by the following equations:

- **Prices**: the notional price is obtained by applying a mark-up rate, that is itself variable, to unit production costs (mark-up theory);
- **Real interest rates**: they are set by the monetary authorities (Taylor's rule);
- **Investment**: it depends on expected production, its past dynamics, substitutions between production factors. In the short term, the capital stock is deducted from the investment according to the standard capital accumulation equation and, in the long-term, results from the optimisation of production factors;
- **Wages**: they are determined by the Wage-Setting curve which establishes a relationship between the unemployment rate and the level of real wages, also taking into account the expected consumption price and labour productivity;
- **External trade**: the imperfect substitution between domestic products and imported products (cf. Armington) is characterised by the relative prices, a substitution elasticity and the level of aggregate demand;
- **The State**: it behaves in an exogenous way, which leads it to spend at the market price, to pay its employees the market wage or even to subsidise a sector according to predetermined dynamics;

- **The function of production**: companies minimise their costs using a "generalised" CES function (Constant Elasticity of Substitution) and three trade offs: between the different production factors, between the different types of goods and the different energy vectors (the electricity mix being exogenous) and between domestic products and imported products;
- **The function of consumption**: households first determine the amount of their house and vehicle investments by taking into account the associated user costs (amortisation of the net purchase price of aid, share of self financing and borrowing, cost of energy consumption, etc.). Notably, the total demand for housing (in m²) grows with the population and that of transport grows with income and the relative fuel prices. The consumption of goods other than energy is modelled using a generalised Linear Expenditure System (LES) type utility function which takes into account incompressible consumption and an optimised trade-off between different consumer goods.

It should be noted that the results presented here are not comparable to those of the assessment of the first MAEP: an additional 1% GDP growth rate cannot be interpreted as a revision upwards of the macro economic projection for the MAEP adopted in 2016. Indeed, the results should be understood as an upwards or downwards difference compared to a "with existing measures" scenario. Hence, the 2018 "with existing measures" scenario is no longer the same as the one assessed in 2016, because it takes into account all the measures adopted by the government on 1st July 2017.

	2023	2028
GDP	1.3	1.9
AV of the market sector	1.8	2.4
Consumption by households	0.4	1.3
Purchasing power of households	1.1	2.2
Jobs (number)	246,000	413,000
Trade balance (% of GDP in value)	0.2	-0.1
Energy bill (% of GDP in value)	-0.6	-0.9
Government balance (% of GDP in value)	0.5	0.8
Cumulative investments (from 2018)	€93Bn	€271Bn

Table 46: Main results of the macro economic assessment (in % deviation from the "with existing measures" scenario excluding jobs, the government balance and investments)

Revitalisation of economic activity: 1.9% GDP growth

GDP should grow by 1.3 % more in 2023 with the measures adopted by the MAEP than if they had not been adopted and by 1.9% in 2028. The rise in GDP should be in the order of +0.2% per year on average, driven by growth in internal demand. In fact, investments in energy efficiency exert a positive knock-on effect on the economy: production grows which stimulates job creation and a rise in consumption which has a positive retroactive effect on the activities of all sectors. A cumulative virtuous circle is unleashed in conformity with the investment multiplier theory.

The renewed economic activity is accompanied by a rise in inflation. That can be explained by three reasons:

- Producers pass on wage increases to their prices;
- The energy efficiency investments in industry and the tertiary sector and the transition from fossil fuel consumption towards electricity stimulate, in the short term, a rise in the unit cost of production which also generates a rise in prices;
- Rising demand encourages companies to increase their margins which makes their products more expensive.

Over the 2019-2023 period, surplus investment in the French economy compared to the business-as-usual scenario should be in the order of 93 billion euros, and in the order of 270 billion euros over the 2024-2028 period

Inflation reduces the competitiveness of companies compared to foreign competition. The price of exports increases by + 1.6% in 2023 and + 5% in 2028 compared to the WEM. Thus, lower volumes of goods are exported but they are sold at higher prices. In parallel to this, the increase in consumption leads to a rise in the level of imports.

It should be noted that if companies lose in terms of competitiveness compared to their foreign competitors, the rise in internal demand is sufficient to push up the added value of the market sector by about 1.8% in 2023 and about 2.4% in 2028. The MAEP measures have either a neutral or an upward impact on the added value of most industrial sectors. The sectors that experience a drop in activity are those dealing in transport, fossil fuels and nuclear.

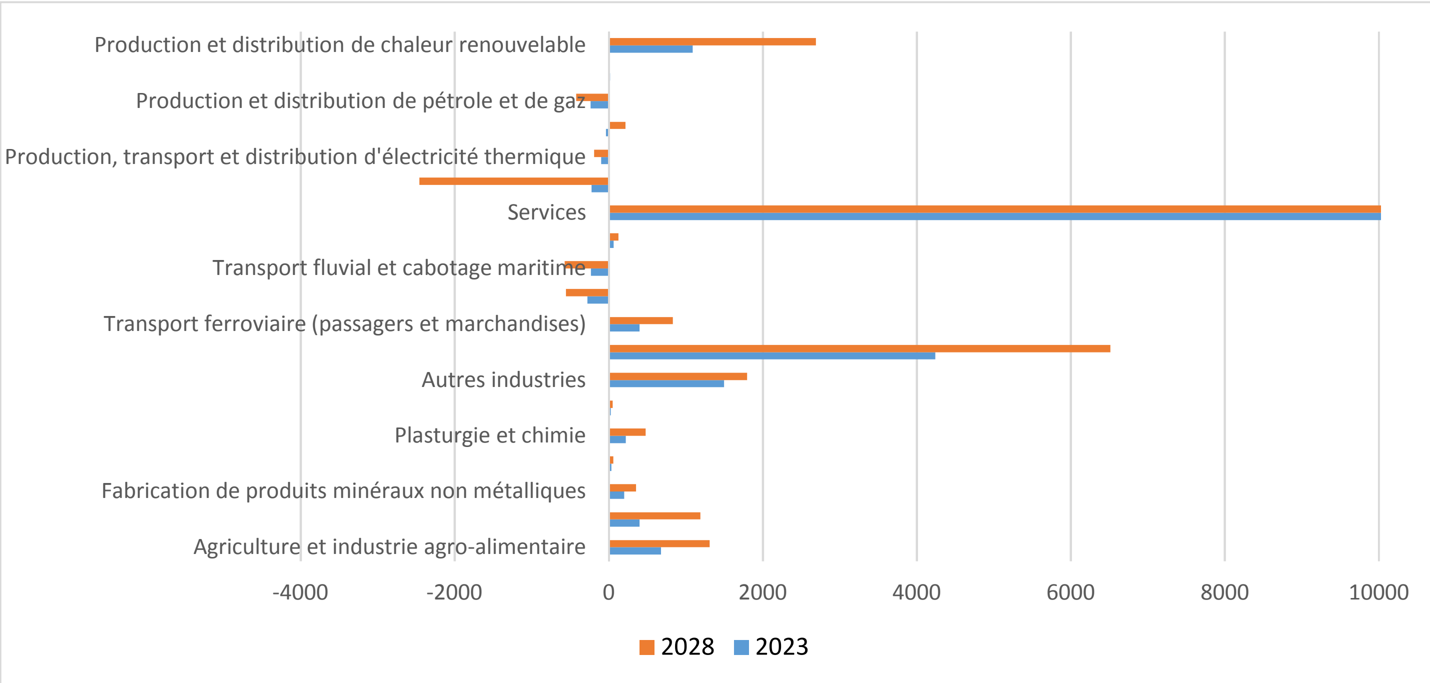


Figure 77: Changes to added values for sectors in €mn

NB: the services sector is the one that grows the most strongly. The scale of the graph has been adapted to make changes to other sectors visible. Consequently the changes in the service sector do not appear correctly: they are in the order of +€$_{2015}$24bn in 2023 and +€$_{2015}$35bn in 2028.

The rise in volume in internal demand, therefore, easily compensates for the reduced exports.

Creation of 413,400 jobs

Relaunching productive activity creates jobs: 246,000 additional jobs should be created in 2023 and 413,000 in 2028.

A growth in employment across all sectors in the economy except for the fossil fuel and combustion and nuclear power stations sectors as well as in road transport of goods.

The majority of indirect and induced jobs are created in the tertiary sector since it represents 80% of GDP.

The purchasing power of households rises by 2.2%

Falling unemployment fosters real wage increases. Ultimately, household purchasing power rises by 1.1% in 2023 and 2.3% in 2028. A lower energy bill for operators also encourages a rise in consumption expenditure to the benefit of other sectors of the economy, which pushes up internal demand and has the effect of increasing companies' productions.

Trade balance stability

Supposing that France is combating climate change alone, its domestic prices go up by 1.3% in 2023 and 3.3% in 2028. In parallel, the average weighted price for French imports goes down by 0.8% compared to the WEM, since fossil fuel purchases are reduced. At the same time, the prices in France are relatively higher than elsewhere.

However, we consider that the rest of the world will also engage in the fight against global warming. In the model, this has been incorporated by supposing that 80% of the rise in domestic prices, forecast in the France-acting-alone scenario, would also be passed on across foreign prices. However, the exogenous inflationary increase for prices of imported goods barely reduces the relative gap between the rises in domestic and foreign prices. That can be explained by two reasons:

- The rise in foreign prices entails a rise in the price of imported intermediate consumption by French companies, which they pass on in part across their domestic prices;
- The rise in foreign prices limits the deterioration of the trade balance, which increases the rise in GDP. At the same time, this return to growth engenders a rise in real wages which is passed on to domestic prices. This second-time-around additional inflationary effect has not been taken into account in the calibration of foreign prices.

Overall, the trade balance remains stable thanks to the joint effect of the changes in imports/exports (decrease in volume but increase in value) and the fall in the fossil fuel bill.

Public finances improvement: +0.6% GDP in 2028

Thanks to the growth-led revival, the energy transition will also be beneficial to public finances in spite of:

- the loss of energy taxation revenue resulting from the decarbonisation of the economy;
- the rise in investments in public building insulation;
- the payment of subsidies.

The payment of subsidies is compensated by the resurgence of revenue generated by the increased activity. By way of example, with a 25% public assistance rate for exterior wall insulation, €100 of work gives rise to €25 of additional public expenditure. Even supposing that a 50% deadweight effect exists (cf; The French Environment and Energy Management Agency's MENFIS model), and that half of this work would have been done without tax credits, the CITE thus generates €50 of additional turnover for the buildings and public works sector (Bâtiment et Travaux Publics, BTP). Because this sector imports very little intermediate consumption from the rest of the world, this €50 entails a nearly equivalent rise in GDP (all things being otherwise equal, excluding multiplier effect, as long as households do not reduce their spending at all or only by very little, which is the case when they borrow to finance their investments). Because the compulsory tax rate on GDP is about 45%, the State collects almost €24 of additional revenue, not counting the additional revenue generated by the knock-on effect of the construction industry on the rest of the economy.

The government balance will improve by 0.5% of GDP in 2023 and by 0.8% of GDP in 2028.

7.2. Protection of household purchasing power

7.2.1. Impact of the MAEP on households

Although households can be impacted, at a constant energy consumption, by certain measures intended to encourage the energy transition, it is crucial to enable them to participate in this transition as best as possible and contribute to it while protecting their purchasing power. The actions intended to help them lower their consumption will lead to a reduction of the overall household bills in spite of any rise in price. Special attention must be paid to the most vulnerable households in order to ensure the energy transition is socially inclusive.

In order to achieve this goal, incentives must been put in place to enable households to improve the energy efficiency of their homes and their journeys, thus reducing their energy consumption and, as a consequence, their bills. These provisions have three goals:

- to support households and give them incentives to continue on their path towards energy transition;
- to limit the impact on households' purchasing power;
- to protect the most vulnerable households, in the interests of social justice.

In this context, several existing measures will be extended and others will be introduced both for housing and for mobility.

The MAEP relies on tax incentives aiming to foster "virtuous" behaviours, by encouraging users of the most polluting energies to turn to cleaner ones.

To support households in their efforts to adapt their homes to the energy transition, provisions have been put in place at two levels:

- an awareness raising and information drive will be conducted when the schemes are rolled out and implemented. This, for example, is the goal of the FAIRE (Facilitate, Accompany and Inform for Energy Renovation) campaign led by the French Environment and Energy Management Agency;
- several schemes aiming to help households to fund improvements to the energy quality of their home: amongst the main tools are the CITE, and ANAH's "Habiter mieux" (Live better) programme which in 2018 continued to improve the support it provides to households for renovation. These provisions provide help to households, by targeting those with the lowest incomes as a priority, to undertake building work to improve the energy performance of their homes, in order to bring down their energy consumption and, therefore, their bills.

Mobility is the other major cornerstone of the energy transition for households, all the more important because mobility will have to change both in its forms and its modalities in the years to come. Two wide-reaching measures have been implemented to speed up the renewal of the car fleet in favour of new vehicles that are more environmentally friendly by granting enhanced aid to the most disadvantaged households:

- The bonus for acquiring a new electric vehicle is kept at a high level (27 % of the purchase price limited to €6,000) while progressively incorporating technological and usage advances;
- Starting from 1st January 2018, the premium for vehicle conversion can go up to €2,500 per person for the purchase of a new electric vehicle. In 2019, the premium will be extended to continue replacing the many aging vehicles on the road with new or second-hand vehicles with much lower emissions:
  - The cap on emissions for admissible bought vehicles has been lowered (from 130 gCO2/km in 2018) to 122 gCO2/km;
  - The premium is doubled for the lowest income households and for persons not subject to taxation living at least 30 kilometres from their workplace or obliged to make long journeys as part of their professional activity: €4,000 for a thermal vehicle and €5,000 for an electric or rechargeable hybrid vehicle, new or second-hand;
  - the premium is further enhanced to make conversion to an electric or rechargeable hybrid vehicle more attractive;
    - €2,500 for the purchase of a second-hand electric vehicle for households below the tax threshold (against €2,000 in 2018);
    - €2,500 for everyone for the purchase of a rechargeable hybrid vehicle (against € 1,000/€ 2,000 respectively for taxable and non-taxable households in 2018);
    - €2,500 for the purchase of a second-hand rechargeable hybrid vehicle for households below the tax threshold (against €2,000 in 2018)

Another measure aims to put in place a "sustainable transport stipend" which will enable private and public employers to make contributions to the car sharing or cycling commute costs of their employees. This stipend could go as high as €400/year, exempt from tax and social security contributions. The State will roll out the sustainable transport stipend to all its employees, between now and 2020, at €200/year. Cycling could also be reimbursed as travel expenses for trips made by employees for professional reasons during job-related journeys.

An affirmation of the right to mobility is reflected in the effort to provide egalitarian infrastructure and mobility services across the territory, principally by enhancing the organisation of services by public transport networks or mobility solutions appropriate to regions with low population densities. It also involves keeping a proper and constant lookout for problems of accessibility to these services, principally for disabled persons or those with reduced mobility, but also for persons in situations of economic, social or energy vulnerability who may require dedicated support schemes.

Alongside these two key measures, the government is introducing financial incentives which will allow the authorities in charge of mobility to organise mobility services themselves or to contribute to the funding of mobility services of a social nature, and also to allocate individual mobility aid in order to facilitate individualised support for vulnerable people, in particular to access jobs and training. Development

The progressive development of tenders for aggregated distributed load shedding, accompanied by calls for load shedding tenders, while placing residential electricity consumption at the service of network balance, will enable private individuals to develop new means of levering competitiveness over electricity prices, with improved purchasing power and better energy consumption management.

To protect the most vulnerable households in the interests of social justice, the government expanded the scope of the energy cheque in 2018 with a higher average amount than the social energy tariffs that the scheme replaces. The number of eligible households will be expanded to reach the 20% of households with the lowest income, i.e. an extension to 2.2 million households and an increase in the energy cheque by €50 from 2019 (cf. below 6.2.2.)

Low income households can also benefit from a departmental version of the socially inclusive housing fund assistance. Energy suppliers are also encouraged to keep disadvantaged people in mind by means of the poverty ESCs, reworked and enhanced in 2018 (see below). These ESCs will facilitate the deployment of programs supporting the transition to sustainable mobility for isolated areas and communities in vulnerable economic or social situations. The fuel poverty requirement for the new 2018-2020 period of the ESCs has been brought to 400 TWh_{cumac} in addition to the original requirement of 1200 TWh_{cumac}. Energy providers will then be required to invest more than €2bn to combat fuel poverty, taking all sectors together.

In this way, the government is introducing tools aimed at households so that the MAEP objectives can be obtained in the best conditions of social inclusivity and justice.

Measures:

- Increase the vehicle conversion premium for lower-income households by immediately moving the goal for replacing old vehicles from 500,000 to 1,000,000 over the five-year presidency, with a doubled premium for households below the tax threshold and quadrupled for very low-income households (as well as non-taxable motorists with big mileages), while working on attractive loans to finance what remains to be paid;
- Develop public transport, car sharing and alternatives to individual car use more generally over the whole territory as soon as possible, while targeting the most vulnerable groups;

- Mobilise the energy savings certificates to help lower income households, in order to reduce consumption by buildings (boosting and extending the energy saving helping hand) and mobility (support for car sharing and develop bike use, address the mobility needs of households in disadvantaged circumstances).

The lowest income households will be the most marginalised by the energy transition

For households, the energy transition requires an effort that is inversely proportional to their level of income: the effort is considerably higher for the lowest income households. The lowest income households on average pay lower bills than the highest income households: their homes are smaller and therefore consume less energy, and they also run fewer vehicles. Nevertheless, in proportion to their income, energy bills have a much greater impact on their budgets. By way of example, in 2015, the total energy bill amounted to €2,200 per year for the 10 % of lowest income households (1st decile) as opposed to €3,600 for the 10 % of highest income households (last decile). However, in proportion to their income, the energy effort rate (Taux d'effort énergétique, TEE) for 1st decile households is three times higher than for households in the last decile (an average of 16 % as opposed to 4 % in 2015).

For some low income households, expenditure on energy for the home presents such constraints on their budget that they can be classed as in fuel poverty. In France, the so-called "Grenelle II" law of 2010 defined this phenomenon as follows: a person in fuel poverty experiences particular difficulties availing of the requisite energy supply to meet their basic needs because of the inappropriate nature of their resources or their housing conditions. This legal definition of fuel poverty incorporates problems with paying for energy used in the home, but it does not take into account fuel expenditure for mobility. This is why we are also interested here in a phenomenon which we will call "energy vulnerability" which includes all energy expenditure, both for housing and transport.

Two indicators have been defined to monitor the impact of the MAEP on these two phenomena. They are both based on the energy effort rate (TEE, i.e., the percentage of energy spending in the household's income):

- a monitoring indicator for fuel poverty[89] which, amongst the 30 % of the lowest income households, measures those who devote more than 8 % of their budget to home energy costs.
- A monitoring indicator for "energy vulnerability"[4] which measures amongst the 30% of the lowest income households those that devote more than 16% of their budget to total energy costs (for their home and transport).

In 2015, according to these two indicators, 11.3 % of households were in fuel poverty and 9.6 % in a situation of "energy vulnerability". The energy cheque, which is there to take the weight of energy bills off the shoulders of the lowest income households, is taken into account again here: it helps reduce the energy effort rate in the home and, consequently, the total energy effort rate.

The planned €50 increase to the energy cheque for 2019 aims to reduce the impact on people in fuel poverty: the fuel poverty rate increases to 11.8 % in the baseline scenario as opposed to 12.0 % in the business-as-usual scenario. By contrast, if the whole bill (housing and transport) is taken into account, energy vulnerability increases more in the baseline scenario than in a business-as-usual scenario (12.0 % as opposed to 11.4 %).

In 2023, the fuel poverty rate will be the equivalent in the scenario including the MAEP measures (11.7 %) to the rate in a scenario without the MAEP. The impact of the impetus given by the MAEP will be one of reducing fuel poverty over the longer term. In 2025, the indicator will decrease in absolute terms in comparison to 2023 (11.8 %) and in relative terms in comparison to a situation where there is no MAEP (11.5 %). The positive effects of the transition will be felt afterwards for those in fuel poverty: 11.4% in 2020 and 11.2% in 2030, as for a business-as-usual scenario. In the longer term, the effects of the MAEP on fuel poverty are better than the status quo.

These results underline the need for redistribution mechanisms during the period of energy transition, to help households marginalised by this transition, particularly the lowest income households. This is the goal pursued by expanding the base of households eligible for the energy cheque, and increasing the amount in 2019 (cf. below).

Household investments

The MAEP presupposes investment costs, for which a part will have to be paid by households: energy renovation costs excluding state housing benefit, vehicle purchase costs, batteries for electric vehicles, "household" charging points. These investments will enable energy savings to be made later.

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[89] This indicator, based on an energy effort rate threshold for the 30 % of lowest income households, is a commonly used indicator for monitoring fuel poverty (TEE_3D). Until recently the national observatory for fuel poverty monitored this indicator with a 10 % threshold. However, this 10 % threshold, defined by fairly old British academic work, is considered obsolete and not appropriate for the current French situation. Rather, an 8 % fixed threshold has been suggested, corresponding to twice the median rate for home energy effort observed recently in France. In the same way, to define the monitoring indicator for energy vulnerability, we keep the 16 % threshold which corresponds to twice the total energy effort rate median.

if we compare the average bill increases and the year-on-year investment costs that households are responsible for, the MAEP balance is no longer neutral in 2030 for households in terms of financial costs since the average impact rises to nearly €200 (figure below). The 2050 timeline on the other hand looks generally favourable.

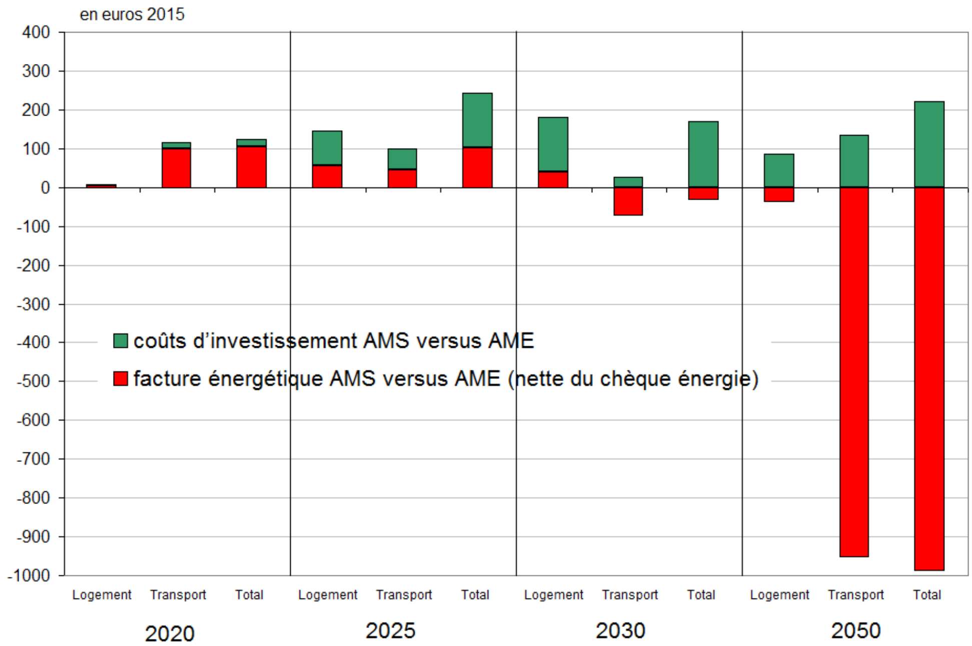

Figure 78 – Total bill surcharges vs year-on-year investment costs for households WAM/WEM

source: Commissioner-General for Sustainable Development (Commissariat Général au Développement Durable, CGDD) (Prometheus-framework MAEP-SNBC)

On an individual level, the households with the means to cover the investment costs will be able to undertake the energy transition and therefore will see their energy bill go down. Inversely, bills will increase for households that not have changed their energy consumption, but they will not have any investment costs to cover . On the other hand, renovation costs in particular will feature heavily in 2025-2030, but these costs can be considered to be relatively "sustainable" in comparison with investment costs connected with transport.

It is effective to invest to reduce one's energy bills but the lowest income households do not have enough savings for that. That is why it is important for the State to provide specific incentives for households on the lowest incomes to assist them in investing in renovations or equipment which will help them significantly reduce their future energy bill. All the energy management incentives take this route: higher premiums for purchasing low emission vehicles; replacement of the tax credit by a renovation premium etc.

Box 19: Regulated sales prices (Tarifs Réglementés de Ventes, TRV)

Between 1999 and 2006, several laws transposed European directives onto French energy markets by stages. In this way natural gas and electricity markets have been gradually opened to competition, starting in 1999 for the very high energy consuming companies, and this process was finished on 1st July 2007 for all natural gas and electricity consumers.

In this context, an Energy Regulatory Commission was also put in place. It is an independent administrative body responsible for ensuring that energy markets work properly.

Currently, two types of tender exist on the French natural gas and electricity market:

- regulated sales prices that are proposed by the incumbent suppliers, the level of which is fixed by the State or by the Energy Regulatory Commission. By design, these prices reflect supply activity costs. Since 2016, these regulated tariffs only exist for consumers whose consumption does not exceed 30 MWh/year for natural gas and, for electricity, whose subscribed power is less than or equal to 36 kVA;
- market offers, which may be proposed by alternative suppliers or by the incumbent suppliers. These offers can be fixed price or variable price, and can be indexed to the regulated sales tariffs or to other products (spot prices…), or evolve according to a formula specific to the supplier.

The decisions of the Council of State on regulated tariffs will lead to the evolution of the associated provisions. Indeed, State intervention on prices is only possible if it enables general economic interest goals to be achieved (for example security of supply, guarantees of a stable and reasonable price, social and territorial cohesion) and if this action is proportionate with regard to this goal. Such regulated tariffs exist in other domains of the economy where this intervention is justified (price of medication, price of fuel in French Overseas Departments and Territories etc.).

In terms of natural gas, the Council of State considers that regulated sales tariffs for natural gas do not fulfill the necessary conditions for a State intervention on prices. Indeed, regulated sales tariffs for natural gas were judged to be contrary to European law and competition law by the Council of State in a decision dated 19 July 2017.

Within this framework, because of the large numbers of consumers subscribing to a regulated sales tariff contract, it has been suggested that legislative and regulatory changes are done in a gradual manner in order to allow consumers to acquaint themselves with market data and to make the best choice for a new contract, whilst allowing competition to operate freely in this transition.

The plan is thus to prohibit the signing of new regulated sales tariff contracts once the legislative provisions have been enacted and to gradually make existing contracts obsolete, one year after enactment of the law for professional customers, and in 2023 for residential customers. At the end of these time periods and to protect consumers from being cut off, the contracts of customers who have not spontaneously opted for a market offer will automatically revert to a market offer from their incumbent operator.

It is also envisaged that these provisions will be accompanied by measures to create benchmarks and protect consumers, by providing them with information on the elimination of regulated sales tariffs for natural gas, as well as reliable, independent and transparent tools to give them a clear view of all the available market offers (by enhancing the market comparison tool made available by the energy mediator), and all the retail energy markets (by asking the Energy Regulation Committee to publish a reference price for gas supply). In the interests of consumer protection, schemes are also planned to ensure emergency supply to consumers in case of failure of their supplier, or as a last resort, in cases where the consumer cannot to find an offer on the market.

The end of regulated tariffs for gas may also be an opportunity for consumers to benefit from the most competitive offers. Indeed, the market offers for gas are nowadays often 5 % to 10 % cheaper than the regulated offers.

As regards electricity, the Council of State has accepted in principle the existence of regulated sale tariffs for electricity (decision of 18 May 2018) because they can guarantee a stable electricity price where electricity is considered a "basic need". The Council of State has nevertheless criticised these regulated electricity tariffs on account of their permanent nature and absence of a periodic reassessment of their necessity, and because they apply to all end-use consumers whose subscribed power is less than or equal to 36 kVA, in particular non-residential sites owned by big companies.

Measures:

- The Government will propose the legislative and regulatory measures necessary to adhere to the State Council's decision and eliminate gas regulated sales tariffs.
- The implementation procedures for electricity regulated sales tariffs will be revised in order to schedule a periodic re-appraisal of their necessity and to exclude sites owned by big companies from benefitting from them. The Government will propose the necessary legislative and regulatory changes.

7.2.2. The measures to combat fuel poverty

Energy bill payment aid: energy cheque

The energy cheque is a payment voucher issued to the lowest income households to combat fuel poverty. This scheme, created by article 201 of the Energy Transition for Green Growth Act (Loi relative à la Transition Énergétique pour la Croissance Verte, LTECV) of 17 August 2015, has replaced the social electricity and gas prices since 1 January 2018. It has a twofold objective:

- to provide a more equitable system than the social energy tariffs, which benefits all households in fuel poverty equally, regardless of their heating energy;
- to significantly improve target attainment, hampered in the previous system by the complex file duplications inherent in the social tariff system.

The energy cheque is assigned based on a single tax criterion, taking income level and household composition into account. It enables the eligible households to pay their energy bills, whatever means of heating they may use (electricity, gas, heating oil, wood, etc.). If they wish, the beneficiaries may use the cheque to fund part of the energy-saving building work that they undertake in their home.

The energy cheque was trialed in 2016 and in 2017 in four departments (Ardèche, Aveyron, Côtes-d'Armor, Pas-de-Calais). The average amount of aid is close to €150, modulated according to family composition and the level of reference fiscal income (Revenu Fiscal de Référence, RFR). The eligibility criteria are:

- the reference fiscal income level per consumption unit (it must be less than 7,700 euros/CU/yr);
- the number of consumption units (CU) in the home;
- the fact of having a home that is subject to housing tax (even if exemptions are provided for in certain cases).

	RFR / CU < €5,600	**€5,600 ≤ RFR / CU < €6,700**	**€6,700 ≤ RFR / CU < €7,700**
1 CU (1 person)	€144	€96	€48
1 < CU < 2 (2 or 3 persons)	€190	€126	€63
2 CU or more (4 persons or more)	€227	€152	€76

Table 47: The 2018 amount for the energy cheque, based on the reference fiscal income (RFR) and household composition (Consumption Unit[90])

90. CU: consumption unit (the first person in the household counts as 1 CU, the second 0.5 CU and the others for 0.3 CU).

The results of the experiment are very encouraging: more than 82 % of energy cheques were used by the beneficiaries for the 2017 campaign, exceeding the number of households benefitting from social tariffs in these regions. The energy cheque was rolled out nationwide in 2018 to 3.6 million beneficiaries. The government has decided to increase the value of the energy cheque and modify its scope in 2019 to limit the impact of the future rises in environmental taxation on these households. The energy cheque amounts paid in 2018 will therefore be increased by an average of €50 after 2019. What is more, the income ceiling for eligibility for the energy cheque will be raised so as to include 2.2 million additional households in the 2019 mailing campaign.

For future years, in order to improve beneficiary cover, two other changes have been planned. The first is to set up specific aid for social housing, in order to include the approximate 100,000 residents in the schemes to combat fuel poverty, starting from 2018. The second is the automatic granting of associated safeguards, which aim to ensure that beneficiaries of the energy cheque also enjoy the rights which are attached to it.

Measures:

- Increase the value of energy cheques (*chèque énergie*) from 2019 onwards: the sums paid in 2018 will be increased by € 50. The eligibility criteria for energy cheques will be widened, so as to benefit the 20 % of households with the lowest incomes. This will extend the allocation of energy cheques to 2.2 million additional households, or 5.8 million households in total;
- Maintain the French National Housing Agency (Agence nationale pour l'habitat, ANAH) contributions to support energy renovation for lower income households so as to meet the targets set for this agency: 75,000 dwellings/year from 2018 to 2022.
- Reform CITE in particular by providing households assisted by ANAH with the option of transforming it into a bonus paid quickly by the latter, thus reducing what remains to be financed;
- Reform the Eco-PTZ in 2019 by greatly simplifying it and eliminating the requirement to undertake a package of renovation work;
- Roll out innovative solutions enabling the industrialisation of renovation solutions to benefit from an economy of scale;
- Boost grants for low and very low-income households for insulation and improvement of their heating scheme (adaptations of the CITE for example for disposal of oil tanks or installing renewable energy equipment, mobilisation of the Energy Saving Certificates with enhanced aid for low and very low-income households, etc.).
- Enhance the premium for lower-income households for converting old vehicles immediately by moving the goal for replacing old vehicles from 500,000 to 1,000,000 over the five-year presidency, with a doubled premium for very low-income households (as well as non-taxable [i.e. low income] motorists with big mileages), while working on attractive loans to finance what remains to be paid;
- Develop public transport, car sharing and more generally alternatives to individual car use over the whole territory as soon as possible, by targeting the most fragile groups;
- Mobilise the energy savings certificates to help lower income households for mobility (support for car sharing and developing bike use, addressing the mobility needs of households in precarious circumstances).

The winter respite scheme

A winter respite scheme for all households has been put in place in the energy field: under this scheme the suppliers are obliged to maintain natural gas and electricity supplies between the 1st November and 31 March. Energy cheque beneficiaries are also protected from power limitations on electricity supply, and benefit from a reduction of certain fees (in the case of moving house or nonpayments).

In the event that a supply interruption is planned outside the winter respite period, its implementation is subject to strict management for all households (dunning notices, time periods, social services information from the supplier when the power has not been restored within five days of the cut-off).

Energy Saving Certificate (ESC) schemes relating to the combatting fuel poverty component

The LTECV has created a specific obligation to achieve energy savings for the benefit of households suffering from fuel poverty (eligibility determined based on household income). The first accounting period covered the two years 2016-2017, with a goal of 150 TWh_{cumac} (compared to the "classic" ESC obligation of 700 TWh_{cumac} over the three years 2015-2017). The goal was achieved.

In order to extend the impetus of the LTECV in imposing a specific obligation to achieve energy savings for the benefit of households suffering from fuel poverty, the fuel poverty requirement for the new timescale of the 2018-2020 ESCs has been brought to 400 TWh_{cumac}, additional to the original requirement of 1200 TWh_{cumac}. The energy companies will thus have to invest more than €2bn in the fight against fuel poverty.

The National Housing Agency's (Agence nationale de l'habitat, ANAH) "Live Better" programme

ANAH is conducting a programme to combat fuel poverty entitled "Live Better". This program enables financial aid and social, technical and financial support to be provided to households suffering from fuel poverty in order to carry out energy renovation work. The programme is funded by the agency's own budget (mainly fed by the sale of carbon allowances), with a participation from energy companies (EDF, GDF-Suez and Total). The ANAH budget is fixed by convention, as well as by the Future Investments Programme (Programme Investissements d'Avenir, PIA), through the Heat Renovation Aid Fund (Fonds d'aide à la rénovation thermique, FART) with its € 483m.

In total more than 250,000 households have benefited from the "Live Better" program since 2013. The beneficiaries of this aid are the lowest income owner-occupiers and co-owners, and co-ownership associations that are in difficulty or disadvantaged (since 2017), as well as landlords, who are not subject to means-testing. The programme provides in particular for payments to occupier households of subsidies covering 25 to 50 % of the cost of the energy renovation work, subject to means-testing. The energy gain obtained at the end of the work must be a minimum of 25 % for owner occupiers and 35 % for landlords and co-ownership associations.

In 2017, the total number of heat renovations rose to about 60,000 homes, with the amount of aid per dwelling averaging €9,600. The scaling up of the program was accelerated for the year 2018, with a commitment capacity corresponding to 75,000 housing units.

The buildings energy renovation plan thus commits €1.2bn of State funds to combatting fuel poverty. In social housing, the objective is to renovate heat sieves at the rate of 100,000 per year, with the support of the Caisse des Dépôts, by multiplying innovative solutions, with an budget of €3bn under the Big Investment Plan.

Finally, through the energy renovation guarantee fund, ANAH will support more than 35,000 households on low income (eco-loans) and 6,000 co-ownerships (loans).

7.2.3. The role of citizens in the transition

Citizens are essential stakeholders in the energy transition, for all aspects of this transition:

Controlling energy demand

The issue of controlling energy demand primarily implicates the building and transport sectors. Informing citizens and getting them involved as users is essential. They must start taking action to renew energy use in their home, to adjust the temperature settings in their living spaces (home and work) and to change their transport habits: increased use of soft modes, use of public transport, intensification of vehicle use where appropriate, purchase of vehicles that have low or very low energy consumption.

Citizens can also have an impact as trendsetters through their consumption choices, principally by favouring products that consume less energy, by minimising equipment standbys and recycling their products at the end of their lifespan.

Diversification of the mix, penetration of renewable energies

The public also has a role to play in the penetration of renewable energies. During house construction or boiler renewal, they can choose heating methods which use renewable energies (heat pumps, thermal solar, biomass).

Members of the public can also become direct producers of electricity by installing photovoltaic panels on their roof, or participate indirectly by helping to fund a renewable energy project. These participative funding initiatives are very important for projects to be accepted locally.

Network modernisation: flexibility, digital

Thanks to the penetration of new technologies in networks, consumers will be able to participate in balancing the electricity network, principally by committing to load shedding contracts: this is about committing to regulating consumption during consumption spikes according to modalities determined with load shedding operators.

7.3. Ensuring competitivity in energy prices

Measures to preserve industrial competitiveness

Energy is a vital factor in the competitiveness of some French companies that are facing strong competition not only from across Europe, but also often worldwide. Thus, for certain industrial activities (production of aluminium, chlorine, silicone etc.), electricity supply can reach 30 % of production costs and can represent more than 100 % of the added value.

The competitiveness and the very existence of these industries that support jobs and combat unemployment, which are government priorities, depend therefore on an electricity supply that is competitive and predictable in the long term. These highly electro-intensive sites subject to international competition sustain about 80,000 direct jobs in France. Some of these sites represent the only sustainable and non-seasonal sources of work in the regions where they are installed, often dating back a long time. Others are structurally important for the sustainability of the platforms on which they are installed. Finally, these sites are often integral parts of regional or national industrial chains.

The measures described aim to reduce the energy bill of these electro-intensive and gas intensive companies and to maintain or improve their competitiveness to boost employment and business activity, by pulling on all the levers available with due regard to competition law and State aid.

Gas

In 2013, a "gas-intensive" status was defined to characterise companies that use natural gas as a raw material or energy source and whose main activities are exposed to international competition.

Decree no 2013-972 of 30 October 2013 specified the definition of the relevant sites, in function to the relationship between the volume of gas consumed and the added value of the company, their international exposure and the stability or countercyclical nature of the consumption (at least 30 % volume consumed outside of the winter period). In total about 150 companies are concerned.

Electricity

The electricity price is set by the addition of a transmission part (network tariffs), a part linked to energy (integrating commercial costs), and a part linked to taxation. All of these levers are subject to measures contributing to supporting the competitiveness of electro-intensive industries.

The consumption profile of these electro-intensive sites, or their capacity to modulate their consumption, is often beneficial to the electricity system, contributing to its stability and to controlling the overall costs. In 2017, 135 sites presented such a stable or countercyclical consumption profile: this kind of profile is distinct from the consumption profiles of residential or tertiary consumers, which vary considerably according to periods (hours in the day, days of the week, months in the year), generating power requirements, and therefore network costs, that are greater with regards to the energy distributed. The industrial sites can take advantage of these profiles and this capacity to modulate consumption.

Box 20: Incentives to control energy use for energy-intensive industries

France's policy in terms of energy efficiency and greenhouse gas emission reduction for energy-intensive industries rests on three focal areas:

1. *market tools and in particular European Directive 2003/87/EC establishing an Emissions Trading Scheme within the European Union*

In France in 2015, the emissions of the sectors subject to this EU ETS Directive represented around 20% of total emissions, i.e. 100 million tonnes of CO_2 equivalent. On a like-for-like basis, the emissions of the sectors covered decreased by 35.6% in 2015 compared to 2005. Energy consumption dropped by 3.7% between 2013 and 2017.

2. *financial incentives:*

- energy saving certificates: the industrial sector represented 20.3 % of the certificates issued between 01/01/2015 and 31/01/2017 (standardised and specific operations);
- the PRO-SMEn, a national programme which gives financial support (up to €40 k) to companies and local authorities to put an energy control system (Système de management de l'énergie, SMEn) in place, certified compliant with ISO 50001. As part of the Energy-Saving Certificates (ESC) scheme, it is coordinated and managed by the Technical Association for Energy and Environment (Association Technique Energie Environnement, ATEE);
- Electricity intensive companies are encouraged to obtain ISO 50001 certification, to set themselves goals, and to put an improvement plan for energy performance into action in order to benefit from a reduction in Public Electrical Power Network Use Tariffs (Tarifs d'utilisation des reseaux publics d'électricité, TURPE);
- The French Environment and Energy Management Agency's aid system "Rational Use of Energy - Investment" supports the investments made within companies to acquire energy saving equipment or to modify existing processes or equipment. The operations receiving aid are demonstration operations or exemplar operations;
- The Heat Fund chiefly supports the recovery of residual heat. In 2016, 20 operations were funded for an investment amount of €23.7m and ADEME assistance of €6.9m and will generate 21 ktoe/year.

3 *regulatory measures, principally in the context of transposing Directive 2012/27/EU on energy efficiency:*

- mandatory 4-year energy audit;
- obligation to carry out a cost-benefit analysis for facilities generating residual heat in order to assess the advisability of exploiting this residual heat through a heat or cold network, before the launch of new combustion plant projects;
- the directive 2010/75/EU of 24 November 2010 on industrial emissions was created using an integrated approach. This directive obliges the implementation of Best Available Techniques (BAT) for reducing polluting emissions in many industrial sectors, in the course of adopting the revised "BREF" conclusions (Best Available Techniques – BAT – REFerence documents) which provide details on the BATs. The BAT conclusions refer to various topics and particularly energy efficiency improvements. Once adopted they can be directly applied.
- A BREF that applies to all sectors takes energy efficiency as its specific theme.

Taxation

Scientific Committee on Problems of the Environment (Comité scientifique sur les problèmes de l'environnement, CSPE / Domestic tax on final electricity consumption (Taxe intérieure sur la consommation finale d'électricité, TICFE)

Ultra electro-intensive facilities and companies and industrial facilities that consume a lot of energy, particularly those subject to the risk of carbon leakage, benefit from reduced CSPE rates, the main tax on electricity consumption.

In compliance with the EU framework laid down in Directive 2003/96/EC, these exemptions lead to a level of CSPE of between €0.5/MWh and €7.5/MWh. The cost of the scheme in 2016 was estimated at €1,425mn, of which €260mn went to ultra electro-intensive sites (40 sites), €960mn to companies that consume a lot of energy (10,000 companies) and €198mn to companies in the transport sector.

Carbon offsetting

A "carbon offsetting" scheme for electricity intensive industries subject to international competition was created by the 2016 Finance Act.

This measure, which is provided for in European law and exists in several Member States, consists of paying beneficiary companies grants corresponding to the indirect cost of the carbon, that is to say the extra cost of the electricity due to the European greenhouse gas emissions trading scheme.

There is therefore a triple objective for "carbon offsetting":

- reduce the risk of carbon leakage (that is to say the relocation of industrial activity outside of the European Union because of a loss of competitiveness due to carbon costs);
- maintain the European Union emissions trading scheme goal of reducing emissions while ensuring a good cost-efficiency ratio;
- limit to a minimum distortion of competition within the internal market.

The provision targets companies in sectors which have a highly intensive electricity consumption and are highly exposed to trade from outside the EU. This relates principally to the production of aluminium, paper and cardboard, iron and steel, basic chemicals, etc. Since 2018, the State has been publishing the list of sectors and subsectors that are beneficiaries and the amount of offsetting they receive on the Ministry for Ecological and Solidary Transition's website.

In 2017, the total amount of carbon offseting paid for 2016 amounted to approximately €140mn. For the beneficiaries, the grant covers around €4/MWh, saving roughly 5 to 10 % on their electricity bill excl. taxes. This scheme is funded by the state budget.

Domestic Tax on Natural Gas Consumption (Taxe Intérieure de Consommation sur le Gaz Naturel, TICGN)

In accordance with the provisions of Directive 2003/96 on the Taxation of Energy Products and the Customs Code, in particular Articles 266d and 265h, companies consuming natural gas benefit from an exemption from the Domestic Tax on Natural Gas Consumption (TICGN) where natural gas is used for the generation of electricity, where the natural gas is dual-use, particularly in the case of metallurgical processes, electrolysis or chemical reduction, or where it is used for the manufacture of non-metallic mineral products.

Energy intensive sites, as defined within the meaning of the 2003 European Directive on the taxation of energy products and included in the greenhouse gas emissions trading scheme, as well as energy intensive sites within the meaning of the European Directive 2003 on the taxation of energy products and conducting an activity at a high risk of carbon leakage, also benefit from reduced rates of TICGN.

Network tariffs

Electricity

Because of the positive effects on stability and the optimisation of the electricity system for sites which consume a lot of electricity in a stable and foreseeable way, the value of this stability is reflected in the bill of the electricity network access tariff, since the latter is designed to reflect consumer costs over the network while taking into account their consumption profile. In this way, the Energy Regulatory Commission decided in 2014 to grant an exceptional 50% abatement of the electricity transmission bill until the end of 2015 for electro-intensive users having consumed more than 10 GWh for a duration of more than 7,000hrs in 2013, or constituting an electro-intensive company under the definition of Article 238b HW of the General Tax Code and having consumed more than 500 GWh in 2013.

The law on the energy transition has extended this first step by introducing a legislative framework for the abatement of network tariffs, that could go up to 90% of the electricity transmission bill for the most electricity intensive users connected in the high tension B domain that meet certain network use technical criteria, in order to take into account the positive effects that these users bring to the stability and optimisation of the electricity system. In exchange for these advantageous price conditions, companies and electricity intensive sites must comply with energy efficiency requirements.

Decree No. 2016-141 of 11 February 2016 specifies the modalities for reducing the user tariff of the public transmission network granted to sites that consume a lot of electricity, depending on their electro-intensive status, the level of energy withdrawn from the network, the duration of use and the rate of use in off-peak hours.

Network tariff reductions total about €120mn to 130mn per year.

The decree states the requirements in terms of energy performance A company or a site is considered to be enacting an energy efficiency policy if it verifies all the following conditions:

- within a 18 month timeframe, it introduces an ISO 50001 energy management system;
- within a 5 year timeframe, it achieves an energy efficiency objective monitored by means of defined indicators such as the ratio between energy consumption and a unit of production defined by the company. These indicators are certified as part of the implementation of the above energy management system. The objectives are defined in relation to the relevant benchmark levels depending on the activity sector or manufacturing process. The energy efficiency objectives and means envisaged for their attainment are described in more detail in the energy performance plan validated by the Préfet of the region where the company has its headquarters.

Tariffs for gas network use

Article L. 461-3 of the energy code provides for the possibility of introducing reductions in the transmission network user tariff for companies that consume a lot of natural gas whose sites have a foreseeable, stable or countercyclical consumption profile. Feedback from trials of reductions in the electricity network user tariffs is taken into account in order to define the modalities of this scheme.

Energy supply

ARENH

The electricity prices for electro intensive companies remain among the lowest in Europe.

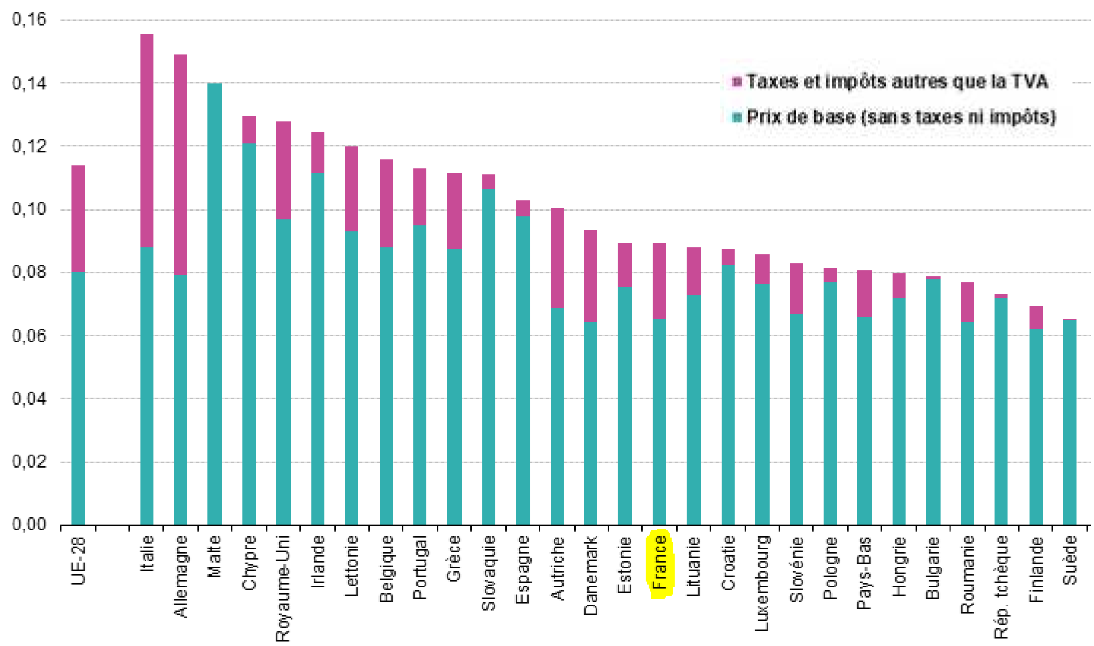

Figure 79 : Electricity prices for industrial consumers (2nd semester 2016)- Source: Eurostat

Despite rising market prices, companies will continue to benefit from competitive electricity prices until 2025, thanks to the Regulated Access to Historical Nuclear Power (Accès régulé à l'électricité nucléaire historique, ARENH) system. This electricity is provided under economic conditions equivalent to those of the incumbent operator, and this must allow all consumers, regardless of their provider, to continue to benefit from the competitiveness of the established system of nuclear power stations.

Hydroelectricity

Article 116 of the Energy Transition for Green Growth Act provides for the possibility of taking long-term supply contracts with electricity intensive companies into account when setting the fee as part of a franchise renewal or extension, so as not to penalize the franchisees wishing to conclude such contracts which give the companies a long-term perspective on supply costs.

Finally, following the experiment conducted by RTE in the summer of 2014, companies can henceforth take advantage of their flexibility as part of the primary and secondary reserves (electricity system frequency and voltage settings) in the same way as the production capacities which are already active in this context.

Taking advantage of flexibility - interruptibility and load shedding

Another characteristic of some companies that consume a lot of electricity is their capacity to modulate their consumption, even interrupt it, when the transmission system operator identifies the need, for example to ensure a balance between supply and demand during winter consumption spikes or during an unforeseeable operational incident within the electricity system.

This capacity relies on industrial processes, whose consumption cannot always be reduced, and not always with the same responsiveness, it depends on the process in question.

It takes several distinct forms for electricity depending on the mechanisms in which this reduced consumption plays a part (interruptibility, load shedding, primary, secondary, quick or complementary reserves, participation in the adjustment mechanism or the energy market), but in every circumstance it is about taking advantage, as a complement, of the capacity of the industrial player to reduce or shift their power consumption to other periods when there is less strain on the electricity system.

By means of the Energy Transition for Green Growth Act, the Government sought to increase the recovery of value from the electrical flexibility of industrial sites, by expanding the scope and volume of existing provisions. Industrial consumers can also take advantage of their flexibility in the context of the capacity mechanism.

For large gas consuming companies, the law has also introduced an interruptibility scheme.

Call for load shedding tenders

Since 2012, companies have been able to participate in the "load shedding" calls for tenders organised by RTE, either by direct participation or by contracting with a load shedding aggregator participating in the call for tenders.

A new tendering procedure for load shedding was introduced by the energy transition law, and put into operational action in 2018, in order to achieve the goals set in the Multi-Annual Energy Plan. Industrial load shedding will make a significant contribution in the context of these tenders.

Provisions for interruptibility of electricity consumption

The law of 15 April 2013 created the so-called "interruptibility" scheme which makes it possible to remunerate industrial electricity consumers able to reduce their power demand at very short notice, as a means of backing up network security.

The volume for this scheme was increased for the first time by decree in 2014 to 600 MW. In view of its contribution to the reduction of the risk of electricity system failure, Article 158 I of the Energy Transition for Green Growth Act, codified in Article L. 321-19 of the Energy Code, has reinforced the existing scheme by raising the level of remuneration for the most affected sites and increasing the volume of calls for tender.

Industrial sites capable of adapting their electricity consumption at very short notice to meet a need within the electricity system and to contribute to ensuring network security will be remunerated for this service to the electricity system.

Interruptibility provisions for natural gas consumption

The Energy Transition for Green Growth Act provides for the possibility of implementing interruptibility schemes whereby some natural gas consumers engage with network operators to reduce their consumption, if required.

These provisions contribute to security of supply for natural gas, while offering gas-intensive companies a means of taking advantage of their flexibility.

The development objectives for the interruptibility of natural gas consumption are specified in the section on security of supply of gas products.

Measures:

- The government will propose the modalities of a new regulation on established nuclear power which will guarantee consumer protection against price rises in the market beyond 2025 by letting them benefit from the competitive advantage linked with agreed investment in the established nuclear power system, at the same time giving EDF the financial capabilities to ensure the economic sustainability of the production tool in order to meet the needs of the MAEP in the low price scenarios.
- The government will continue to compensate rises in tax measures relating to energy products by a corresponding easing of taxation on other products, work or income.
- Sustaining the "tool box" of aid schemes for electro-intensive and gas intensive companies;
- Finalising the implementation of the framework for the interruptibility of natural gas consumption.

7.4. Assessment of the impact on jobs and the occupational skills requirements

7.4.1. Employment issues

The energy transition will have direct, positive or negative consequences in terms of jobs in the energy sector but also more general consequences at the macroeconomic level. Relaunching productive activity creates jobs: 246,000 additional jobs should be created in 2023 and 420,000 in 2028.

A growth in employment across all sectors in the economy except for the fossil fuel and combustion and nuclear power stations sectors as well as in road transport of goods.

The majority of indirect and induced jobs are created in the tertiary sector since it represents 80% of GDP.

7.4.2. Professional skills issues

Background and Objectives

Article 182 of the **Energy Transition for Green Growth Act of 17 August 2015 states that "*The State*** *draws up, in consultation with employee trade union organisations, employer representative organisations and regional authorities, an employment and skills programming plan taking into account the guidelines laid down by the Multi-Annual Energy Plan provided for in Chapter I, Heading IV of Book I of the Energy Code. This plan indicates the need for changes in employment and skills across the regions and in professional sectors with regard to the ecological and energy transition. It encourages all players at the regional level to measure and structure the forecasted changes in employment and skills resulting from the implementation of regional climate, air and energy schemes and territorial climate-air-energy plans."*

In March 2018, the Minister of State, the Minister for an Ecological and Solidary Transition, the Minister for Labour, the Minister for National Education and the Minister for Higher Education, Research and Innovation, entrusted to Mrs Laurence Parisot the mission of working up the Employment and Skills Programming Plan (Plan de programmation de l'emploi et des compétences, PPEC), which will be published at the end of 2018 in conjunction with the update of the Multi-Annual Energy Plan.

The goals assigned to the mission are:[91]

- To propose a "vision of the future impacts of the energy transition in terms of employment and skills in professional sectors and across the regions";
- To design a "methodology to cover all sectors of the MAEPC [...] by involving the relevant stakeholders in the work";
- To propose a quantitative forecasting of jobs and of the qualitative transformation of skills related to the energy transition;
- To analyse training needs;
- To define an appropriate method for the regional approach;
- To "Create synergies between stakeholders in the ecological and solidarity transition, both nationally and regionally, promoting forward planning in the needs for jobs and skills for the ecological transition".

Governance

The mission makes three recommendations with regard to governance:

- To set up an information-sharing body bringing together the Ministries of the Environment, of the Economy and of Finance and of Labour, the representatives of the National Confederation of Industry (Confédération nationale de l'industrie, CNI), employers' organisations and employee organisations to meet twice a year;
- Raise awareness within the professions and ask them to regularly examine the social impacts of the energy transition;
- Encourage the regions and the larger local authorities to monitor these impacts on their territory and to prepare the transitions.

From 1st January 2019, the new law on future careers creates an operator with a central and strategic role, France Compétences. As a single body for the governance of vocational training and apprenticeship, France Compétences will be a key player in defining the strategy, direction and implementation of lifelong vocational training. However, to describe its governance, its operation and its missions, the law refers to decrees which have not yet been enacted and which should be extended to all stakeholders.

Quantitative evaluations: report and long-term forecast

Jobs accounting

It appears that national statistics do not enable jobs linked to the energy transition to be identified by direct extraction. However, the work of the French Environment and Energy Management Agency on the one hand, and the National Observatory of Jobs and Professions in the Green Economy (Observatoire national des emplois et métiers de l'économie verte, ONEMEV) on the other, does permit estimates. These can range from around 300,000 jobs (concentrated in the construction, transport and renewable energy production sectors) to 900,000 if the definitions are extended to include eco-activities and their peripheral activities. It is likely that there are also jobs tied to the Energy Transition in the 3.9 million green and 'turning green' jobs as defined by ONEMEV.

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91. AcTE: the mission letter from Nicolas Hulot, Muriel Pénicaud, Jean-Michel Blanquer and Frédérique Vidal to Laurence Parisot (29 March 2018). *Ministry for Ecological and Solidarity Transition* [online] consulted on 20 July 2018. Available at:

https://www.ecologique-solidaire.gouv.fr/sites/default/files/2018.03.30_D_Lettre_mission_Me_Parisot.pdf

The current framework does not make it possible to precisely identify jobs linked with the energy transition. To improve this accounting, guidelines should be discussed within the governing body on the annual study of markets and jobs in the energy transition in order to:

- Increase the involvement of the professions and sector committees;
- Discuss the scope of this study with them each year, based on the changes in each sector. Some sectors could be observed for a few years, and then cease to be when the transition is finalised;
- Together with the professions, reflect on the possibilities of monitoring start ups and the regionalisation as requested by the mission.

Quantitative employment forecasting

Different economic models attempt to assess the economic impacts of energy transition scenarios over a timeline going from 2020 to 2050. The majority of economic models predict a net job creation of between 100,000 and 600,000 FTEs by 2030. The 2016 MAEP thus estimated the number of net job creations at the 2030 horizon to be 283,000 FTEs, while the SNBC estimated a job creation of between 108,000 and 350,000 by 2035. Economic models, however, are based on particular choices, which lead to an interpretation of their results in the light of the scenarios, assumptions and methodologies used.

Besides, the economic models do not for the moment take the question of skills development into account. Regional economic models have been designed over the past few years to provide local decision-makers and economic players with the tools to assess the economic effects of the energy transition policies they are putting into practice at the local level. Hence, the Climate Action Network and the French Environment and Energy Management Agency presented the Regional Employment Ecological Transition (Transition Ecologique Territoires Emplois, TÉTE) tool in January 2018.

Skills progression

The mission estimates that the energy transition will create only a few entirely new jobs, mainly located in services: energy advisers, energy managers (or flow economy advisers), traders, materials engineers. The transition will have greater effect in transforming existing trades and the acquisition of new skills.

For example, an automotive industry engineer will have to become more familiar with electrical power. In building, an interior finisher will have to master new insulation techniques. An electrical maintenance technician will have to learn how to maintain a wind turbine.

At the request of the economic players concerned, the creation and revision of new certifications is already taking effect.

Beyond the need for new skills relating to the new equipment in use for example, the energy transition generates a greater need for transversality and coordination between different trades as well as a global and systemic approach. This requirement is particularly essential in the building sector to ensure maximum energy performance. Initial training and vocational training must integrate these soft skills.

It is also vital to raise the awareness of employees, and of all working people in general, of the energy transition and its associated standards and regulations.

The energy transition and the digital transition are two profound transformational movements that interact and must be considered together. A structure cannot become more energy efficient without measurements and without data processing. Indeed, the smart grid concept, the smoothing out of consumption peaks and the introduction of intermittent sources and storage are linked to progress in energy management computing. As such, the mission recommends that both transitions should be regularly addressed in the companies in the usual framework of social dialogue.

Initial and continuous training issues

Initial training issues

Since 2010 the Ministry of National Education has been transforming its diplomas to take the new issues related to the energy transition into account. The work within the Professional Advisory Committees (Commissions Professionnelles Consultatives, CPC) has made it possible to revise the existing diplomas and create several new specific diplomas, in association with players from the relevant economic sectors, State departments and social partners. For the time being, the mission does not identify a marked shortage of initial training in connection with the energy transition. It is furthermore necessary for the professional branches that are members of the CPCs to continue to bring about changes. Responsiveness in the work process of the Professional Advisory Committees is essential in this respect, as is the activation of other certifications (diplomas and Professional Qualification Certificates (Certificat de qualification professionnelle, CQP)).

Several issues need to be considered to ensure that the training adequately meets the needs of economic players: that of the opportune moment to set up training, its measurement, its geographical location, the facilities of the institutions that provide it and the study and career choices of participants. The introduction of appropriate training courses, information for young people and adults, and the economic responsibilities at the regional level require support from regional authorities and academic bodies.

Vocational training issues

Similarly to initial training, vocational training is essential to ensure worker skills development in connection with the energy transition. Therefore, the certifications of the National Committee for Professional Certification (Commission Nationale de la Certification Professionnelle, CNCP) are starting to be revised to take these transformations into account. For example, a professional diploma has been created for project managers in building energy renovation, and the diploma for maintenance technicians for heating, air conditioning and renewable energy equipment has been revised.

The draft law "for freedom of choice in one's future profession", currently being debated in Parliament, aims at transforming vocational training and apprenticeship. The Government's objective is to give people new rights to enable them to choose their professional life throughout their careers, as well as enhancing companies' investment in the skills of their employees. As part of this reform of vocational training and apprenticeship, an Investment in Skills Plan (Plan d'Investissement dans les Compétences, PIC) was launched in 2017. With a budget of €15 billion over 5 years, it includes the "10kverts" (10kgreen) programme, designed to provide 10,000 training courses for green and 'turning green' jobs for young people and jobseekers. The Investment Plan will also finance the Forward Planning of Employment and Skills (Gestions Prévisionnelles de l'Emploi et des Compétences, GPEC) for the professions and sectors in order to identify the changes in skills required in the coming years.

Measures:

Starting in January 2019 the State will entrust the new France Compétences agency with the mission of opening a specific worksite relating to the energy transition and providing the secretariat of a body composed of the Ministries of the Environment, for the Economy and Finance, of Labour, CNI representatives, employers' organisations and employee organisations to meet twice a year. This body will be responsible for providing guidance on

- the statistical inventory done by the French Environment and Energy Management Agency;
- the definition and monitoring of long-term forecast work: the establishment of specifications for the professional branches in order to carry out analysis within the branch on:
    - expected changes to jobs;
    - quantification of the impact on jobs in the branch after 10 years.

  The results will be submitted to the global governance body annually.
- changes to trainings
    - initial training: The certifying ministries will organise an annual review of:
        - the changes to their certificates and the degree to which they incorporate interdisciplinary dimensions and systemic management, which are essential to achieving the energy transition;
        - the attractiveness of diplomas with an energy transition dimension;

- the advisability of revising the diplomas of each CPC following advice from the professions.

The Ministry for Ecological and Solidary Transition (Ministère de la Transition écologique et solidaire, MTES) will continue to power the work of the certifying ministries' CPCs (Professional Advisory Committees) to ensure that the ecological transition is properly taken into account in the benchmark systems.

- Continuous training: in the framework of its future missions, France Compétences will lead a reflection on updating the changes within trades and the adaptability needs of lifelong vocational training. The professions will be responsible for revising the benchmark systems for their trades and the specific continuous training for their sector (CQP), when a need is identified. The question should be considered at least every two years.

On the specific point of training State agents, the MTES will undertake experiments using a specific worksite in order to develop training courses for State officials, chiefly its agents, and for regional officials in partnership with the National Centre of Territorial Public service (Centre national de la fonction publique territoriale, CNFPT).

7.5. Assessment of the public funds dedicated to achieving MAEP goals

7.5.1. Cost of supporting energy control

In buildings

Tax credit and reduced VAT

In order to achieve the MAEP goals, two fiscal expenses are implemented:

- CITE tax credit covering up to 30% of the cost of renewable heat production equipment and work to reduce energy consumption in primary residences completed more than two years ago;
- VAT rate reduced to 5.5% for renewable heat production equipment and work to reduce energy consumption in residential properties completed more than two years ago, as well as inextricably linked ancillary work.

ANAH aid

The National Agency for Housing (ANAH) is working in particular to improve the energy performance of the private homes of low and very low income households. The majority of the National Agency for Housing (ANAH) funding is ensured by extrabudgetary means, the main resource comes from the auctioning of carbon allowances. Since 2019, €420mn/year from this resource are dedicate to ANAH, i.e. a rise of €110mn compared to 2017. Since 2018, the Agency benefits from a budgetary support of €110mn per year and, since 2019, from an extra receipt of €40mn for vacant accommodation. In total, ANAH benefits, under area 1, initiative 1 of the Big Investment Plan of €650mn.

Eco-loans for Social Housing

The main incentive measure for energy renovation in social housing is the social housing eco-loan. This subsidised rate loan is distributed by the Caisse des Depots et Consignations (CDC). The following progression of the ecoPLSs (Social housing loan = Prêt logement social) signed since 2012 has been observed :

- in 2012, 7,000 homes for an eco-PLS sum of €70m;
- in 2013: 19,000 homes for a sum of €300m;
- in 2014: 34,000 homes for a sum of €515m;
- in 2015: 45,306 homes for a sum of €610m;

- in 2016: 41,055 homes for a sum of €585m;
- in 2017: 54,336 homes for a sum of €720m;

On average over the period, the provision per home is about €13,000, with a maximum amount of aid set at €16,000 and €18,000 for a renovation achieving the low energy building status (Bâtiment basse consommation, BBC) .

The goal is to renovate 100,000 homes per year by 2022 within the framework of the Building Energy Renovation Plan. As such, the Big Investment Plan seeks to meet this goal by unlocking 3 billion euros between now and 2022.

Relief on energy saving work for rent-controlled 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 work, on property tax contributions for properties built for HLM organisations and SEMs" is intended to help with funding the energy saving work undertaken by social landlords for the renovation of their social housing stock. Its order of magnitude was €31m in 2014, €59m in 2015, €80m in 2016 and €70m in 2017.

In 2016, more than 6,000 landlords benefited from this scheme.

It is proposed that the total budget be sized depending on the progression of the eco-PLS (scheme for social housing energy renovations - see above). The result would be an average budget allocation of around 350 million euros over the period.

Heavy building work - compliance and rehabilitation of State buildings

The "State-owned Assets: Energy Efficiency" Directive consists of renovating State buildings that do not comply with thermal regulations. It has been evaluated quantitatively to renovate 3% of the State buildings stock per year over the period 2015-2020. When establishing the scenarios, the SNBC retained the following surfaces of renovated public building stock (in millions of m^2):

	2016	2017	2018	2019	2020
Renovated surface area for the State building stock (mn m^2)	1.559	1.514	1.460	1.522	1.563

Table 48: Renovated surface area of the building stock between now and 2020 (millions of m^2)

The renovation of State buildings mobilises several budget programmes (programme 309 - maintenance of State buildings, National Gendarmerie - 152, civil defence - 161, justice -166, etc.). The estimated amount based on the figures in the transversal policy document, "combating climate change", ends in 2014 with an sum of €97.2mn.

Assuming that the cost of the heavy renovation works is about €210/m2, as an annual average over the period 2016-2023, the amount of the total budget for the renovation of the building stock is estimated at just under €200mn.

In transport

Contribution to financing the acquisition of clean vehicles

Programs 797 and 798 finance grants for acquiring clean vehicles ("bonus/penalty"). The amounts in commitment appropriations were €207.5m in 2016, €265.6m in 2017 and €266m planned for 2018. These amounts are covered by income from the penalty.

The Climate Plan sets the goal for ending sales of new cars emitting 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").

The Climate Plan has boosted the conversion premium. Petrol vehicles registered for the first time before 1st January 1997 are now eligible. All natural or legal persons may, subject to eligibility, receive a premium of

€1,000. An over-premium of €1,000 is paid to non-taxable physical persons. This premium should lead to the scrapping of 500,000 vehicles between now and 2022.

7.5.2. Cost of support for REn

Support for renewable heat production

The costs of supporting the Heat Fund and the CITE already take the announced changes in the carbon component into account. These have already been taken into account in estimating budget needs.

Heat fund

The heat fund was endowed with €1.9 bn in legal commitments over the period 2009-2017. As underlined by the Court of Auditors, this is an efficient system with an average aid rate of € 4/MWh produced, i.e. around €16/tCO_2 avoided, and a useful leverage effect (€1 from the heat fund for €3 of investments).

In 2017, heat fund aid corresponded to budget support of:

- €1/MWh for residual heat recovery;
- €4/MWh for support for wood;
- €7/MWh for geothermal;
- €8/MWh for heat networks;
- €11/MWh for heritage and territorial REn contracts (clusters of small projects concerning the same owner or the same area);
- €33/MWh for solar thermal (roofs and large surface areas).

The forecast requirement for the heat fund was estimated based on the objectives of scenario B of the 2028 MAEP and takes into account the carbon tax (Contribution climat-énergie, CCE) trajectory: it increases up to 2020, when the impact of the CCE alters the trajectory of the heat fund while maintaining an upward trajectory in TWh. Over the 2018-2028 period, the cumulative need is about €3.21 bn.

Energy transition tax credit (Crédit d'impôt transition énergétique, CITE)

To achieve the MAEP objectives, the CITE requires €600m per year for renewable heat.

Reduction of VAT rates for heating networks

The table below shows the cost of the reduced VAT rate for heating and cooling networks to public finances when the 50% R&REn threshold is reached. This estimate takes into account the objectives set for the networks by the end of the MAEP timeline:

Benchmark year 2016	2017-2023	2023-2028 lower option	2023-2028 higher option
55	65	70	75

Table 49: Cost of the reduced VAT rate for heating networks on public finances (€m)

Support for the promotion of electricity REn

The State supports the differential between the electricity sales price and the cost to the channel. The budgetary cost must therefore be assessed according to the projected costs to the channels and the projected changes to the sales price of the electricity produced by renewable energies. For each sector, the outlook for changes to the expected costs is presented and followed by an assessment of the amount of budget support. This amount is broken down into the costs resulting from previous government commitments and the new costs to support new capacity.

Public support costs were calculated based on MAEP scenario A targets. This is the total budget that will be allocated by the State to REn development to achieve these goals. In the event of a greater cost reduction, the allocated budget will enable the objectives of scenario B in the MAEP to be met.

The costs already engaged are the ones linked to Call for tenders already attributed with contracts signed before 2018, December, 31st and to projects with a purchase obligation that have asked for to an obliged buyer. Thus, it is not only the running installations at the date of 2018, December 31st, but of more installations: depending upon technologies, the installations begin to produce between 2 and 4 years after the contract has been signed.

Two scenarios for electricity prices have been studied to assess the public costs of support of renewable electricity. These two trajectories reach €56/MWh and €42/MWh in 2028 for the average market price and are stable after. The average selling prices of main renewable energies are as follows:

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

Table 50a: Sales prices of the main renewable energies with a scenario that reaches €56/MWh in 2028

	2023	2028
Market price	€40/MWh	€42/MWh
Sale price for wind	€34/MWh	€33/MWh
Sale price for photovoltaics	€34/MWh	€30/MWh
Sale price for offshore wind	€36/MWh	€36/MWh

Table 50b: Sales prices of the main renewable energies with a scenario that reaches €42/MWh in 2028

The average selling prices of renewable electricity are lower than the average market prices of electricity because of the link between the installations production in a same sector. The PV production, for instance, will intervene at the same moment of the day for all the PV installations, and the rise of installed capacities by 2028 will lead to a decrease of the market price of electricity during these hours, thus decreasing the average selling price of these installations. That is the price used to assess the needs for public support.

Terrestrial wind turbines

	2023	2028
Production costs of the new facilities	€68/MWh	€58/MWh
Cost already committed	€21.5bn	
Additional cost resulting from the goals of the present MAEP	€4.4bn	€8.4bn
Total	€34.2bn	

Table 51: Assumptions and budgetary costs related to supporting the wind energy sector (€bn) with an average market price for electricity of €56/MWh in 2028

It should be noted that for this sector, a certain number of installations will be released from the purchasing obligation during the course of the MAEP. It is assumed that these systems will continue to produce for a few years (at least 5) without receiving any support.

Photovoltaics

	2023	2028
Production costs of the new ground-level PV installations	€60/MWh	€50/MWh
Production costs of the new large rooftop PV installations	€73/MWh	€60/MWh
Cost already committed	€39.6bn	
Additional cost resulting from the goals of the present MAEP	€ 3.6bn	€ 3.8bn
Total	€ 47.1bn	

Table 52: Assumptions and budgetary costs for supporting the photovoltaics sector (€bn) with an average market price for electricity of €56/MWh in 2028

The support costs for the sector heavily depend on the distribution across the different segments: ground, large rooftop, small rooftop. The assumption made in the modeling corresponds to that of the call for tenders timeframe presented in the section on renewable electricity. 60 % of the capacity will be developed on the ground.

Bioenergy: biomass and methanisation

	2023	2028
Cost already committed	€ 6.8bn	
Additional cost resulting from the goals of the present MAEP	€ 0	0 €
Total	€6.8bn	

Table 53: Budgetary costs of supporting the biomass sector (€bn) with an average market price for electricity of €56/MWh in 2028

	2023	2028
Production costs of the new facilities	€ 200/MWh	€200/MWh
Cost already committed	€4.8bn	
Additional cost resulting from the goals of the present MAEP	€0.5bn	€1.2bn
Total	€6.5bn	

Table 54: Budgetary costs of supporting the methanisation sector (€bn) with an average market price for electricity of €56/MWh in 2028

Offshore wind and renewable marine energies

	2023	2028
Cost already committed	€18.7bn	
Additional cost resulting from the goals of the present MAEP	€0bn	€6.7bn
Total	€ 25.4bn	

Table 55: Budgetary costs of supporting the offshore wind and renewable marine energy sector (€bn) with an average market price for electricity of €56/MWh in 2028

Geothermal electricity

	2023	2028
Cost already committed	€ 0.7bn	
Additional cost resulting from the goals of the present MAEP	0 €	0 €
Total	€0.7bn	

Table 56: Budgetary costs of supporting the geothermal sector (€bn) with an average market price for electricity of €56/MWh in 2028

Support for the promotion of injected biogas

The support costs for injected biogas were calculated on the basis of the production costs indicated in the table below, allowing the goal of 10% renewable gas in 2030 to be achieved. If production costs do not fall as much as expected, the pace of construction of new production capacity will be adapted.)

	2023	2028
Production costs of the new facilities	€67/MWh	€60/MWh
Cost already committed	€2.3bn	
Additional cost resulting from the goals of the present MAEP	€1.8bn	€3.8bn
Total	€7.9bn	

Table 57: Budgetary costs of supporting the injected biogas sector (€bn)

7.5.3. Public service charges for electricity

The renewable energy development trajectories provided for in the MAEP will be implemented by increasing in the public service charges for electricity.

In a scenario where the electricity market price averages € 56/MWh in 2028, the total annual charges for supporting the production of renewable electricity would then rise from € 4.8 bn for the year 2018 to € 6.8 bn in 2023 and € 7.2 bn in 2028 for the REn development baseline scenario. The corresponding commitments are about € 30 bn, assuming a stable electricity price beyond 2030.

	Engaged expenses	To be engaged to reach the 2028 objectives	Total
Terrestrial wind turbines	21.5	12.8	**34.2**
Photovoltaics	39.6	7.4	**47.1**
Biomass	6.8	0.0	**6.8**
Biogas	4.8	1.7	**6.5**
Geothermal energy	0.7	0.0	**0.7**
Hydraulic	2.5	1.1	**3.6**
Offshore wind	18.7	6.7	**25.4**
Total	**95**	**30**	**127**

Table 58a: Public costs for electric renewables (€bn) with an average market price for electricity of €56/MWh in 2028

Additional amounts have already been allocated to support cogeneration: they were €836mn in 2018 and will be €836mn in 2023 and €374mn in 2028.

In case of an electricity price at €42/MWh on average in 2028, the annual charges will be €7.1 bn in 2023 and €8.9 bn in 2028 for renewable energy. For cogeneration, the annual charges will be €870mn in 2023 and €426mn in 2028.

	Engaged expenses	To be engaged to reach the 2028 objectives	Total
Terrestrial wind turbines	25.4	25.3	**50.8**
Photovoltaics	42.4	15.1	**57.5**
Biomass	7.5	0.0	**7.5**
Biogas	5.2	1.9	**7.1**
Geothermal energy	0.8	0.0	**0.8**
Hydraulic	2.9	1.4	**4.4**
Offshore wind	21.3	11.0	**32.3**
Total	**105**	**55**	**160**

Table 58b: Public costs for electric renewables (€bn) with an average market price for electricity of €42/MWh in 2028

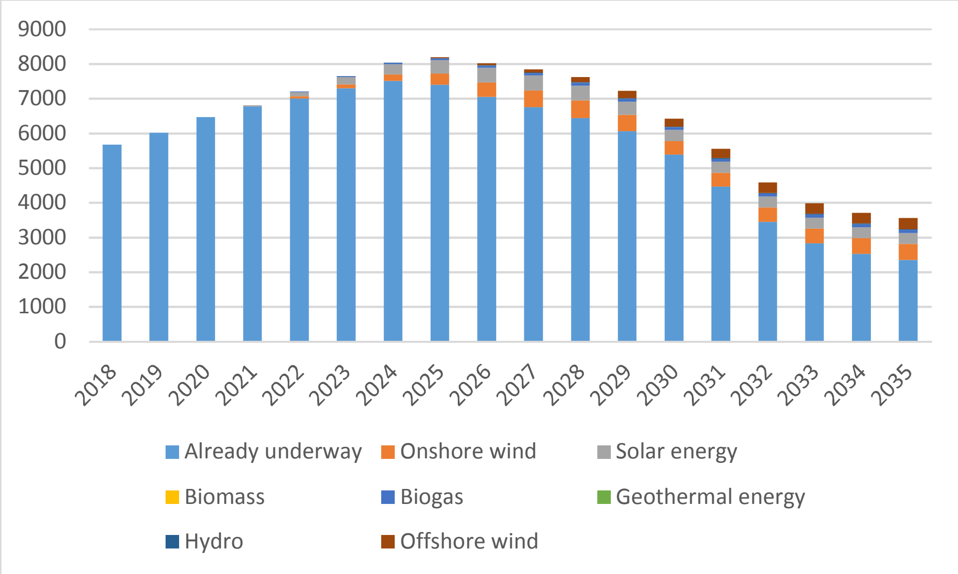


Figure 80 Estimate for the evolution of public service charges to support renewable energies and cogeneration (€mn)

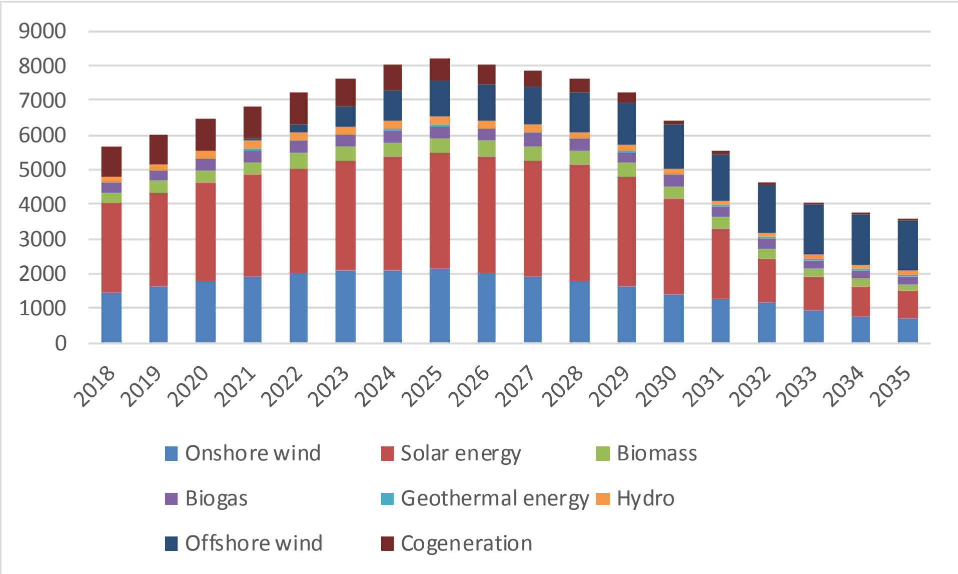


Figure 81. Estimate of the evolution of annual public service charges to support renewable energies and cogeneration (€mn)

8

Local involvement

8. Local involvement

Local action is at the heart of the energy transition, be it in terms of energy efficiency, renewable energies, storage, or networks. All these projects have a strong local component. In this context, the drive provided by local authorities is essential.

Local governance mechanisms exist. Their coordination with the national framework, in particular the MYEP, in the area of the free administration of communities, is still being explored.

8.1. Local governance of the energy transition

8.1.1. Regional schemes for spatial planning, sustainable development and equality between regions

The regulation requires the SRADDET to set medium- and long-term objectives for:

- The control of energy consumption, both primary and end-use, notably through energy renovation;
- The development of renewable energies and recovery energies, in particular wind and biomass, where appropriate, by geographical area.

These objectives can be broken down into prescriptive rules with accompanying measures intended for other agencies involved in regional planning and sustainable development. With regard to energy, the rules must at least relate to measures favourable to the development of renewable energies. The development of SRADDET can also be an opportunity for the regions to enter into contracts with other local authorities, to find ways to achieve the objectives.

During the initial SRADDET development work, the regions expressed their interest in using this tool to develop a voluntary policy of development for renewable energies. By mid-2018, at least four of them had announced their ambition to produce at least as much renewable energy as their energy consumption by 2050. To achieve this, they set themselves strict targets for both reducing their energy consumption and producing renewable energy. They then translate it across their locality in a differentiated manner, using prescriptive rules or negotiating with the local areas.

Box 21: Assessment of regional climate-air-energy models

A survey of the Regional Directorates of the Environment, Planning and Housing led to the drafting of a CETE assessment study of the SRCAE (Regional Climate Air Energy Plans). The study was based on a written questionnaire and a set of indicators defining the common framework for monitoring and analysing the progress of the SRCAE and enabling comparable data to be obtained.

Analysis of the progress of the regions towards the 2020 objectives shows the following:

- Regarding energy savings: 13 out of 16 regions responding had progress rates above 75% in 2017. At that time, one region had already achieved its 2020 objectives. Accordingly, based on the available results, many regions appear to be on track to meet the energy saving targets set in the SRCAE by 2020. It is of note that the sum of the objectives of all SRCAE by 2020 (1555TWh / year of total end-use energy consumption*) is slightly higher than the national target for the same year (1528TWh / year);
- Regarding reductions in greenhouse gas emissions: 12 out of 14 regions responding had progress rates above 75% in 2017. Three regions had already achieved their goals. The available results therefore offer a favourable assessment of progress towards the objectives set for 2020. Note that the sum of the SRCAE targets for greenhouse gas emissions in 2020 (424MtCO_2eq / year in total) is greater than the national target by the same year (2020 annual share of the 2019-2023 carbon budget): 407MtCO_2eq / year); the sum of the SRCAE is therefore less ambitious than the national objective.

- Regarding renewable energy production: 14 out of 17 regions responding had progress rates above 50% in 2017, including four with rates of over 75%. One region is a long way off its 2020 target, with a 9% progress rate. The production from renewable energies in 2017 of the 17 regions that responded is equal to half of the national target of the National Action Plan for Renewable Energies (407TWh / year). It should be noted that the sum of the 2020 SRCAE targets (321TWh / year of total renewable energy production) is less ambitious than the national target.

The SRCAE have had a strong mobilising effect in the local areas. In particular, they have led to the establishment of governance mechanisms for maintaining this dynamic beyond the plan's development phase. The failure to translate the SRCAE guidelines into measures and the lack of communication with the general public are, however, two major obstacles to their ownership.

* Note that the consolidated regional figures leave a large margin of error because of very different methods of compilation from one region to another. To develop a consolidated assessment, it would be necessary to harmonise the control instruments, including the development of the technical monitoring indicators (scope, frequency, unit, etc.).

8.1.2. Local Climate-Air-Energy-Plans (PCAET)

The Local Climate-Air-Energy-Plans were established by the Energy Transition for Green Growth Act, to follow up from local climate-energy plans. These plans serve two purposes:

- Mitigation by limiting the impacts of the local area on climate change;
- Adaptation to reduce the vulnerability of the local area to climate change
- Air quality improvement

All inter-municipality groupings of more than 50,000 inhabitants were required to develop the plans by 31 December 2016, this obligation being understood to be extended to all inter-municipality groupings of more than 20,000 inhabitants as of 31 December 2018.

In particular, these plans must be compatible with the rules defined by the SRADDET, in particular on the development of renewable energies, and with atmosphere protection plans where appropriate.

Through these documents, local authorities are invited to undertake the implementation of the energy policy throughout their area. These plans are intended to define quantified targets for reducing greenhouse gas emissions and for reducing energy dependence. They are based on a work of prospective and a programme of actions relating to all activities and actors.

These plans form the operational grid of the approach to the fight against climate change. They are incorporated into the medium- and long-term political project of inter-municipal groupings and influence all community policies and planning.

Through SRADDET and PCAET, regions and inter-municipal authorities with more than 20,000 inhabitants are invited to define their energy trajectory for 2050, taking account of the objectives of the SNBC (National Low Carbon Strategy), and to commit to the short-term actions to achieve it. They provide the committed pilot areas with an opportunity to reinforce their commitment to the medium-term search for a balance between their consumption and the local production of energy, and provide areas that have not yet developed an energy policy with an opportunity to do so. The main actions of the local areas involve:

- Developing urban forms that generate few energy needs;
- Limiting energy consumption in dwellings by promoting and supporting ambitious thermal renovations;
- Promoting low-carbon mobility and developing transport alternatives to cars;
- Mobilising economic actors, including those in the agricultural sector, to control energy;
- Promoting and supporting the development of renewable energies;
- Encouraging changes in practices through public awareness.

8.2. Energy issues at regional level

8.2.1. Renewable energy resources

The potential capacity of renewable energies, while important in all localities, varies in its composition by technology.

The table below provides an ADEME evaluation of the renewable energy capacities of each region. It shows that although some regions have a higher potential, notably greater than 70GW (Auvergne-Rhône-Alpes (87.3GW), Nouvelle-Aquitaine (85.4GW) and Occitanie (71.8GW)), all regions are capable of developing renewable energies in their local area. The potentials are, however, differentiated, which is why the national approach is not enough and must be complemented by a good understanding of territorial issues. The exploitation of this potential will depend on the technical and economic conditions of the projects, and the coordination of national and local incentive policies.

Regions	Renewable energy resources (GW)
Auvergne-Rhône-Alpes	87.3
Brittany	59.5
Centre-Val de Loire	37.5
Grand-Est	58.4
Haut-de-France	45.2
Île-de-France	33.3
Normandy	45
Nouvelle-Aquitaine	85.4
Occitanie	71.8
Pays de la Loire	53
Provence-Alpes-Côte d'Azur	44.5

Table 54: Renewable energy production potential by region (GW)

Box 15: Regionalisation of tenders

Each region aims to participate in the energy transition in accordance with its own natural resources (wind, sun, biomass). The regions of the northern half of France with the fewest solar projects are, for example, those with the greatest wind power resources (Hauts-de-France region for example).

In the context of solar tenders, more and more projects are nevertheless being carried out in the northern half of France given its land resources and the existence of significant amounts of wasteland or degraded land that is particularly suited to the deployment of photovoltaic energy. Grand-Est was the 3rd most frequently appearing region in the second period of the land tender and Hauts-de-France was the 4th most frequently appearing region during the 3rd period. These two regions are respectively 4th and 5th in the 4th period of the call to tender.

Local initiatives such as the creation of solar land registries or the development of renewable energies in public buildings also contribute to this rebalancing.

The collective economic optimum means the development of projects by technology based on their costs. It is therefore important to maintain national and non-local calls to tender to ensure optimum development of the natural resources that France boasts.

Moreover, local authorities can be prime contractors in the development of facilities or acquire shares in the capital of renewable energy companies. Public mixed economy companies have proliferated in recent years and some regions have developed funds combining public and private capital to support local projects.

More and more territories are aiming to cover at least their energy consumption with the energy that they produce. Potential renewable energy production capacity is unevenly distributed, so this objective is not always achievable at the level of the administrative area of the inter-municipal grouping. Local alliances are developing to pool efforts across larger areas. For example, the metropolitan cooperation contracts to promote cooperation between metropolitan areas and neighbouring areas also frequently include an energy component.

Box 23: IFER, a regional financial incentive for the development of renewable energies

The Flat-Rate Tax on Network Companies (IFER) was established in 2010 following the abolition of the Professional Tax. The IFER has 9 components:

- Wind turbines and tidal turbines;
- Nuclear power or flame thermal generation facilities;
- Photovoltaic or hydropower plants;
- Electricity transformers;
- Radio-electrical stations;
- Gas plants and pipelines for the transmission of natural gas, other hydrocarbons and chemicals;
- Railway rolling fleets used on the national rail network for passenger transport;
- Certain rolling fleets used on passenger transport lines in Île-de-France;
- Main splitters of the local copper loop and some telephone switching equipment.

The IFER is divided between the department, the public establishment of inter-municipal cooperation (EPCI) and the target municipality of the deployment, based on the tax arrangements of the EPCI. With regard to power generation facilities:

- For land wind and photovoltaic installations with capacity in excess of 100kW, the rate is €7470 per megawatt of installed capacity. The amount of IFER revenue is about €86M / year for wind power and about €40M / year for photovoltaics.
- For hydropower plants: the rate is €3084 per megawatt of installed capacity The IFER amount is about €70M / year.
- For nuclear or flame thermal power generation facilities with an installed electrical capacity greater than or equal to 50 megawatts: the rate is €3084 per megawatt of installed capacity. The IFER amount is about €255M / year of which €60M is from flame thermal power installations.

8.2.3. Regional needs for investment in electricity networks

Regional Plans for the Connection of Renewable Energies to the Network (S3REnR) and coordination of planning exercises

Regional Plans for the Connection of Renewable Energies to the Network (S3REnR) are a major territorial planning tool. They were established in 2012 and play a central role in facilitating the development of renewable energies. Drafted by the transmission system operator, in accordance with the distribution system operators in question, based on the renewable energy development objectives set by the Regional Development, Sustainable Development and Territorial Balance Plans (SRADDET), they define the scope for pooling between producers of the cost of the electrical works to be established, including the transport stations, the source stations and the links between the stations. Within this pool, the same share must be paid by all renewable energy producers connecting as part of an S3REnR. This mechanism therefore makes it possible to avoid the barrier and windfall effects of the application of the common connection fee applicable to renewable energies prior to the creation of the S3REnR, under which the first producer whose connection required the creation of a structure financed this structure alone, with the subsequent producers then benefitting from the available capacity free of charge.

The plans are established for ten years and can be revised based on the rate of deployment of renewable energies. Possible saturations of a plan are addressed so as to provide enough flexibility to allow continuous development of renewable energies, by establishing, on the one hand, an adaptation procedure enabling quick adjustment of the existing plans to the rate of deployment of renewable energies, if it is faster than expected, and secondly by specifying the procedures applicable as part of the saturation of the plan.

The whole of metropolitan France is now covered by regional plans. Some of them are already saturated (Haut de France) and are being revised. The plans will be revised after the approval of the SRADDET, in order to enable the integration of the renewable energy volumes provided by these plans and by the current programme.

New facilities connected mostly on the distribution grid may require the creation or reinforcement of the basic structures of the upstream network, which will take several years to complete. These basic structures identified during the drafting of the S3REnR shall be integrated in a coordinated way in the planning documents at national and European levels. They must be sufficiently anticipated in order to enable the renewable energies to be received in timescales compatible with the project development times.

In order to guarantee overall coordination and anticipation of the necessary investments in the networks, the different levels of planning (European TYNDP, national SDDR for RTE, CSDPE for national monitoring of the distribution network investments, regional objectives in terms of energy in the SRADDET or SRCAE, regional S3REnR, inter-municipal PCAET) will be consistent and mutually supportive.

Improving and strengthening local governance

While the company Enedis is the operator of the distribution network over the vast majority of the country, it operates under local concessions on behalf of the licensing authorities, the owners of the networks. These municipalities and inter-municipal groupings, which often exercise their powers through departmental energy syndicates, play an increasingly important role in the energy transition, especially in the Energy Transition for Green Growth Act (LTECV). In particular, the Local Climate-Air-Energy Plans (PCAET) contain a dedicated segment on energy networks, including electricity networks, with forward-planning and forecasting for these networks.[92] In addition, the drive to support local development of renewable energies and electric transport has recently strengthened local councils' interest in issues regarding electrical distribution network management, encouraging them to bolster their roles in related projects. Together, these aspects reinforce the collective interest in improving local governance between the various parties involved.

This need is all the more significant given that public contracting authorities play a significant role in directing investments towards electricity networks, notably in rural areas via the "CAS Facé" (France's electrification financing programme for local councils). The LTECV places inter-municipalities at the heart of this governance model, giving them a coordinating role in the energy transition of their local region. They are therefore responsible for federating the activities of public and private operators in order to achieve the objectives set out in their PCAET.

92 Please refer to the section on energy interactions for more details

Recently, general investment plans have been implemented to provide a framework for electricity concession contracts, which could be further developed in the future. These general plans are essential tools in constructing a shared local vision of the networks, their current and future limitations, investment requirements, and associated commitments from the network administrator. They should be the subject of strengthened collaboration between contracting authorities and network administrators for the sharing of network diagnostics, evolution predictions based on local specificities, and the prioritisation of investments – which must be clearly identified, localised and data-based. These general plans will also constitute operational steering tools for investments, with the proviso that measures be drawn up to ensure proper monitoring of the work to be carried out. Certain large metropolitan areas, having chosen not to delegate energy distribution authority to a syndicate, have developed general energy plans for their surrounding areas, directly transposing the objectives they have set in their PCAET.

At a more operational level, Enedis' recent initiatives to provide visualisation tools (showing how suitable various network zones are for the installation of charging infrastructures for electric vehicles, or production sites for renewable energy), constitute a major boost in enabling local operators to get to grips with the challenges present in their networks. This information is intended to be shared widely with all operators conducting energy network projects.

In a general sense, when network administrators provide greater amounts of data regarding the status and limitations of their networks, as well as local levels of consumption and production (on a geographic scale that enables data to remain confidential, where necessary), this contributes to improving local governance of networks, and more generally to the development of public policies for local energy transition. The mass deployment of Linky will enable further progress in this regard, helping to achieve more detailed monitoring and faster detection of electricity outages, which are currently based on manual collection.

Measures:

- Provide each territory with a mobility authority (AOM) and extend the role of the AOM to active or shared mobility and mobility services of a social nature;
- Implementing instruments enabling authorities responsible for electricity distribution (AODE) and distribution administrators to improve the prioritisation and coordination of their investments;
- Revising the Regional Plans for the Connection of Renewable Energies to the Network (S3ENR) in order to prevent saturation;
- Improving planning by ensuring improved coordination between the various geographical spheres of electrical planning (Europe with the TYNDP, France with the SDDR, regions with the SRADDET and S3RENR, departments with the NOME legal convention, inter-municipalities with the PACET), as well as between electricity and other energy networks;
- Encouraging open access to data pertaining to local network limitations, notably in order to optimise the establishment of production projects or infrastructure installations for the charging of electric vehicles, and to facilitate local energy planning exercises.

Box 24: Regional challenges in the electricity transport network: Brittany and Alsace

The transport network must consider local disparities, in terms of both demand (linked to economic dynamics and attractiveness of the local area), supply (share of electricity produced locally), and network limitations. In France, Brittany is the region where the electricity supply is most fragile. The pressure on electricity supply to the Provence-Alpes-Côte d'Azur region has been largely alleviated thanks to the network reinforcement efforts carried out by RTE. However, the network still experiences periods of high pressure during cold spells, which are linked to regional production of electricity from gas.

The fragility of Brittany's electrical supply is linked to low levels of regional production, which covered only 14% of consumption in 2016. Brittany is therefore an electricity peninsula, and depends on far-off production sites located for its supply, particularly the nuclear power plants in the Loire valley. The regional increase in consumption, meanwhile, is higher than the national average due to strong demographic dynamics in the area. This structural imbalance between production and consumption is only partly offset by the electricity transport network.

This situation requires specific measures to be taken for Brittany in order to guarantee supply security for this region. It is in this context that the electrical pact has been developed, proposing a plan of action balanced across three major avenues of energy policy:

- Significant efforts to control electricity demand (MDE);
- Ambitious development of renewable energy production;
- Essential measures to secure the electrical supply (network reinforcement, increased production, and experiments on storage and smart networks).

The development of renewable energy and energy savings, even when implemented in a highly resolute manner as outlined in the Brittany Electricity Pact, will not be enough to alleviate the structural fragility of Brittany's electrical supply. For this reason, several infrastructural projects have been carried out in recent years by RTE, including the "Brittany Safety Net", which involves a 255,000-volt subterranean link stretching 76km between Lorient and Saint-Brieuc and the electrical substation at Mûr-de-Bretagne, in order to secure supply to the northern and central areas of Brittany and establish the capacity to host renewable energies. This safety net was inaugurated on 15 January 2018.

Furthermore, the risk analysis carried out (examining the availability of various means of production, and transport network improvements) identified the necessity of creating a new means of production in order to provide a sustainable response to Brittany's fragile electrical status. Following a call for tenders launched by the State in 2011 for a gas-powered, combined-cycle power station with 450MW capacity, the Brittany Electrical Company (supported by Direct Energy and Siemens) was selected to build this power station in Landivisiau, which will be available to provide the additional power needed by the network, particularly during cold spells.

Elsewhere, in Alsace, in preparation for the closure of the Fessenheim nuclear power plant, RTE has installed capacitors on several source outlets in order to regulate the voltage produced so far by the power station, as well as two new transformers as the Mulbach substation (Fessenheim). These measures will help to ensure the same levels of safety and quality of supply in Alsace once the power station is closed.

8.2.4. Regional experiments with smart networks

The Energy Transition for Green Growth Act introduced the possibility of implementing experimental processes, aiming to optimise the management of electricity flows between consumers and producers on a local level, across portions of the public distribution network.

In order to encourage the deployment – over a wider geographic scale – of smart grid solutions in order to cover more consumers, more means of production and a wider diversity of areas, a call for projects was launched in 2015 by the Ministries for Energy and the Economy, leading to the following initiatives being green-lit:

- FLEXGRID, led by the Regional Council of Provence-Alpes-Côte d'Azur;
- SMILE, led by the Regional Councils of Brittany and Pays de la Loire;
- YOU & GRID, led by the European Metropolis of Lille and the Regional Council of Hauts-de-France.

Each of these programmes encompasses a portfolio of smart grid projects linking multiple local operators, notably focusing on auto-consumption and energy control, as well as the integration of renewable energies into the network, electric vehicles, data management platforms, and cybersecurity. FLEXGRID and SMILE also benefit from €80M in dedicated investments from network administrators RTE and Enedis. These initiatives will now help to accelerate the development of this sector, while also serving as an industrial "showroom" for French expertise in the field of smart electrical networks.

8.3. Ecological Transition Contracts (CTE)

An innovative approach

Announced as part of Climate plan in July 2017, the new tool of ecological transition contract launched by the ministry for ecological and solidary transition aims to support the territory ecological transition.

The approach was given an initial framework at the end of 2017 with the publication of a CTE doctrine, which was presented at the national territorial convention. The experimental process was launched in early 2018 on a voluntary basis.

The method has been precised in 2018, May, on the basis of the first works. The first partnership charters has been signed in July during a National forum for ecological transition contracts where 160 persons met: national or regional civil servants and concerned collectivities.

The first phase for experimentation is soon closed. 8 areas are today involved in a CTE way of thinking: 4 contracts have been signed since 2018, October, 2 will be signed in 2019, February, and 2 others by 2019, April. Such a procedure will also be engaged in the 4 areas concerned by the shutdown of the electric production with coal.

A second phase of experimentation is programmed since 2019 January, and will go on during the first semester with new areas in order to implement a CTE in each metropolitan French region. All the learning will feed in a methodological kit to implement CTE during the second semester of 2019.

The drawing up of a CTE is realised with local projects between State and local authorities, with all the stakeholders, in priority with companies to merge ecological transition and economic growth.

A CTE is composed with an action program with precise commitments between partners and objectives which are monitored over time and assessed.

It is the specificity of the "CTE method": the concrete projects have been developed between partners and are ready to begin when the contract is signed, after a short and very intensive period of elaboration of 6 months. Each action of the CTE has a documented paper will all the details related: actors involved, calendar of implementation, and financing plan.

With the CTE, the State tries to facilitate projects. It involves technical and legal knowledge and financial procedures for the projects. It tries to facilitate or simplify with specific projects. It involves public agencies, in particular ADEME with objectives territory contracts and the CDC as territory bank, and others agencies depending upon contracts: CEREMA, Agencies for water, French agency for biodiversity, VNF, ANAH, ANRU…

The Departments and Regions each have a role to play in the CTE initiative, both with regard to the public policies they oversee and their duty to provide support to inter-municipalities. The Regions have signed the 4 first CTE.

This procedure on the whole territory allows to support the project developers (local authorities, companies association): project building, go-between, advice relating to administrative procedures…

Renewable energies, new mobilities, new green professional sectors, industrial conversions, evolution of production process, healthy and high quality food, short processes for agriculture, natural resources management, circular economy, biodiversity: all the fields could involve a structural evolution for green growth and can be incorporated in a CTE.

Examples of energy or ecological transition projects:

- Renewable energies and energy efficiency: building of a regional technocenter on methanisation, building of a NGV station and switch to NGV for the bus fleet, collective self-consumption projects on an economic activity zone, potential solar plant installation register, energy-efficiency works on built heritage, development of new training programme (renewable energy, thermal renovation, smart energy systems…)
- Mobility: cycle paths, multimodal hubs, intercompany and interagency mobility plans to decrease urban displacements, territorial mobility plan, putting a canal back into operation, set up of third places…
- Natural resources: establishment of natural reserves, "starry sky" certification, steam restauration…
- Innovation and companies: information and orientation centre, counselling for innovative SMEs…
- Quality of life: brownfield land rehabilitation, upholding and promotion of hedgerows, flood prevention…
- Sustainable agriculture: development of organic agriculture and local distribution channel, new training programme in agricultural college, quality upgrading of local products, territorial food programme...

The CTEs represent two major innovations.

- CTEs are drawn up based on projects led by local operators, backed by the coordinated mobilisation of every available institutional support service.
- The CTEs assemble different types of projects being carried out within a given area under an integrated approach, intersecting the three goals of the ecological transition: environmental performance, economic development, and social and professional mutations. The integration of companies within the process is a major objective of the CTEs.

Box 25: the four ecological transition contracts signed (December 2018)

Le Grand Arras (Pas-de-Calais)

The Communauté urbaine de Arras launched a widespread mobilisation regarding the drawing up of the CTE: "le Grand Arras : en T.E.T.E. : Territoire Exemplaire de la Transition Ecologique" ("exemplary territory for ecological transition"), which enables to incorporate projects led by private companies and to include environmental, consumer and professional integration NGOs. The main themes of the CTE: renewable energies and energy efficiency (regional technocenter on methanisation), clean mobility (natural gas bus fleet, multimodal hubs), circular economy and societal commitment of companies, preservation of water resources and of natural areas. The territorial authority aims for a 40% reduction of energy consumption by 2050 and to increase its renewable energy generation ten-fold.

La Sambre-Avesnois (Nord)

Four territorial authorities (Sud Avesnois, Cœur Avesnois, Maubeuge Val de Sambre, Pays de Mormal) joined forces for 4 broad policies : reduction of territorial gaps (cycle paths, mobility, third places, inland navigation), support to sustainable development via the third industrial revolution (support to innovative companies, brownfield land rehabilitation), energy management and preservation of natural resources (renewable energies, fight against fuel poverty, ecological corridors, upholding and promotion of hedgerows), sustainable agriculture (agricultural practices, local distribution channel and local products, territorial food programme).

La Cleantech vallée (Gard)

Following the shutdown of EDF's power plant of Aramon, the communauté de communes du Pont du Gard (local council community) and the communauté d'agglomération du Gard rhodanien (conurbation authority) worked together and with EDF to develop clean technology. The main themes of the CTE: support to companies and to vocational streams for clean technology, forward planning of employment and skills within the territory, development of relationships between schools and the corporate sector, development of renewable energies and energy efficiency, brownfield land rehabilitation, multimodal transport.

La haute Côte d'Or

The communauté de communes du Châtillonais and the communauté de communes du Montbardois engaged in cooperation approach together and with local economic stakeholders in order to develop a green economy on their territory while developing in the meantime professional trainings on this matter: trainings to professions relating to renewable energies, biogas generation, development of a production channel of alfalfa, development of local distribution channel and of local products with high added value.

The benefit of the CTE approach is to make different stakeholders join forces, to create partnerships and to organise the coordination of the support of both state departments and publics operators toward the project holders. The State supports territories which elected officials and local stakeholders want to involve themselves in the ecological transition.

9

Clean mobility development strategy

9. Appendix 2: Clean Mobility Development Strategy

9.0. Summary

Background and Objectives

The Clean Mobility Development Strategy (SDMP) is provided by the law of 17 August 2015, the Energy Transition for Green Growth Act (LTECV). This strategy, annexed to the Multi-Year Energy Programme (MYEP), is the second SDMP, the first covering the 2016-2018 period. The current SDMP presents the guidelines and actions planned for the 2019-2023 and 2024-2028 periods, in order to meet with France's objectives and commitments in the fight against global warming and lower energy consumption, and in particular:

- The 2015 Paris Agreement: to contain global warming at under 2°C by 2100;
- The Energy Transition for Green Growth Act (LTECV, 2015), which sets different targets for reducing greenhouse gas (GHG) emissions, reducing end-use energy consumption, and increasing energy efficiency;
- The Climate Plan, announced in 2017, which made the target more ambitious by aiming for carbon neutrality by 2050.

Reaching carbon neutrality in 2050 entails totally stopping greenhouse gas emissions in land transport, inland navigation and domestic maritime transport sectors either through transition to electric motors or through transition to decarbonised alternative fuels. The complete conversion of the car fleet (carbon-free energy used by vehicles and vehicle energy efficiency) along with the development of alternative fuel refuelling station infrastructures is vital. Nevertheless, other means have to be launched in order to mitigate energy demand: shifting traffic to the least polluting and the most energy efficient means of transport, control of the energy demand, optimisation of vehicle use.

This strategy takes place in the context of the drawing up of the mobility law. It will reform deeply the general framework of the mobility policies to offer displacement solutions which meet citizen's expectations and which are in line with environmental constraints. Managing the environmental impacts of the transportation sector is necessary regarding to France's commitments but it is also a demand widely shared in the society and a public health issue. It corresponds also to an economical issue (purchasing power): having vehicles more energy-efficient and fostering alternatives against individual car-driving lead to a reduction of greenhouse gas emissions, a reduction of pollutants emissions and a decrease in the dependency from expensive fossil energies.

Scenarios and trajectories for the development of vehicle fleets

Scenarios

This strategy sets out in particular the approach of the National Low Carbon Strategy (SNBC) based on a quantified baseline scenario to enable the establishment of five-year carbon budgets consistent with the above objectives.

The SDMP in particular identifies assumptions for the development of vehicle fleets, the growth outlook for the number of charging stations for the development of alternative fuels, changes in consumption of the different types of energy by transport and the proposed approach for each of the levers (decarbonisation of the energy consumed by vehicles, energy performance of vehicles, managed growth in transport demand, modal shift, optimisation of vehicle use). It complements the SNBC baseline scenario with a scenario based on the MYEP.

The energy price scenarios are based on a 2020-2035 framework set by the European Commission in relation to the greenhouse gas emissions of Member States. They are based on an increase in the price of fossil fuels (+41%, +46% and +25% for oil, coal and gas respectively between 2018 and 2028).

For the baseline scenario (scenario with additional SNBC measures), the economic growth assumptions are 1.4% per year on average from 2015 to 2028. Over this same period, population growth is assumed to be 0.5% per year on average. This scenario assumes a 26% increase in passenger traffic and a 40% increase in freight traffic between 2015 and 2050, with average growth of 0.6% and 0.7% per year, respectively, from 2020 to 2030.

Trajectories

The proposed scenarios reflect a major change in vehicle fleets, modal shares and vehicle occupancy rates.

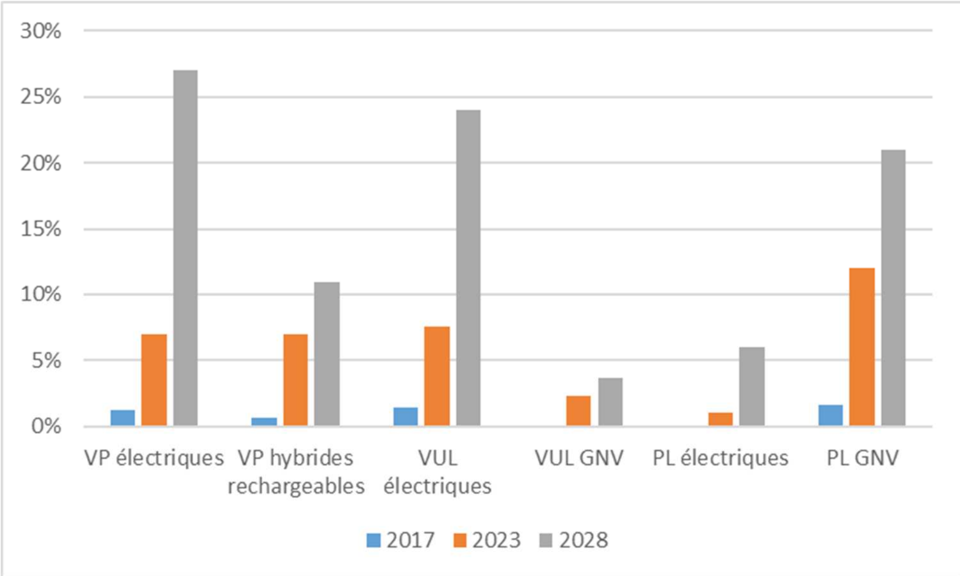


Figure 1: Change in market share in vehicle fleet registrations

Bicycles	3.3x the modal share of bicycles as early as 2024 and 4x in 2028
Public transport	+3% in modal share
Road transport (travellers)	5% shift towards active modes and public transport
Mass transport (freight)	Stabilisation of modal shares of rail and river freight

Table 1: Evolution of modal shares 2015-2028

Private vehicles	From 1.63 in 2015 to 1.69 in 2028
HGV	From 9.75 tonnes in 2015 to 10.4 tonnes per vehicle in 2028

Table 2: Evolution of vehicle occupancy rates 2015-2028

The evolution of vehicle energy performance leads to a 16% reduction in transport consumption between 2015 and 2028:

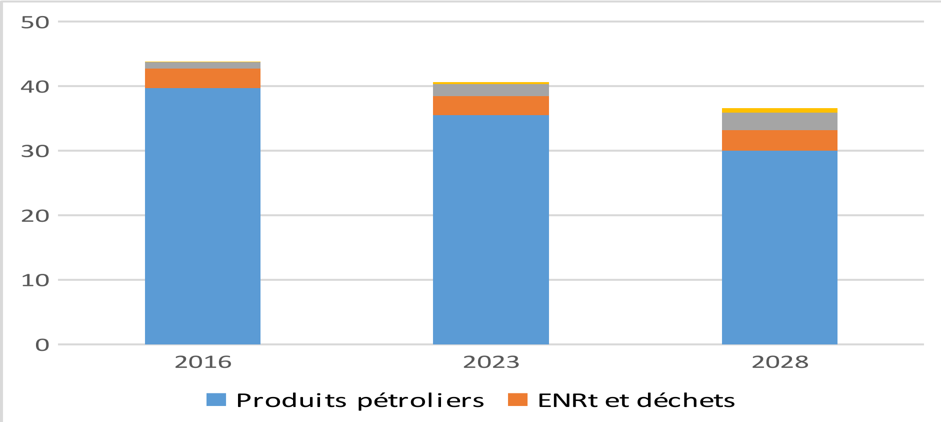


Figure 2: Evolution of transport energy consumption from 2015 to 2028 (in Mtoe)

Transportation sector is not compliant with its assigned carbon budget. This sector has significant structural inertia. The measures of the PPE and, on a broader level, the strategic orientations should allow the transportation sector to reach the carbon neutrality trajectory from the period 2029-2033. Finally, the trajectory of GHG emissions for transport resulting from these scenarios is as follows:

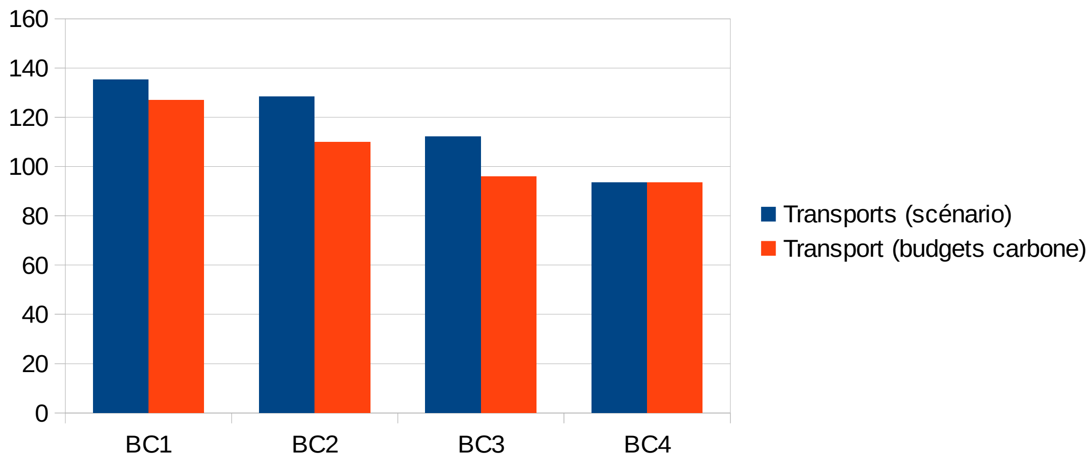


Figure 3: GHG emissions from the SNBC2 scenario and evolution of carbon budgets for transport

These scenarios show, for a continuation of the current trend (scenario with equivalent measures), a 4.9 Mtoe reduction of the energy consumption by 2028:

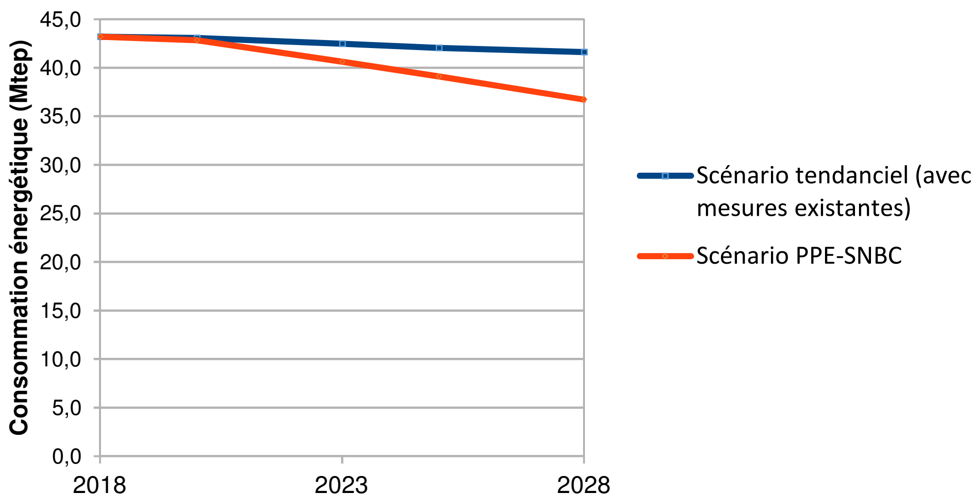


Figure 4: Energy consumption forecast (Mtoe)

Guidelines and action plans for the development of clean mobility

For the production of these scenarios, the main guidelines and courses of action are notably derived from the Consultative Meetings on Mobility and the draft Mobility Law (LOM).

Enabling all areas to benefit from clean mobility and freeing up innovation

- Make clean mobility accessible to all by providing each area with a Mobility Organisation Authority (AOM) and extending the role of the AOMs to active or shared mobility and mobility services of a social nature. The objective is to ensure that anyone can choose its mobility within a range of services of mobility more diversified, more efficient, more connected, more shared in any area.
- Facilitate experimentation and implementation in new mobility solutions, including driverless vehicles travelling on public roads through a dedicated legislative and regulatory framework.

Managing mobility demand

- Optimising travels by implementing incentives procedures, enhancing the role of employers and the coordination of local public authorities and giving incentives to companies to adopt action plans to reduce emissions on the whole logistic chain.
- Promote more virtuous behaviours by implementing low-emission areas in conurbations and valleys affected by air pollution issues.

Developing low-emissions vehicles (included river, sea and air ones) and improving fleet efficiency by building on the alternative fuels market

- Set ambitious growth targets for the market share of low-emission (light and heavy) vehicles and using purchase and tax incentives to achieve these targets (bonus-malus, grants to switch vehicle), accompanying all people;
- Support this development through the deployment of alternative fuel distribution infrastructures by increasing funding for electric charging stations, simplifying the right to install charging facilities, and creating new gas stations (CNG) and hydrogen stations;
- Promote energy efficiency of river and sea domestic transport and reach the carbon neutrality, allowing the distribution in low carbon energy in every French harbour and facilitating the switch to other low carbon technologies (battery, biofuels, hydrogen, sail…);
- Limit air transport greenhouse gas emissions with huge energy efficiency improvement and an important switch from fossil fuels to biofuels (50%).

Favouring modal shift for passenger transport

- Developing multi-modal mobility as a result of the accelerated opening of the data and the possibility for the actors to offer a journey planning and ticket payment service integrating all links for the same journey;
- Boost the share of active modes in daily mobility by creating a national fund of €350M to make cycling safer (secure parking, anti-theft tagging of bicyclcles, bike box at traffic lights…) and creating incentives (grant for sustainable mobility) and more accessible (cycling proficiency);
- Develop public, shared and collaborative modes of transport by investing in rail infrastructures, in collective transports, in clean mobility through calls for tender and by encouraging the use of shared transport thanks to a sustainable mobility grant and dedicated ways.

Promoting modals shift and freight transport towards river routes and railways and improving efficiency

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

9.1. Introduction

This document presents the Clean Mobility Development Strategy provided by article 40 of the Energy Transition for Green Growth Act (LTECV).

Box 1: Article 40 of the Energy Transition for Green Growth Act

"The State defines a strategy for the development of clean mobility. It relates to:

1° The development of low-emissions vehicles and the deployment of infrastructures to enable them to be fuelled. In particular, it sets forth the national action framework for the development of the alternative fuels market and the deployment of the corresponding infrastructures;

2° Improving the energy efficiency of the vehicle fleet;

3° Modal shifts from private cars to public land transport, cycling and walking, as well as from road to rail and river transport;

4° The development of collaborative modes of transport, especially car-sharing or carpooling;

5° Increasing freight vehicle filling rates.

This strategy is set by regulations.

It includes an evaluation of the existing supply of clean mobility, quantified and broken down by type of infrastructure, and, for the timescales of the Multi-Year Energy Programme, mentioned in Article L. 141-1 of the Energy Code, in its wording resulting from I of article 176 of this law, to which it is an appendix, sets the objectives for the development of the vehicles and deployment of the infrastructures mentioned in section 1 of this article, on intermodality and filling rates of freight vehicles. It defines the local areas and the priority road networks for the development of clean mobility, in particular in terms of infrastructures, consistent with a targeted strategy of deployment of certain types of low-emissions vehicles.

The Government submits this strategy for consultation to the National Council for Ecological Transition for an opinion and then presents it to Parliament."

The Clean Mobility Development Strategy (SDMP) first presents the public action framework for the development of clean mobility, while providing quantified information on the existing supply and its environmental and health impact related to GHG emissions and atmospheric pollutants. Finally, based on short- and medium-term macroeconomic assumptions, demand scenarios and emission reduction targets, it sets out the change trajectories for vehicle fleets in response to these targets. It then sets out the issues, guidelines and measures taken by France relating to the development of low-emissions mobility which should enable to be in compliance with the trajectory of the National Low Carbon Strategy.

The document does this by building on the National Consultation on Mobility from September to December 2017, the conclusions of which led to the development of guidelines serving as a basis for the drafting of the Mobility Law (LOM). Other strategies and action plans also fed into this document (see Appendix 2), in particular the Climate Plan and the Hydrogen Plan, the Strategic Contract for the automotive sector 2018-2022, and the Bicycle & Active Mobility Plan.

The strategy is based on the following five levers:

- Enabling all local areas to benefit from clean mobility and freeing up innovation;
- Managing mobility demand;
- Developing low-emissions vehicles and delivery infrastructures for alternative fuels, and improving the energy efficiency of the vehicle fleet;
- Favouring modal shift for passenger transport;
- Promoting modal shift and freight transport efficiency.

While the strategy set out in Article 40 of the LTECV focuses on land transport, it is useful to mention the contribution of other modes of transport, such as air and maritime transport, to the development of cleaner mobility.

The monitoring of the SDMP will be made at the same time as the monitoring of the Multi-Annual Energy Plan, via the monitoring indicators defined in the PPE and related to the transportation sector.

9.2. Public policy framework

9.2.1. The international framework of the fight against climate change

All countries worldwide are concerned about global warming. France has been internationally involved since the start of the development of an international policy to combat climate change under the auspices of the United Nations. By approving the Paris Agreement in 2015, the States undertook a commitment to act to keep global warming under 2°C by 2100, by stepping up efforts to avoid exceeding 1.5°C.

The international agreement drawn up under the French presidency deals, in a balanced way, with attenuation – i.e. efforts to reduce greenhouse gas emissions – and with the adaptation of societies to existing climate disruptions.

The “Paris Climate Alliance” is broken down into four components:

1. A universal agreement that establishes rules and mechanisms that can progressively raise the ambition to respect the limit of 2°C;
2. The presentation by all countries of their national contributions in order to create a knock-on effect and to demonstrate that all States are moving, in accordance with their national situations, in the same direction;
3. The financial component helps support developing countries and finances the transition to low-carbon, resilient economies;
4. Enhanced commitments of civil society and non-state actors in order to involve all actors and to start specific actions quickly.

Emissions from international shipping, like air transport, are not subject to national contributions – as these modes of transport are exempted from the Paris Agreement – but their emissions are regulated by their international bodies, the International Maritime Organisation (IMO) and the International Civil Aviation Organisation (ICAO).

With regard to maritime transport, in April 2018 the IMO adopted a decarbonisation strategy compatible with the objectives of the Paris Agreement. For aviation, the ICAO has developed a "basket of measures" to limit the impact of aviation on climate change.

9.2.2. The European framework

European Low Emissions Mobility Strategy

In Europe, the transition to a low-carbon, circular economy has begun and is accelerating. In July 2016, the European Commission adopted a Low Emissions Mobility Strategy, which sets out the European approach to meeting the challenges of reducing emissions and the increasing mobility needs of people and goods.

The main elements of the strategy are as follows:

- Increasing the efficiency of the transport system by making the most of digital technologies, by applying smart pricing – adapting prices to demand fluctuations – and by continuing to encourage the shift to less polluting transport;
- Accelerating the deployment of renewable or bio-sourced alternative fuels in transportation, such as advanced biofuels, biogas, renewable electricity and renewable synthetic fuels, and also by removing barriers to the electrification of transport (batteries and storage, production of electricity, etc.);
- Moving towards zero-emissions vehicles. If further improvements to internal combustion engines are needed, Europe must accelerate the transition to low- and zero-emissions vehicles.

Finally, the strategy reaffirms Europe's commitment to participating in the global effort to combat GHG emissions from international aviation and maritime transport.

Clean Mobility Package

Passenger transport and freight are expected to grow in Europe by 42% and 60% respectively by 2050. This sector directly employs almost 5% of European workers, i.e. 11 million people. As a result, in 2017 the European Commission proposed "packages" for clean mobility to address the specific challenges of road sector development in Europe. These "packages" are series of new legislative proposals concerning the governance of road transport in Europe. The European Commission calls on all stakeholders to work closely together to ensure that these measures are put in place as soon as possible.

The first clean mobility package[93] includes many initiatives to make road traffic safer, encourage next-generation routes, reduce CO_2 emissions, air pollution and congestion, simplify administrative procedures, combat illegal employment and improve the working conditions of truck drivers.

The second package (November 2017) proposes the following measures:

- New targets for the reduction of CO_2 emissions from light vehicles, to nudge manufacturers to innovate and produce low-emissions vehicles. This includes targets with two timeframes:
  - 2025, making it possible to ensure the start of investments right away;
  - 2030, to provide stability and a long-term view of these investments;
- Clean Vehicles Directive to promote clean mobility solutions in public procurement;
- Action and investment plan for the trans-European deployment of alternative fuels supply infrastructures through a €350M call for projects, the aim of which is to raise the ambitions of national plans, increase investment, and improve social acceptability;
- The revision of the Combined Transport Directive, which promotes the combined use of different modes of transport for freight, and will make it easier for businesses to obtain financial incentives;
- The Passenger Bus Directive, to stimulate the development of connections between long-distance buses across Europe and offer alternatives to the use of private cars. This will help reduce pollutant emissions and road congestion by offering new, numerous and affordable mobility options, especially for low-income families;
- The battery initiative is of strategic importance for the EU's integrated industrial policy, so that vehicles

[93]Europe on the Move, May 2017

and other mobility solutions, as well as their components, are invented and produced in the EU. The Commission proposes €200M between 2018 and 2020 for battery development and innovation, through national initiatives.

The third and final component (May 2018) involves global communication, several proposals for regulations and guidelines, action plans and evaluation reports divided into four sections:

- Improving the environmental and climate performance of road transport: a set of proposals for technical and regulatory adaptations (minimum standards for CO_2 emissions for heavy vehicles, energy labelling of tyres, etc.), transparency in consumer information and a battery action plan;
- Enhanced road safety: a new target of halving the number of road deaths and serious injuries between 2020 and 2030, new standards for infrastructure safety management and the requirement for car manufacturers to introduce new safety devices (emergency braking, lane keep assist, etc.);
- Preparing Europe for the future of mobility through a strategy for automated mobility;
- Simplifying procedures (digitisation of administrative documents, simplification of rules for the priority projects of the trans-European transport network, simplification in the area of maritime transport).

9.2.3. The national framework

LTECV, the Climate Plan and the Mobility Law

The Climate Plan, adopted on 6 July 2017, carries a strong commitment from the Government regarding the fight against climate change by aiming for carbon neutrality by 2050. This ambitious goal is in line with France's long-standing commitment to the fight against climate change, and contributes to the implementation of the Paris Agreement while respecting the principle of climate justice.

The transport sector must, like all other economic sectors, play its part in the overall goal of carbon neutrality. A number of measures have already been taken to make clean mobility accessible to all and to develop innovation. The Consultative Meetings on mobility in the second half of 2017 provided an opportunity for an in-depth consultation with stakeholders and citizens, to build, in partnership, a Mobility Law (LOM). The measures outlined in the LOM are included in Part 4.

The Climate Plan reinforces the political ambitions that France has adopted under the LTECV. The law sets a broad framework for energy policy, which must, in particular[94]:

- Foster the emergence of a competitive and job-rich economy;
- Ensure supply security and reduce import dependency;
- Maintain an internationally competitive and attractive energy price and control consumer energy spending;
- Protect human health and the environment, in particular by combating the worsening of the greenhouse effect and by reducing the exposure of citizens to air pollution;
- Contribute to the establishment of a European Energy Union.

The LTECV covers the European commitments and proposes ambitious national targets in terms of energy, in particular:

In 2020: 23% of energy consumption from renewable sources in 2030;

By 2030:

- -40% greenhouse gas emissions (compared to 1990);
- -20% of end-use energy consumption (compared to 2012);

94 Only the issues that make sense with regard to mobility are repeated here. The full set of issues are listed in Article L. 100-1 of the Energy Code.

- -30% of primary fossil energy consumption (compared to 2012);
- +27% energy efficiency;
- 32% of energy consumption from renewable sources. This target is broken down by energy vector (15% of end-use fuel consumption);

In 2050:

- -75% of greenhouse gas emissions (compared to 1990). This goal is now replaced by the 2050 Carbon Neutral Objective of the Climate Plan.

The LTECV has created two governance instruments: the National Low Carbon Strategy (SNBC) and the Multi-Year Energy Programme (MYEP) to which the Clean Mobility Development Strategy (SDMP) is annexed.

Box 2: The LTECV and aviation

Article 45 of law No. 2015-992 of 17 August 2015 on the Energy Transition for Green Growth Act requires the 11 largest metropolitan airports to establish a "programme of actions to reduce greenhouse gas emissions and atmospheric pollutants resulting from direct activities and activities on the airport apron, in terms of aircraft taxiing and vehicle traffic on the apron in particular".

The objective is to reduce the intensity of greenhouse gases and atmospheric pollutants by at least 10% in 2020 and by at least 20% by 2025, compared to a 2010 baseline.

Basel-Mulhouse, Beauvais-Tillé, Bordeaux-Merignac, Lyon-Saint-Exupéry, Marseille-Provence, Nantes-Atlantic, Nice-Cote d'Azur, Paris-Charles-de-Gaulle, Paris-Le Bourget, Paris -Orly and Toulouse-Blagnac airports are covered by this provision of the law.

The National Low Carbon Strategy

The National Low Carbon Strategy provides the strategic guidelines for the implementation in France of the transition necessary to meet the objectives relating to the fight against climate change. It defines a long-term trajectory for the reduction of greenhouse gas emissions in France to reach the 2050 target, and sets "carbon budgets". These are greenhouse gas emission ceilings that must not be exceeded at national level over five-year periods.

Carbon budgets are consistent with the trajectory. Thus, for each period, the carbon budget is set lower than that of the previous one. The National Low Carbon Strategy puts forward recommendations that policy makers must take into account. These recommendations are formulated:

- By activity sector: transport, building, industry, agriculture, forestry, energy production, waste;
- On cross-cutting policy issues: investment, research, education and training, etc.

The National Low Carbon Strategy adopted in 2015 defined three carbon budgets for the 2019-2023, 2024-2028 and 2029-2033 periods. They are broken down for illustration by major area of activity.

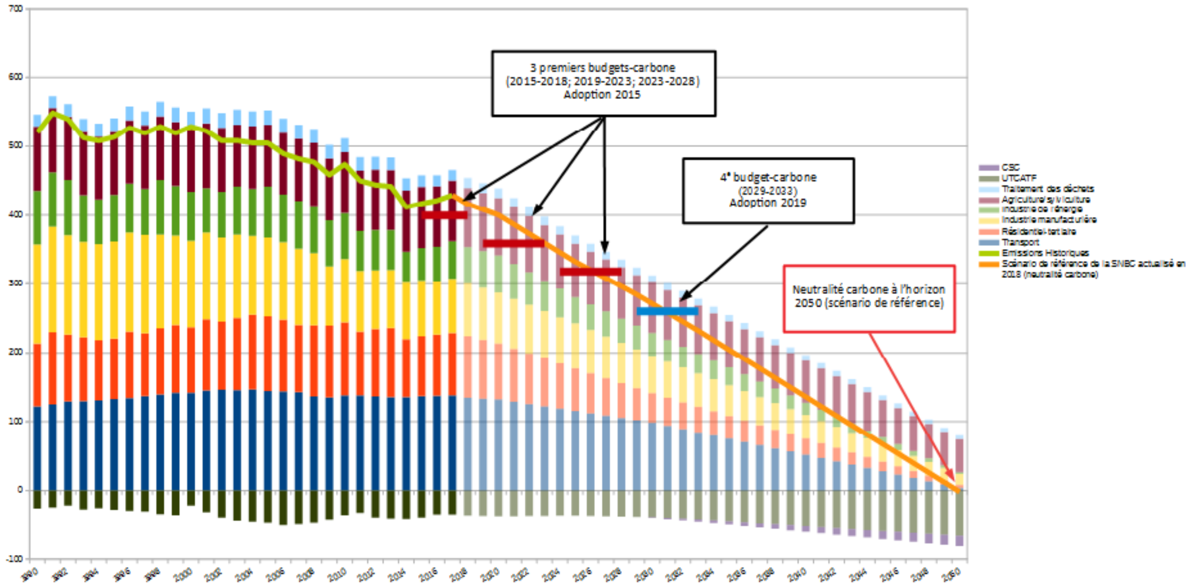


Figure 5: Greenhouse gas emission reduction trajectory, carbon budgets and fourfold target in 2050 – Source: *DGEC*

In accordance with the objectives set by the 2015 law, the previously approved strategy aimed to be "fourfold" i.e. it seeks to achieve a four-fold reduction (-75%) in greenhouse gas emissions by 2050 compared to 1990. In accordance with the Climate Plan, published in July 2017, the SNBC review incorporated the more ambitious goal of carbon neutrality. Hitting this target will require an almost total decarbonisation[95] of the energy produced and consumed in all sectors of activity, and in particular in the transport sector. The following chart details the revised carbon budgets under the new SNBC.

The SNBC and the carbon budgets are adopted by decree. The law specifies that public decisions (State, local authorities, public institutions) in the areas concerned must take it into account. The Multi-Year Energy Programme must be compatible with the National Low Carbon Strategy.

Multi-Annual Energy Programme

In application of the Energy Transition for Green Growth Act of August 2015 and, in particular, of the objectives that it set, the Multi-Year Energy Programme defines the priorities of the Government for the energy system. A Multi-Annual Energy Programme is established for the metropolitan French mainland, and another for each non-interconnected zone, notably the overseas departments. It covers all energies and at the same time the supply of energy, demand control and the evolution of the networks which connect them. The Multi-Year Energy Programme adopted for the first time in October 2016 sets the priorities for the 2016-2018 and 2019-2023 periods. It is then revised every five years on a sliding scale. The second covers the 2019-2023 and 2024-2028 periods.

The actions provided for by the Multi-Year Energy Programme must particularly make it possible to comply with the "carbon budgets" set by the National Low Carbon Strategy. It must also contribute to achieving the air pollution reduction objectives defined by the National Plan for Reduction of Atmospheric Pollutant Emissions (PREPA).

Certain planning documents must be compatible with the Multi-Year Energy Programme:

- This document, the Clean Mobility Development Strategy, appended thereto;
- The National Biomass Mobilisation Strategy which, among other things, secures the supply of individual and collective wood-burning appliances and biofuel production facilities;

95 Decarbonisation is only "almost complete" given the partial use of fossil fuels for international air and maritime transport and domestic air transport, as well as "incompressible" residual leakages of renewable gases.

- The Employment and Skills Programming Plan, which will define skills and employment development requirements in the territories and in the professional sectors, in respect of the ecological and energy transition;
- The energy component of the National Energy Research Strategy.

9.2.4. Coordination with public policies and sectoral benefits

Public action for sustainable transport systems and mobility is among France's commitments to combat global warming, atmospheric pollution, and improving energy efficiency. It contributes to the competitiveness objectives of the economy and local areas, health, social support, employment and purchasing power. Public action also falls within a framework set, as the case may be, by subsidiarity, at European level and/or within international organisations such as the IMO or the ICAO. The benefits of implementing a strategy for the development of clean mobility are multiple: lowering the environmental and health costs of atmospheric pollution, increasing the purchasing power of consumers and preserving the competitiveness of industries, reducing the consumption of resources and French dependence on fuel imports, and job creation. The development of clean mobility thus lies at the intersection of a range of transport policies with urban and spatial planning policies, energy and environmental policies, particularly those relating to air quality, as well as tax policy.

The mobility of people and goods cannot be conceived without an overall understanding of spatial planning, urban and rural, and of France's integration in European and global transport strategies. Urban mobility is both an element and a product of the design of conurbations. The law has planning tools for anticipating and organising urban changes in order to save land and control urban sprawl.

Finally, beyond the tax incentives for the development of clean mobility, it appears that the predictability for stakeholders of the tax framework over a period of five to ten years is crucial in enabling decision-making in favour of lower carbon-intensive, cleaner, and more efficient transport.

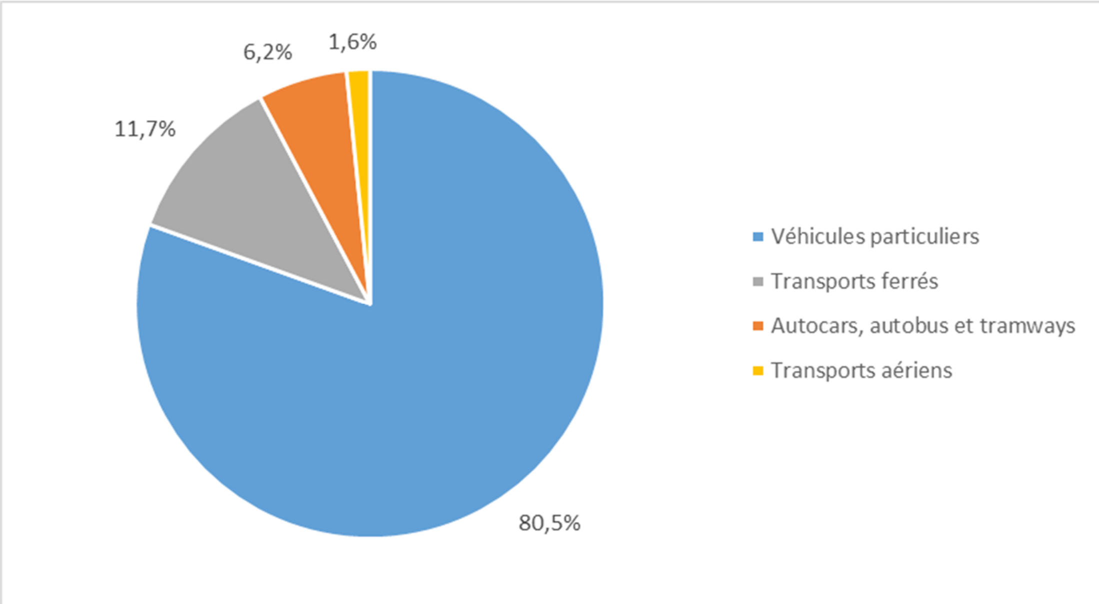
9.3. Elements on mobility in France and its environmental impact

9.3.1. Contextual data

Passenger transport

941.3 billion passenger-kilometres were travelled in France[96] in 2017, the majority being private transport, possibly shared (PC, LCV and two-wheelers[97]). The share of maritime transport, not shown in the graphs below, remains marginal. 28 million passengers passed through the main French ports in 2017.

96 "Transport accounts in 2017, volume 1 – 55th Commission Report on the National Accounts of Transport", 2018.
97 Active and river modes are not taken into account because their number of passenger-kilometres is relatively low compared to other modes.



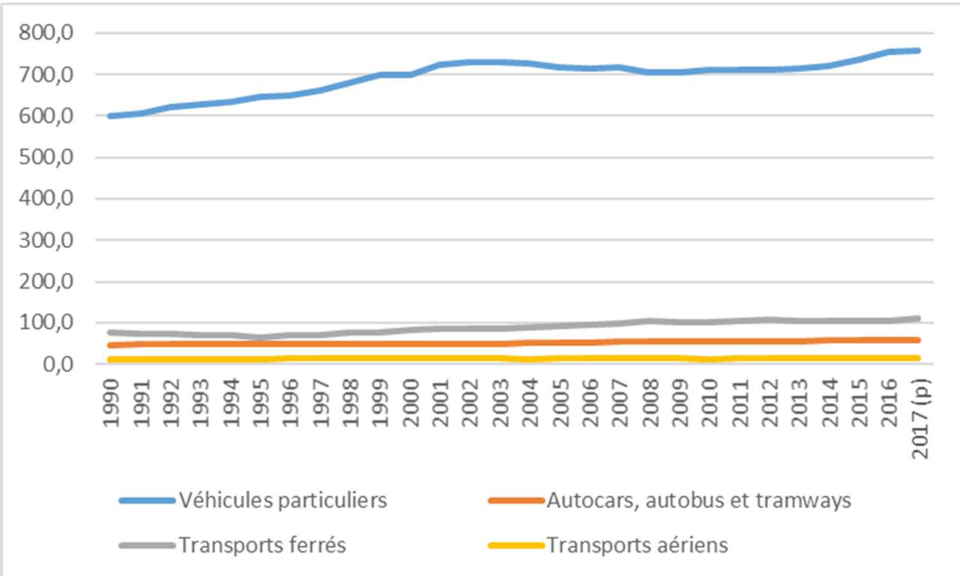
Source: MTES/SDES

*Active and river modes are not included because their number of passenger-kilometres is relatively low compared to other modes.

*Figure 6: Modal distribution of passenger-kilometres transported in 2017**

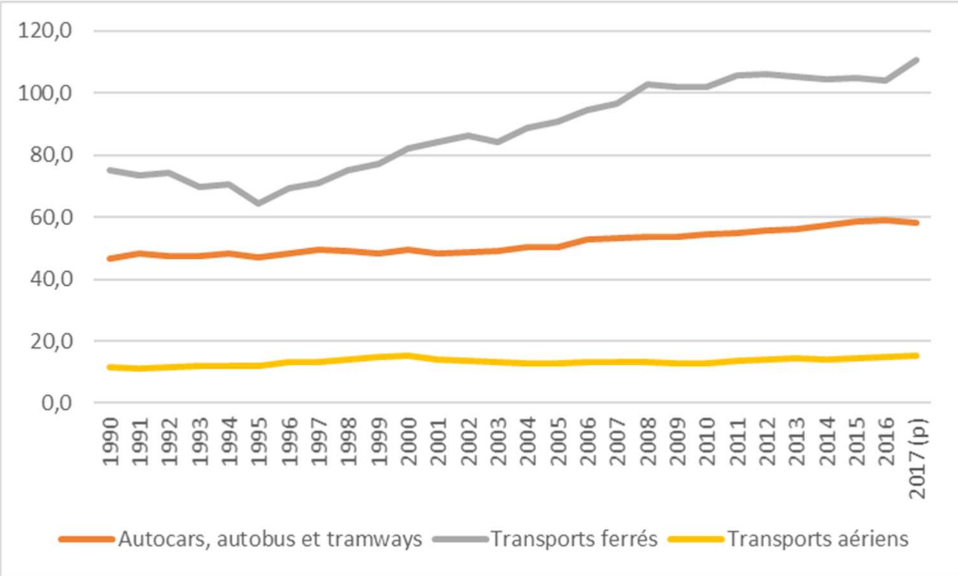
Long-term trend

Domestic passenger transport has increased by 28.6% since 1990, an average of 1.1% per year, but only air, coach, bus and tram transport traffic have grown steadily over this period.



Source: MTES/SDES

Figure 7: Domestic passenger transport from 1990 to 2017 based on transport mode (in billions of passenger-kilometres)



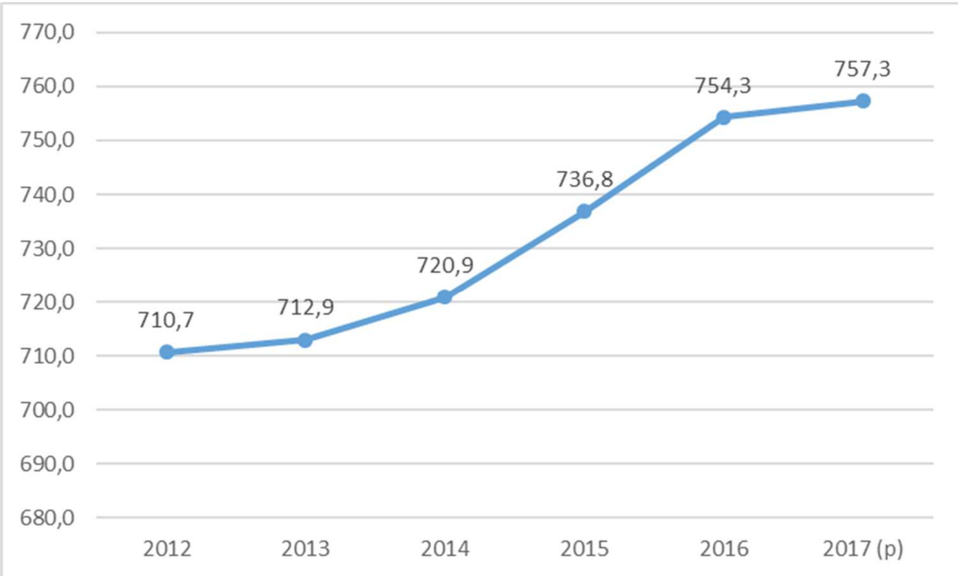
Source: MTES/SDES

Figure 8: Collective domestic passenger transport from 1990 to 2017 based on transport mode (in billions of passenger-kilometres)

Short-term trend

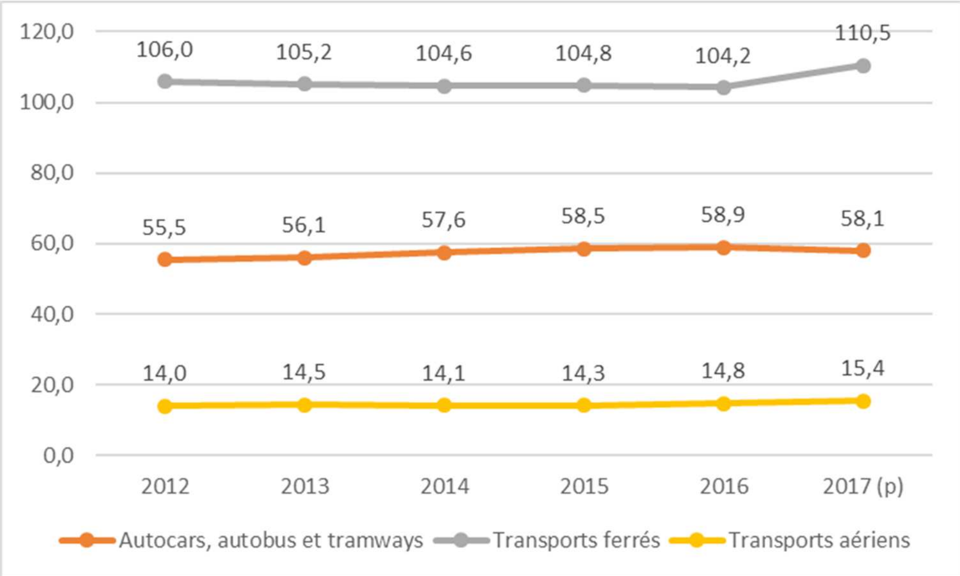
Domestic passenger transport has increased overall by 6.2% since 2012, averaging 1.2% per year.

In 2017, this growth increased to 1%, mainly due to public transport (+3.4%) while the growth of passenger transport by private vehicles was limited to 0.4%.



Source: MTES/SDES

Figure 9: Domestic passenger transport from 2012 to 2017 based on transport mode (in billions of passenger-kilometres)

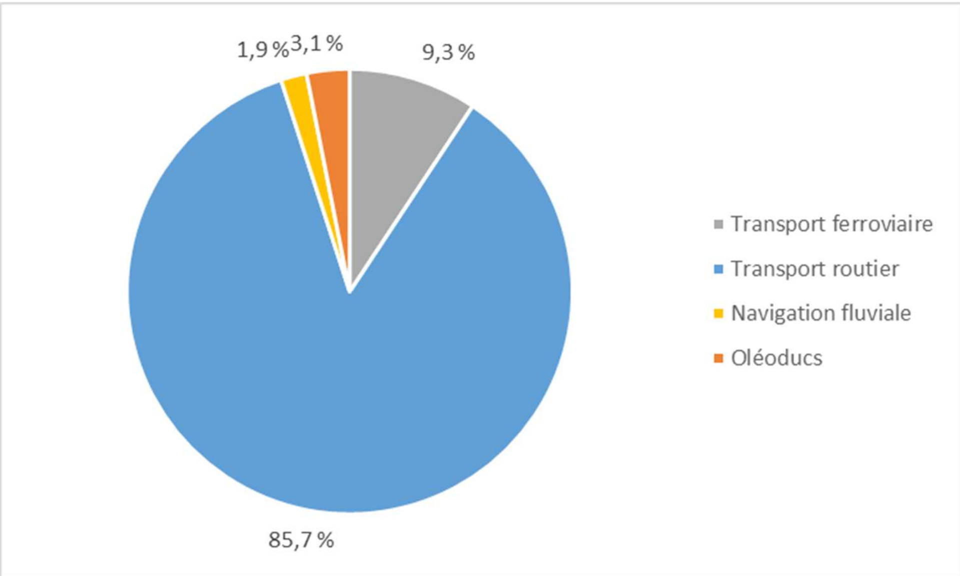


Source: MTES/SDES

Figure 10: Collective domestic passenger transport from 2012 to 2017 based on transport mode (in billions of passenger-kilometres)

Freight transport

359 billion tonne-kilometres were transported in France[98] in 2017, most of them by road. The bulk of international trade in goods (80% in volume and 70% in value) is by sea, but maritime transport accounts for a very small share of domestic transport.



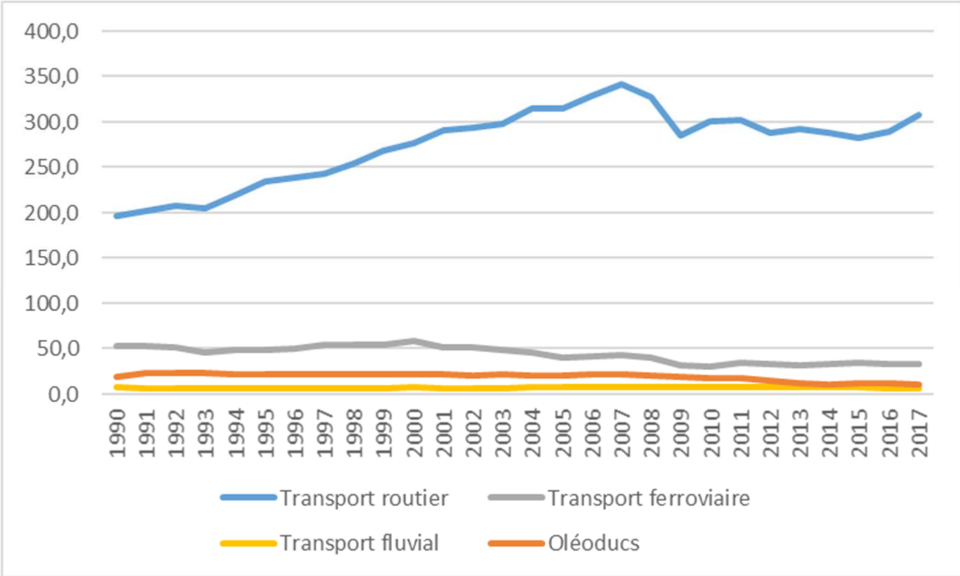
Source: MTES/SDES

Figure 11: Modal distribution of tonne-kilometres transported in 2017

Long-term trend

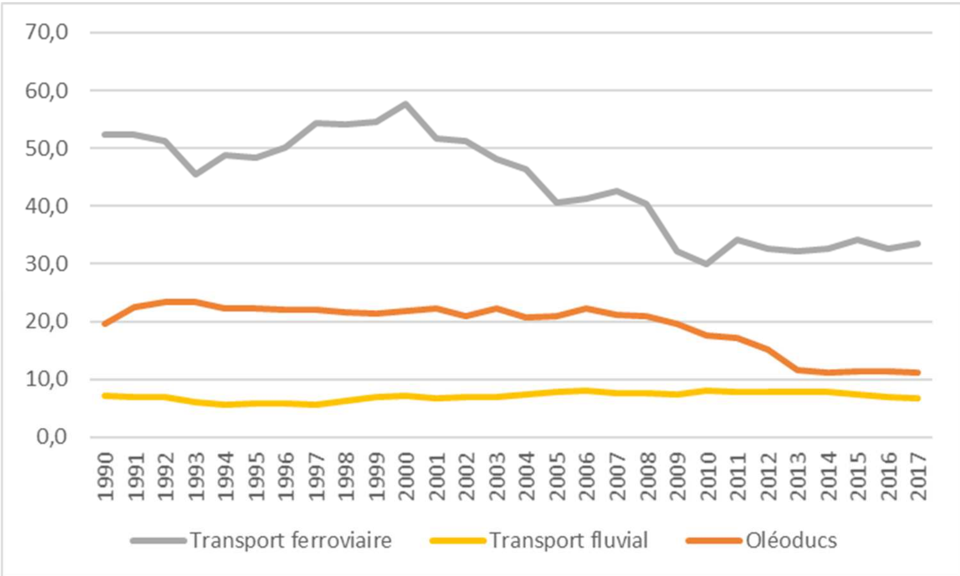
Domestic freight transport has increased by more than 30% since 1990, averaging about 1.1% annually, mainly due to the sharp increase in road freight transport.

98 Source: "Transport accounts in 2017, volume 1 – 55th Commission Report on the National Accounts of Transport", 2018.



Source: MTES/SDES

Figure 12: Domestic freight transport from 1990 to 2017 based on transport mode (in billions of tonne-kilometres)



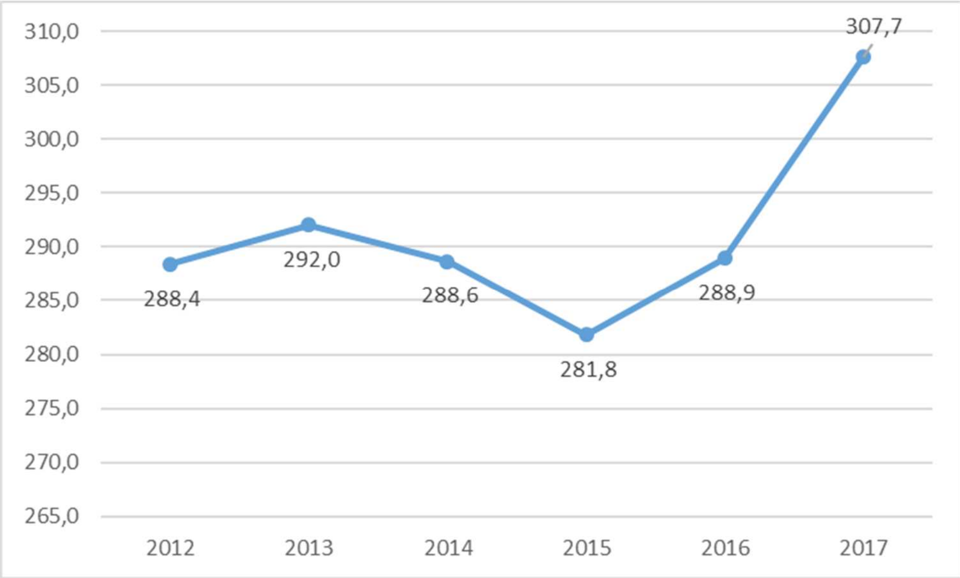
Source: MTES/SDES

Figure 13: Domestic freight transport from 1990 to 2017 based on transport mode (in billions of tonne-kilometres)

Short-term trend

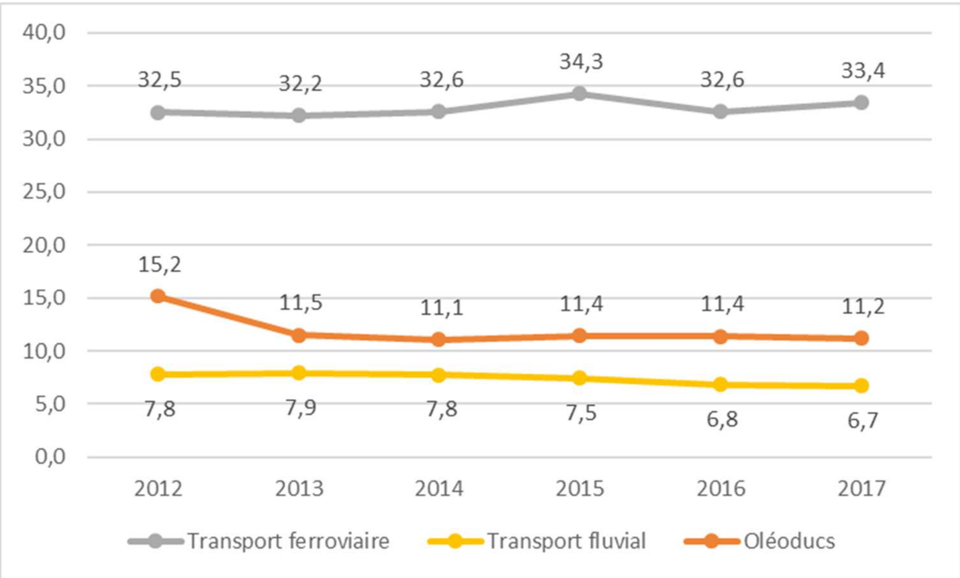
In 2017, land freight transport rose sharply (+6.0%).

Since 2012, land transport (excluding pipelines) has increased by 1.1% on average annually, with an increase of 1.3% for roads, 0.5% for rail and a decrease of 3.0% for river.



Source: MTES/SDES

Figure 14: Road freight transport from 2012 to 2017 (in billions of tonne-kilometres)



Source: MTES/SDES

Figure 15: Domestic off-road freight transport by mode from 2012 to 2017 (in billions of tonne-kilometres)

Box 3: Alternative fuels

Alternative fuels are defined by Directive 2014/94/EU on the deployment of an alternative fuels infrastructure, such as:

"Fuels or energy sources that serve, at least partially, as a substitute for fossil fuels in the transport energy supply and can contribute to the decarbonisation of these and improve the environmental performance of the transport sector. They include:

- Electricity;
- Hydrogen;
- Biofuels within the meaning of Article 2 (i) of Directive 2009/28 / EC;
- Synthetic fuels and paraffinic fuels;
- Natural gas, including biomethane, in gaseous form (compressed natural gas (CNG) and in liquefied form (liquefied natural gas (LNG)); and
- Liquefied petroleum gas (LPG)."

Alternative Fuels: Vehicles and Distribution Infrastructures

Electricity

Electromobility is continuing to develop, with an increase in the number of registered electric vehicles. Compared to 2016, the fleet of electric passenger cars doubled while the fleet of electric light commercial vehicles grew by almost 40%.

Private cars	86,570
Light commercial vehicles[99]	35,711
Heavy vehicles[100]	150
Buses and coaches	477
Two-wheelers[101]	≈ 14,000

Source: MTES/SDES-RSVERO, fleet estimates by the application of an age threshold (<=15 years for cars, two-wheelers, light and heavy specialised self-propelled vehicles, <=17 years for buses, <=18 years for coaches, <=20 years for vans and trucks).

Private cars	43,255
Light commercial vehicles	249
HGV	19
Buses	87
Two wheelers	≈ 100

Source: MTES/SDES-RSVERO, fleet estimates.

Table1: Number of plug-in hybrid vehicles 01/01/2018[102]

Charging infrastructures are also developing in parallel. As of 1 May 2018, there are 25,157 charging points open to the public, 9513 charging stations open to the public including 1916 stations in Île-de-France. 58% of

99 This corresponds to light specialised light trucks and motor vehicles (<3.5 tonnes of GVWR).
100 This corresponds to trucks and specialised heavy self-propelled vehicles (>3.5 tonnes of GVWR).
101 This takes account of tricycles and quadricycles.
102 This includes petrol-electricity, petrol-natural gas-electric, petrol-LPG-electricity, diesel-electric, super-ethanol-electricity and rechargeable hydrogen-electric.

the stations were deployed directly by local authorities and 92% received financial support under the Future Investments Programme (PIA). The majority of charging stations open to the public offer a normal charge, of which 37% are stations with loads of 22kW, and 641 stations (8%) offer a strong power charge[103].

Certain French sea and river ports, such as the Grand Port Maritime of Marseille (GPMM), are embarking on the electrification of ships at berth to reduce fuel consumption at each port stopover.

CNG and LPG

With regard to fleets of road transport vehicles in France running on natural gas vehicles (CNG) – natural gas or biogas (bioCNG) released for consumption in compressed form (CNG) or liquefied (LNG) – and liquefied petroleum gas (LPG), as of 1 January 2018, they included:

Private vehicles	2707 of which 86% is bi-fuel + 14% natural gas
Light commercial vehicles	8045 of which 78% is bi-fuel + 22% natural gas
HGV	1997 of which 0.2% is bi-fuel + 99.8% natural gas
Private vehicles	2707 of which 86% is bi-fuel + 14% natural gas
Buses and coaches	2437 of which 0.5% is bi-fuel gas-natural petrol and 99.5% natural gas

Source: MTES/SDES-RSVERO, fleet estimates.

Table 3: Number of vehicles running on CNG as of 01/01/2018[104]

Private vehicles	144,373 of which 99.9% is bi-fuel + 0.1% natural gas
Light commercial vehicles	13,092 of which 98% is bi-fuel + 2% natural gas
HGV	32 of which 62% is bi-fuel + 38% is natural gas
Buses and coaches	70 of which 26% is bi-fuel + 74% is natural gas

Source: MTES/SDES-RSVERO, fleet estimates.

Table 2: Number of vehicles running on LPG as of 01/01/2018[105]

CNG and LPG have environmental benefits compared to traditional fuels such as petrol and diesel. The introduction in 2016 of over-depreciation for CNG heavy vehicles led to a sharp rise in sales of these vehicles, with a five-fold increase in the total fleet.

In terms of CNG distribution infrastructures in the national territory, there are 87 public stations, including 63 stations distributing CNG and 24 distributing LNG[106]. Some have received financial support under the Future Investments Programme since 2016 ("CNG mobility integrated solutions" call for projects). The stations can be for quick filling, for trucks or LV, or slow filling, for local authority buses whose tanks fill up during the night.

Hydrogen

As far as hydrogen is concerned, the fleet is still very small. It consists of 73 private cars, ten vans and one specialised heavy self-propelled vehicle,[107] which benefitted at the end of 2017 from 20 filling stations, half of which were private stations[108].

Active modes

103 A charging point can also be characterised by its technical specificities, and in particular the maximum capacity at which electricity can be transferred from the charging station to the electric vehicle. For this document, two types of charging points have been selected:
- Normal charging point: power less than or equal to 22kW (kilowatt)
- Strong power charging point: power above 22kW (kilowatt)

104 This includes 100% natural gas vehicles as well as petrol-natural gas and super-ethanol-natural gas biofuels.

105 This includes 100% LPG vehicles and petrol-LPG bi-fuel vehicles and super-ethanol-LPG biofuels.

106 Source: OpenData Gas Mobility

107 Source: MTES/SDES-RSVERO, fleet estimates.

108 Source: AFHYPAC – February 2018

Walking accounts for a quarter of all urban travel. The modal share of cycling remains low today, accounting for 3% of daily trips and 2% of commuting to work[109]. The dynamism experienced by cycling is confined to the city centres of some major cities – of more than 100,000 inhabitants – where the modal share sometimes exceeds 10% (Strasbourg, Grenoble, Bordeaux). In France, around 45,700 self-service bicycles (VLS) are available in 36 cities, including 20,000 in Île-de-France, for a total of 3550 stations[110]. There are also 35,000 secure parking spaces at train stations and in city centres[111].

Electric-assisted bicycles have grown exponentially over the past ten years and now represent a market of about €400M, with around 255,000 sold in 2017, almost twice as many as in 2016.

In 2017, use of intercity routes – cycle routes – increased by 8%[112]. Since 2013, the increase is 18%.

Car-sharing

On average, car occupancy rate is 1,63. Car occupancy rates vary with the distance travelled. It is more than 2 for trips over 200 kilometres and ranges from 1 to 1.1 for commuting[113]. The trend in private vehicle occupancy rates varies according to geographical area and household characteristics, but carpooling can help to increase it. Most carpooling trips are currently focused on medium- and long-distance journeys and not on commuting to and from work. In 2015, 11 million long-distance trips were made by car-poolers, representing 1.6% of these trips[114].

9.3.2. Findings on energy consumption in the transport sector, its emissions and impacts on health and the environment

Traction energy consumption in transport

In 2016, transport represented 31% of France's end-use energy consumption. Between 1990 and 2002, transportation consumption increased significantly. Transportation consumption remained relatively stable between 2001 and 2008, in line with other activity sectors (industrial, agricultural, building). Since then, it has been declining, but more slowly than in all other sectors. For two years, it increases slightly mainly because of temporary circumstances like the price of petroleum products and traffic increase.

Road transport alone accounts for 94.1% of the sector's energy consumption. It is followed by air, with 2.2%, then rail and maritime and river with 1.8% respectively.

109 Source: MTES/SDES – CCTN 2017.
110 Source: MTES/SDES – CCTN 2017.
111 Evaluation study on bicycle services – Ademe, 2016.
112 Analysis of cycling use data 2017, Departments and cycling regions.
113 National Study on Short-Distance Carpooling – Ademe, 2015.
114 Source: MTES

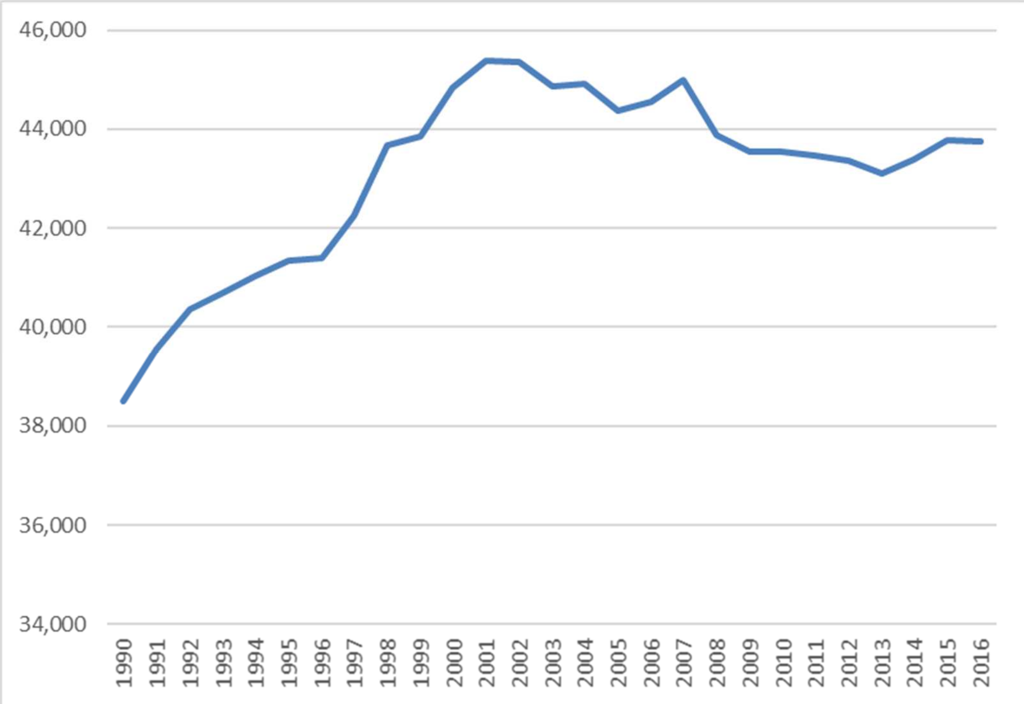


Figure 16: Energy consumption from transport between 1990 and 2016 (Mtoe)

Greenhouse gas emissions (GHG) from transport

The first version of the National Low Carbon Strategy defined carbon budgets for the 2015-2018, 2019-2023 and 2024-2028 periods. Overall, CO_2 emissions in 2016 exceeded this first carbon budget by 3.6%. Transport overshot the ceiling by 6%, mainly due to economic factors such as the low oil prices and the increase in traffic.

In 2017[115], the transport sector accounted for 30% of GHG emissions and 38% of CO_2 emissions, with a total volume of 138MtCO_2eq. It is the largest emitter of GHGs in France followed by residential / tertiary and agriculture. This is the result of the contrasting trends in the different sectors. While other sectors, such as industry, energy and, to a lesser extent, the residential-commercial sector, have reduced their emissions from the early 1990s to the present, the transportation sector is an exception, with higher emissions in 2016 than in 1990 (+12%). Between 1991 and 2016, GHG emissions from transportation rose by 0.4% per year on average, with a reversal of the trend between 2004 and 2009. This increase is in line with the increase in travel, population growth, economic growth and growth in the supply of transport services, with the increase in traffic only being partially offset by the improved performance of new vehicles. GHG emissions from road transportation, which is highly dependent on fossil fuels, account for 96% of the sector's GHG emissions. Private vehicles are responsible for more than half of road transport GHG emissions, while light commercial vehicles emit 20% and heavy vehicles a little more than 20% [116].

115 2017 = provisional estimate. Source: CCTN 2017
116 "Transport accounts in 2016, volume 1 – 54th Commission Report on the National Accounts of Transport", 2017.

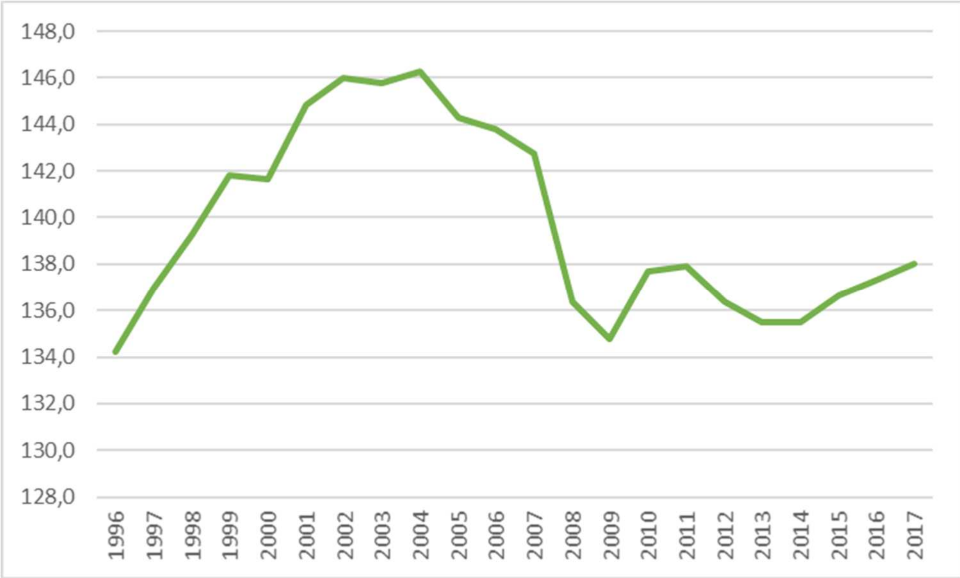
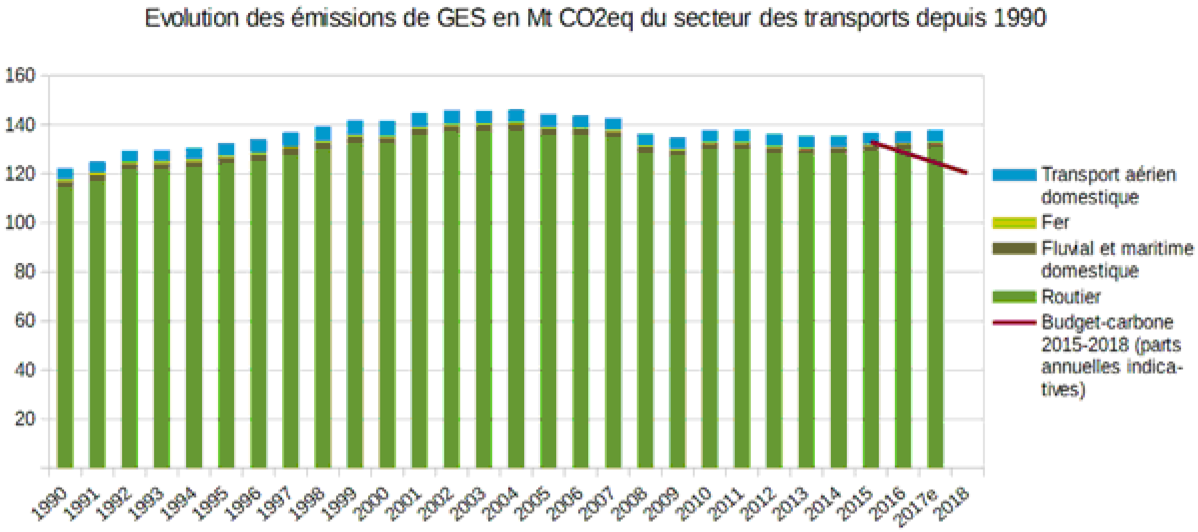


Figure 17: Greenhouse gas emissions from transport in France (MteCO$_2$) (Source CITEPA)



Atmospheric emissions from transport

The transport sector, particularly road transport, is a major contributor to atmospheric pollutant emissions.

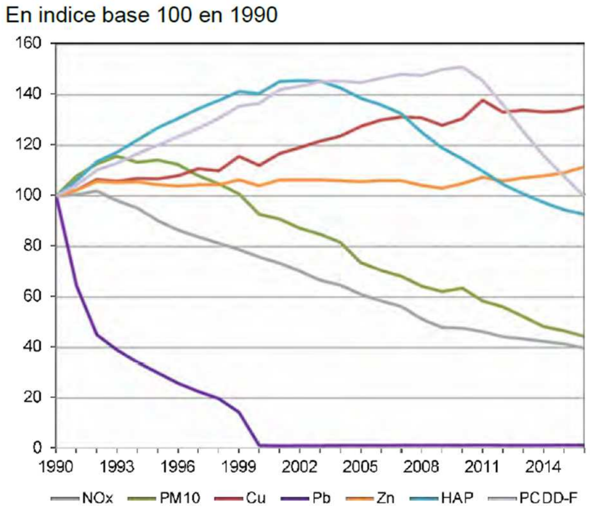
	NOx	PM2.5	VOC
Share of transport sector in national emissions of NOx, PM2.5 and VOC[117]	63%	19%	11%
Share of road transport in national emissions of NOx, PM2.5 and VOC	57%	17%	9%

Sources: SDES; CCTN 2017

Table 3: Share of transport sector and road transport in national emissions of atmospheric pollutants

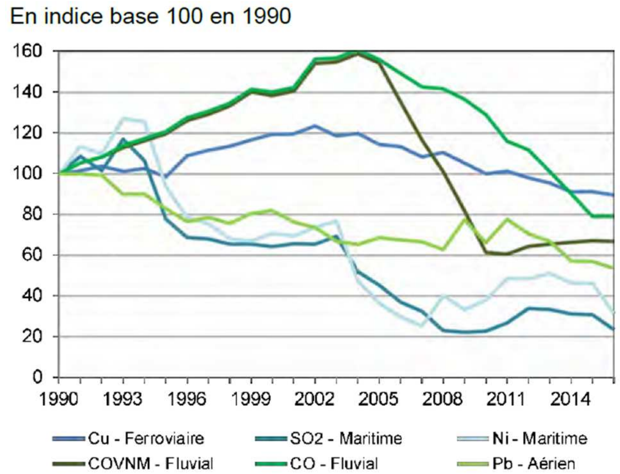
117 VOCs: volatile organic compounds – Source: SECTEN report, CITEPA, 2017. Data for 2015

Since 1991, emissions of most atmospheric pollutants have decreased in all sectors. In transport, and more particularly road transport, Euro standards and technical progress, particularly in fuels, have led to a steady decline in these emissions. Only road-related copper emissions have increased since 1990.



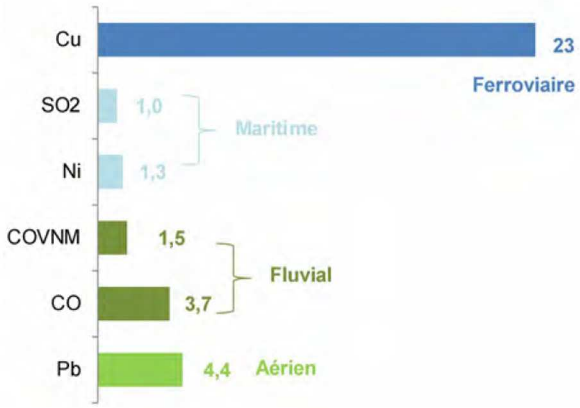
Graph 1: Evolution of emissions of the main road transport pollutants

Source: Citepa, April 2018 – Secten Format



Graph 2: Evolution of emissions of major pollutants from non-road modes of transport

Source: Citepa, April 2018 – Secten Format



Source: Citepa, April 2018 – Secten Format

Figure 18: Share of non-road modes of transport in total emissions of certain pollutants in 2016 (in %)

The distribution of atmospheric pollutant emissions from transport is not homogeneous throughout the country. The share of road transport is increasing in urban areas and near major roads: road transport accounts for about 35% of PM2.5 emissions in Île-de-France and 58% in Paris[118]; annual average NO_2 concentrations are twice as high in the vicinity of road traffic as in urban areas, and 34% of stations located near road traffic do not meet European standards; for particles with a diameter of less than 10µm (PM10), in 2015, 10% of measurement stations located near the road traffic failed to comply with the regulations[119]. Exhaust gases are not the only source of particulate emissions from road transport: a significant proportion of these emissions comes from tyre abrasion, roads and brakes. In Île-de-France, for example, 46% of PM10 primary emissions come from these abrasion phenomena[120].

118 Source: Airparif. Data for 2012
119 "Transport accounts in 2016, volume 1 – 54th Commission Report on the National Accounts of Transport", 2017.
120 "Prospective assessment of air quality by 2020 in Île-de-France", Airparif, September 2017

Impacts on health and the environment

Emissions of atmospheric pollutants pose significant health problems. In France, atmospheric pollution is responsible for around 48,000 premature deaths a year, nearly 10% of total mortality,[121] in addition to significant morbidity (respiratory and cardiovascular diseases, lung cancer, etc.). In June 2012, The International Agency for Research on Cancer (IARC), part of the World Health Organization (WHO), classified diesel engine exhaust as a carcinogen[122]. NO_2, in addition to causing respiratory and cardiovascular diseases, contributes to the acidification and eutrophication of environments. Like CO, it is a gas that is involved in the formation of ozone.

The cost to society of air pollution has been estimated in France at €30Bn per year, including nearly €1Bn directly borne by the health care system[123].

The health impacts of air pollution come mainly from regular exposure to pollution, more than pollution peaks. It is therefore the reduction in background levels of pollution (annual average) that will maximise health benefits. In its air quality guidelines, the WHO has defined threshold values beyond which air pollution is harmful.

9.4. Trajectories for 2023-2028

This section outlines the underlying assumptions used in the modelling and explains the results of the model in terms of energy and greenhouse gas emissions.

9.4.1. Assumptions used in the modelling

The Following orientations and measures enable to justify the parameters used to draw up the scenarios. The following table summarises the link between these 2 aspects:

121 "La prévention de la mortalité attribuable à la pollution atmosphérique: pourquoi agir maintenant ? (Preventing mortality attributable to atmospheric pollution: why act now?)" Public Health France, 2016

122 The IARC working group also concluded in 2012 that petrol engine exhaust is potentially carcinogenic, a result that remains unchanged from the previous assessment of 1989.

123 Source: MEEM, 2012.

Parameters to draw up the scenarios	Matching between orientations and measures
Massive electrification of individual vehicles	Setting ambitious growth targets for the market share of electrical vehicles and using purchase and tax incentives to achieve these targets (bonus-malus, grants to switch vehicle), accompanying all people.
A more balanced energy mix for freight transport	Development of low-emission vehicles, of alternative fuels and deployment of alternative fuel distribution infrastructures.
International transport decarbonation (inland navigation, maritime transport and air transport)	Promoting low-emissions maritime and river transport via strengthened ecological criteria and via incentives for alternative fuel use. Limit air transport greenhouse gas emissions with huge energy efficiency improvement, an optimisation of air navigation procedures and an important switch from fossil fuels to biofuels.
Vehicle energy efficiency	Replacing fleets of companies, the State and local authorities by enforcing a minimal share of low-emissions vehicles.
Modal shift from car to active means	Boosting the share of active modes in daily mobility by creating a national fund of €350M to make cycling safer (secure parking, anti-theft tagging of bicycles, bike box at traffic lights…) and creating incentives (grant for sustainable mobility) and more accessible (cycling proficiency).
Modal shift from car to public transport and vehicle use optimisation	Developing public, shared and collaborative modes of transport by investing in rail infrastructures, in collective transports, in clean mobility through calls for tender and by encouraging the use of shared transport thanks to a sustainable mobility grant and dedicated ways.
Modal shift and improving freight transport efficiency	Streamlining urban logistics by taking them into account in planning documents and by overseeing the activity of digital platforms. Developing mass modes for freight by increasing investments in mass transport infrastructures (railway, river routes and ports)
Managing mobility demand	Optimising travels by implementing incentives procedures, enhancing the role of employers and the coordination of local public authorities. Promoting more virtous behaviours by implementing low-emission areas in conurbations and enable them to establish congestion charge.

Macro-economic assumptions

Baseline and alternative energy scenarios

The energy price scenarios are based on a 2020 to 2035 framework set by the European Commission in relation to the greenhouse gas emissions of Member States in 2017. These scenarios are based on price levels above those recorded for 2016-2017.

	2018	2023	2028
Oil (€2013/boe)	64	81	90
Coal (€2013/boe)	13	16	19
Gas (€2013/boe)	44	51	55

Table 6: International fossil fuel prices (in 2013 euros, per barrel of oil equivalent)

The economic growth assumptions are taken from the European Ageing Report, i.e. an average of 1.4% per year between 2015 and 2028). Over this same period, population growth is assumed to be 0.5% per year on average[124].

124 Source: Population projections for France 2013-2070, Insee – Results no. 187 on Society, November 2016.

The law requires the MYEP to put forward an alternative to the baseline scenario, to assess the impact of a different macroeconomic situation and the consequences on energy supply and demand, as well as on public policies.

The alternative includes the following changes:

- Higher demographics (high life expectancy and high immigration);
- Energy prices 10% lower than in the baseline scenario;
- growth: 1.7% from 2020.

Emissions reduction and energy efficiency targets

The emission reduction targets for 2030 for all sectors are set by the Energy Transition for Green Growth Act (LTECV), partially listed in 1.3.

The baseline scenario for the MYEP and SDMP is the revised SNBC scenario for 2018-2028. This scenario is therefore in line with the SNBC's long-term approach, notably carbon neutrality by 2050. This baseline scenario was developed under the auspices of a steering committee consisting of departmental and sectoral experts. It outlines a possible sectoral trajectory for reducing greenhouse gas emissions until carbon neutrality is achieved by 2050, used as the basis for the definition of carbon budgets. It is not prescriptive, but indicative. It does not offer an action plan, but serves as a baseline, in particular for defining carbon budgets and providing elements for monitoring the management of the energy transition. The data below should therefore be understood as assumptions resulting from technical-economic discussions between experts, stakeholders and administration.

Assumptions for the evolution of the road vehicle fleet

The main approaches and measures included in the transport scenario are as follows:

- Electrification, about three times more efficient than thermal solutions in terms of energy performance, is prioritised, especially for private vehicles (almost 100% of sales of private electric vehicles from 2040);
- An approach involving a more balanced mix (renewable gas, electricity, biofuels) is proposed for freight.
- Gradual decarbonisation of international transport (aviation and maritime) using biofuels and biogas is considered as part of a 50% decarbonisation target by 2050.
- Significant efforts made in terms of vehicle efficiency, in particular thermal vehicles.
- The increase in traffic is channelled through actions to control rising demand, modal shift and optimised vehicle use to limit energy demand.

➤ *Private cars*

As part of a continuous development trajectory, and with the aim of ending sales of thermal vehicles by 2040, the share of electric and plug-in hybrid vehicles will grow rapidly, reaching 38% of sales by 2028. Given fleet renewal times, the share of electric and plug-in hybrid vehicles would reach 16.5% of the fleet in 2028, or 4.8 million vehicles in circulation by that year.

There are 150,000 LPG-powered vehicles in the fleet. LPG provides a substantial environmental gain over petrol or diesel. It can reduce emissions from existing passenger car fleets with little investment by public authorities.

It is therefore consistent with national objectives and provides a viable alternative in the period of transition of the private vehicle fleet to vehicles with low or very low emissions.

In view of the end of the use of thermal vehicles by 2050, the consumption of LPG could follow a dynamic similar to that of petrol consumption.

PV	2017	2023	2028

Electric	1.25%	7.00%	27.00%
Plug-in hybrid vehicles	0.60%	7.00%	11.00%

Table 4: Evolution of the market shares of the different engines in new private vehicles

NB.1: Given the low volume of registrations (0.06% of sales in 2017), no precise quantified trajectory is available for the registrations of LPG vehicles.

	As of 01/01/2018	**2023**	**2028**
Electric	89,000	660,000	3,000,000
Plug-in hybrid vehicles	28,600	500,000	1,800,000
Gas (LPG)	150,000	150,000	150,000

Table 5: Evolution of the fleet of private vehicles in circulation

- *Light commercial vehicles (LCV)*

Data on electric vehicles are aggregated with those for plug-in hybrid vehicles (short- and medium-term timeframes, in a transitional approach and to support clean mobility of all sectors) and hydrogen vehicles.

	2017	**2023**	**2028**
Electric, plug-in hybrids and hydrogen	1.40%	7.60%	24.00%
CNG	0.10%	2.30%	3.70%

Table 6: Evolution of the market shares of the different engines in new light commercial vehicles

	As of 01/01/2018	**2023**	**2028**
Electric, plug-in hybrids and hydrogen	31,500	170,000	500,000
CNG	8200	40,000	110,000

Table 7: Evolution of the fleet of light commercial vehicles in circulation

- *Heavy vehicles*

The development of heavy vehicles is based on:

- An assumption of major development of CNG in the truck fleet: 60% of HGVs powered by CNG within in 2050.
- An assumption of development of electric HGVs: 30% of HGV registrations in 2050.

	2017	**2023**	**2028**
CNG	1.60%	12.00%	21.00%
Electric (including hydrogen)	0.00%	1.00%	5.60%

Table 8: Evolution of the market shares of the different engines in new HGVs

	As of 01/01/2018	**2023**	**2028**
CNG	1350	21,000	54,000

Electric (including hydrogen)	100	400	11,000

Table 9: Evolution of the rolling fleet of HGVs in circulation

Buses and coaches

The evolution of the market shares of the various engines in bus and coach registrations includes the impact of the purchase obligation measures as part of the renewal of the public transport fleets (decree in force from January 2017 and implementation deadlines in 2020 and 2025).

	2017	2023	2028
CNG	17.2%	26.60%	31.00%
Electric (including hydrogen)	4.80%	28.80%	42.00%

Table 10: Evolution of the market shares of the different engines in new buses

For the whole fleet of buses and coaches, the changes are as follows:

	2017	2023	2028
CNG	5.00%	8.40%	9.70%
Electric (including hydrogen)	1.60%	8.10%	11.80%

Table 11: Evolution of the market shares of the different engines in new buses and coaches

	As of 01/01/2018	2023	2028
CNG	2600	4900	7500
Electric (including hydrogen)	550	2200	5900

Table 12: Evolution of the fleet of buses and coaches in circulation

Energy performance of vehicles

In order to fit in with the SNBC, the energy performance assumptions set in the scenarios are as follows:

	2018	2023	2028
Petrol (L/100km)	5.9	5.3	4.5
Diesel (L/100km)	5.2	4.6	4.0*
EV (kWh/100km)	17.5	16.9	16.1

**and aim towards a goal of 2L/100km*

Table 13: Energy performance of new passenger cars

	2018	2023	2028
Diesel (L/100km)	8.2	7.4	6.5
CNG (kg/100km)	5.8	5.3	4.6
Electric (kWh/100km)	23.7	22.8	21.7

Table 14: Energy performance of new light commercial vehicles

	2018	2023	2028
Diesel (L/100km)	31.6	29.2	26.8
CNG (kg/100km)	25.8	23.8	21.8
Electric (kWh/100km)	190.0	179.0	167.0

Table 15: Energy performance of new HGVs

Assumptions of transport demand projections

Projections of transport demand were made for the MYEP and SNBC timescales by including assumptions about the economic context and a translation of the measures and approaches of Part 3. The models take account of the economic context, an evolution of the transport prices including the price of energy imports, evolution of taxation, evolution of the energy mix and gains in vehicle performance. They include the evolution of transport supply and the translation of measures used to control demand growth, modal shift and the optimised use of the vehicles presented in Part 3. Demand scenarios were constructed against a 2015 baseline.

Evolution of passenger mobility

In the baseline scenario, passenger mobility grows by 7% by 2028 (an average annual growth rate of around 0.5% per year) in line with demographic and economic growth.

Modal shifts, development of collaborative modes of transport

Modal shift towards soft modes is encouraged. The modal share of bicycles is multiplied by 3 by 2024 and by 4 by 2028. Public transport will grow (+1.4% per year for long-distance rail transport and +2% per year for local public transport). The modal share of the car will decrease by 5 percentage points between 2015 and 2030 in favour of active modes and public transport whose modal share will increase by 3 percentage points. Air transport will continue to grow but at a slower rate than in the recent period: the growth of air transport in mainland France will thus be limited to 0.7% per year.

By volume, the growth of road mobility in terms of passenger-kilometres is limited to 2% between 2015 and 2028, and traffic in terms of vehicle-kilometres will decrease by 2%, due to an increase in the vehicle occupancy rate of 4% between 2015 and 2028 as a result of growth in carpooling.

- *Freight traffic:*

Evolution of demand

Freight traffic in tonne-kilometres across all modes will increase by 15% between 2015 and 2030, an average growth rate of around 1% per year.

Modal shifts from road freight to rail and inland waterways and changes in the filling rate of vehicles

The modal share of rail freight will stabilise and returns to its 2015 level (11.4%) in 2030. The modal share of river transport will remain at 2.3% by 2030.

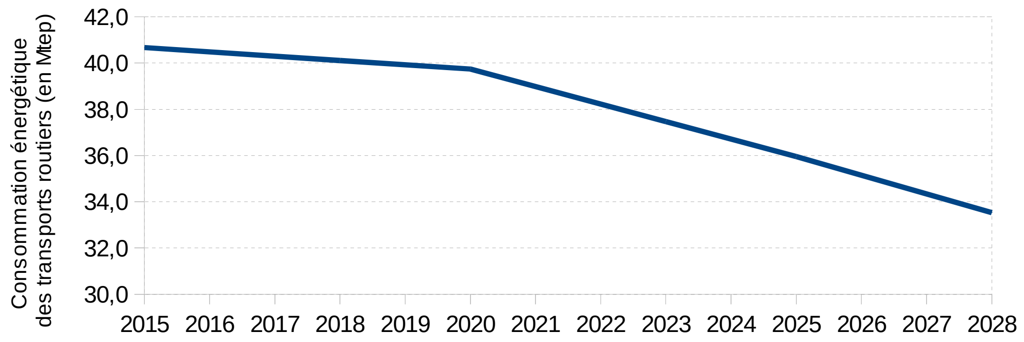
While road freight traffic in tonne-kilometres will grow by 15% between 2015 and 2028, growth in traffic in terms of HGV-kilometres is limited to 8% (an average growth rate of 0.6% per year) due to an increase in truck load rates, from 9.75 to 10.40 tonnes per HGV. Light commercial vehicle traffic will grow at a similar rate of 8% between 2015 and 2028.

9.4.2. Modelling results

Road transport energy consumption

Energy consumption in the road transport sector is expected to reach 40.1Mtoe in 2018 and 33.5Mtoe in 2028, a reduction of 16.5%.

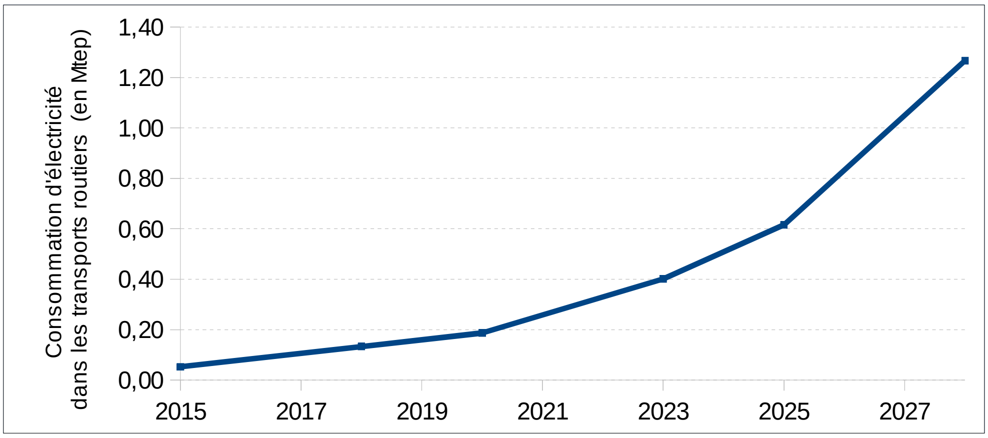
The figure below shows the evolution curve of road transport energy consumption between 2015 and 2028, which is expected to result from the measures implemented.



Graph 3: Evolution of road transport energy consumption from 2015 to 2028 (in Mtoe)

Road transport electricity consumption

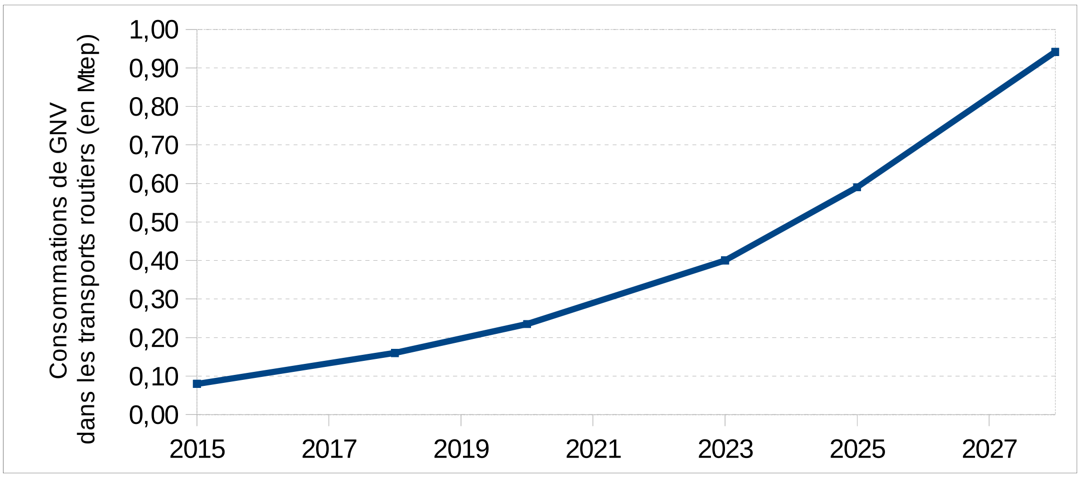
The figure below shows the evolution curve of road transport electricity consumption between 2015 and 2028, which is expected to result from the measures implemented.



Graph 17: Evolution of road transport electricity consumption from 2015 to 2028 (Mtoe)

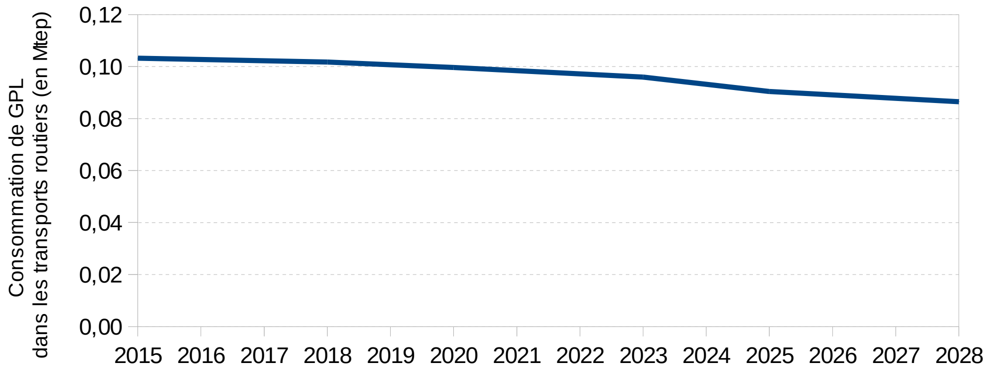
Energy consumption of gas-powered vehicles (LPG and CNG)

The figure below shows the evolution curve of road transport CNG consumption between 2015 and 2028, which is expected to result from the measures implemented.



Graph 4: Evolution of road transport CNG consumption from 2015 to 2028 (in Mtoe)

The figure below shows the evolution curve of road transport LPG consumption between 2015 and 2028, which is expected to result from the measures implemented.



Graph 5: Evolution of road transport LPG consumption from 2015 to 2028 (in Mtoe)

International bunkers

International bunkers represent significant energy consumption volumes (around 7.3Mtoe, including 5.9Mtoe for air transport and 1.4Mtoe for maritime transport).

International air traffic is expected to continue to grow at a steady pace until 2030, but this will be offset in part by air transport efficiency gains (-1.50% per year). The increase in the energy consumption of international air bunkers will therefore be contained at 1.5% per year (before stabilisation after 2030).

International maritime bunkers are assumed to remain stable (energy efficiency gains are expected to offset the increase in traffic).

GHG emissions trajectory in the National Low Carbon Strategy (SNBC)

This section serves as a reminder of the GHG emissions trajectory of the low carbon strategy, and outlines the trajectory for the transport sector.

The first three carbon budgets were adopted by decree in 2015 at the same time as the first National Low Carbon Strategy, and cover the 2015-2015, 2019-2023 and 2024-2028 periods (Decree No. 2015-1491 of 18 November). Every five years, a new carbon budget – with the third being due – is defined during the revision of the strategy. The SNBC provides a breakdown by activity sector for information only. For the transport sector, the indicative carbon budgets of the first SNBC were (in yellow in the table below): 127MtCO_2 for the first, 110MtCO_2 for the second and 96MtCO_2 for the third. The fourth carbon budget, defined as part of the SNBC review, matches the scenario presented.

CO_2 emissions recorded in 2016-2017 exceeded this first carbon budget by (137MtCO_2 in 2017). As part of the SNBC review, a revised scenario was devised with a dual objective of enhancing long-term ambition (carbon neutrality in 2050) and realism on the trajectory. The assumptions of the SNBC2 scenario lead to higher emissions projections than the SNBC1 scenario over the three periods of the first carbon budgets. However, the emissions target of the third carbon budget (96MtCO_2) will be reached by 2030: SNBC2 therefore forecasts a fourth carbon budget of 94MtCO_2 for 2029-2033.

The following tables and graphs show the emissions of the SNBC2 scenario and the carbon budgets for the transport sector and for all sectors.

Budgets carbone transports (valeur moyenne annuelle)	BC1 2015-2018	BC2 2019-2023	BC3 2024-2028	BC4 2029-2033
Transports (scénario)	135	128	112	94
Transport (budgets carbone)	127	110	96	94

Table 16: GHG emissions from the SNBC2 scenario and evolution of carbon budgets for transport. Budgets from the SNBC1 are indicated in yellow. The first budget (BC1) of the scenario is reckoned based on the observed (2015 and 2016) and forecasted emissions.

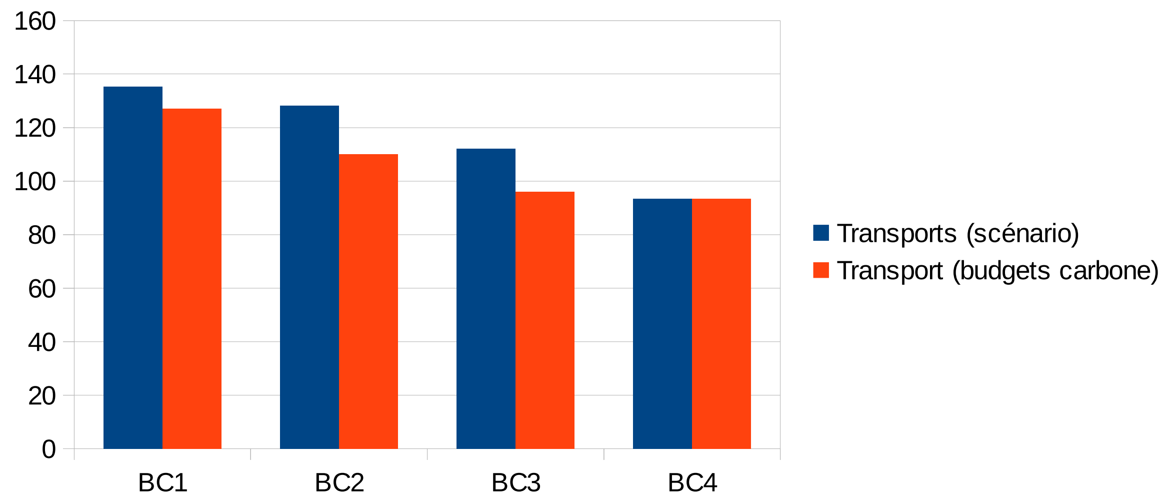


Table 17: GHG emissions from the SNBC2 scenario and evolution of carbon budgets for transport

Carbon budgets for all sectors are presented below.

Budgets carbone (valeur moyenne annuelle)	BC1 2015-2018	BC2 2019-2023	BC3 2024-2028	BC4 2029-2033
TOTAL hors UTCATF (scénario)	458	422	357	299
Total (budgets carbone)	440	398	357	299

Table 18: GHG emissions of the SNBC2 scenario and evolution of carbon budgets for all sectors. Budgets from the SNBC1 are indicated in yellow. The first budget (BC1) of the scenario is reckoned based on the observed (2015 and 2016) and forecasted emissions.

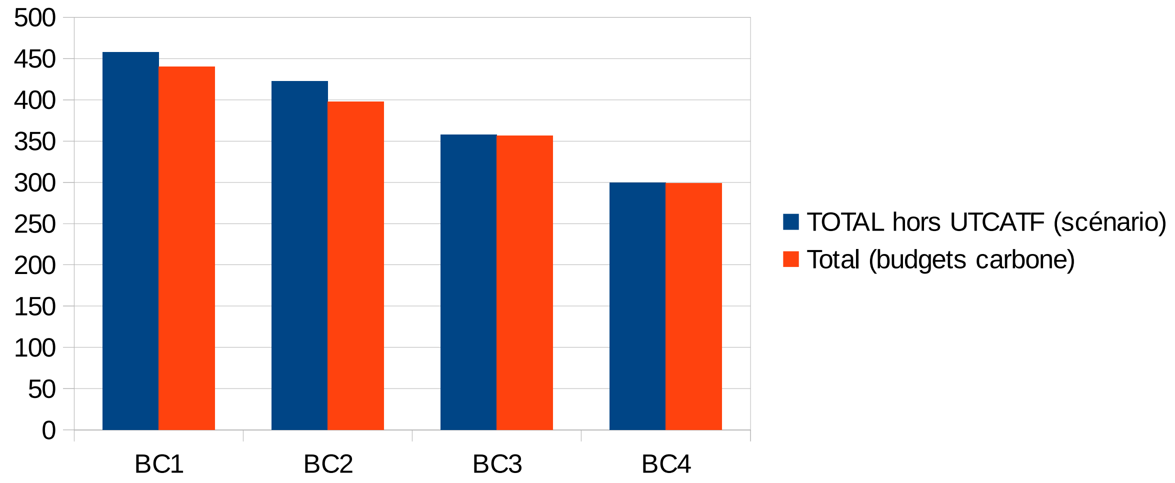


Table 19: GHG emissions from the SNBC2 scenario and evolution of carbon budgets for all sectors

NB: UTCAF: Land Use, Land-Use Change and Forestry

9.4.3. Elements relating to the supply of alternative fuels

Electric charging networks

The electric vehicle charging network must be developed while ensuring that vehicles are properly integrated into the energy distribution network. The public electric vehicle charging network is currently sufficient for the number of vehicles in circulation. Nevertheless, it could be undersized if EV sales evolve in line with targets. It is therefore necessary to continue the efforts made in public charging stations.

In order to scope needs, European Directive 2014/94 / EU of 22 October 2014 sets an indicative ratio of one public terminal per ten electric vehicles, i.e. a total of 100,000 public charging stations in 2022 if the sector achieves its objectives. However, this ratio must be adapted in response to the context. The form in Appendix 3 aims to put forward an assessment of the demand for 7kW/low power and 22kW charging terminals based on their geographical location; in particular, this approach helps to identify zones in which demand will be highest. The results of this simulation show that 2.2 million charging terminals will eventually be required to cover the needs of all vehicles (excluding moderate power charge), a ratio of 6.5 per 100 vehicles, one terminal for every 15 vehicles. This includes 0.8 terminals per 100 vehicles for charging at 22kW / high power. However, this distribution is not uniform across the whole country. Public charging requirements are higher in dense urban areas, where the number of private parking spaces is reduced. These urban areas are also of relevance for electric vehicles. It is therefore necessary to provide a dense public charging network. In rural areas, the dispersion of housing facilitates the installation of home terminals and the need for public charging essentially seeks to ensure geographical coverage. Finally, a network of charging terminals with 22kW / high power capacity will need to be developed along major routes, at regular intervals, to enable electric vehicles to travel long distances. This network must be large enough to absorb seasonal peaks. Particular attention must also be paid to the development, production and recycling of batteries.

Gas distribution networks

- *Natural gas vehicles*

France has the largest network of CNG stations for trucks in Europe. The development of CNG stations is linked to biomethane development to ensure European mobility. The lack of natural gas refuelling stations is currently the main obstacle to the adoption of this mode of propulsion by road hauliers. The number of stations should be scoped to provide coverage of major road routes, as well as 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, but today it is about forming a more ambitious vision.

The form in Appendix 4 aims to scope the network of CNG stations in line with the SDMP timescales, to provide an effective network in the country to meet energy demand without unreasonable wait times at the stations while respecting a break-even point for the station. In order to meet the energy objectives of this SDMP, it is estimated that 138 and 326 are the minimum numbers of stations required in 2023 and 2028 respectively. Furthermore, the maximum number of profitable stations is estimated at 367 and 845 in 2023 and 2028 respectively.

- *Liquefied petroleum gas*

LPG consumption in the world and in Europe is growing strongly. France is reporting very stable consumption. There is a dense European network. France is one of the only European countries where the network has decreased slightly in the last ten 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. The network is ready to accept bio-LPG: It is important to take advantage of the current situation.

- *Hydrogen*

The development of hydrogen charging stations will continue based on the so-called "captive fleet" method, which involves helping to deploy stations near to those who choose hydrogen. Thus, the plan for the deployment of hydrogen is based on the roll-out of regional mobility ecosystems, in particular via fleets of commercial vehicles:

- 5000 light commercial vehicles and 200 heavy vehicles (buses, trucks, 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 2000 heavy vehicles and from 400 to 1000 stations by 2028.

9.4.5. Longer term trajectories

Target 2040: End of sale of thermal vehicles

To achieve the target of ending sales of cars emitting greenhouse gases in 2040, it will first be necessary to achieve the intermediate objectives set for 2022 and then maintain a highly attractive system of incentives and penalties for 2040: to reach a rate of 85% electric vehicles in sales in 2040, we must envisage, based on simulations carried out with a carbon tax of €400 / tCO_2 in 2040, an incentive / penalty with a difference of about €2400 between an electric and a thermal vehicle.

Possible breakthroughs

Driven by technological advances, changes in governance systems, behavioural changes on the part of individuals and regulatory changes, new mobility practices are emerging and different types of breakthroughs may appear:

- Technological breakthroughs, involving changes in the type of technology used, such as the emergence of driverless vehicles for transporting passengers or drones for the delivery of goods;
- Organisational breakthroughs, involving transport policy, traffic management, organisation of activities, logistics;
- Behavioural breakthroughs, involving changes in the preferences of individuals and economic actors;
- Regulatory changes.

These can directly affect the transport sector or impact it by a significant change in demand for transport services. The development of service mobility using driverless vehicles instead of bus services could indeed reduce the modal share of private vehicles as well as increase their occupancy rate.

9.5. Guidelines for the development of clean mobility

The goal of carbon neutrality requires major ambition in terms of the energy demand of the sector, requiring increased energy efficiency efforts.

It implies an almost total decarbonisation[125] of the domestic land, river and maritime transport sector,[126] either by switching to electric propulsion or by switching to carbon-free alternative fuels (in life cycle analysis). A share of non-bio-sourced fuels would be reserved by 2050 for air and international maritime bunkers. The transformation of the vehicle fleet is therefore necessary, as is the development of electric charging and renewable gas distribution infrastructures (biogas, hydrogen, etc.). However, these two projects are only one part of the transition of the sector. Indeed, to limit the impacts on demand for carbon-free energy, very substantial progress in efficiency and energy savings is also needed.

It is therefore imperative to mobilise the following five major levers in tandem:

- Decarbonisation of the energy consumed by vehicles;
- Energy performance of vehicles;
- Control of demand growth (for passenger and freight transport);
- Modal shift (for passenger and freight transport) towards the most energy-efficient and low-emitting modes;
- Optimisation of the use of vehicles (for passenger and freight transport).

Sector developments in terms of both mobility demand, modal choice and the renewal and conversion of vehicle fleets are guided by:

- Setting up incentivising price signals;
- Regional land use and planning policies;
- The effectiveness of European and national regulations on air quality and vehicles;
- Increased consumer demand;
- Management of the growth of mobility demand;
- Policies to support active and public alternative travel modes and the development of alternative routes (simultaneously targeting networks, infrastructures, and vehicles) and support for companies in setting up ambitious initiatives;
- Traffic management measures at regional level, policies to support new mobility types.

All these levers are to work together: for land and river transport, the current Clean Mobility Development Strategy takes account of all these requirements and details the changes necessary in the development of vehicles with low emissions and in the deployment of refuelling infrastructures, improving the fleet's energy efficiency by taking account of the specific performance of each engine and the dynamics of fleet renewal, modal shift for freight and passengers, development of public and collaborative modes of transport, including car-sharing or carpooling, increasing the load rate of freight vehicles and controlling the increase in transport demand for both freight and passengers.

For air transport, there are fewer decarbonisation levers, as these essential economic sectors depend on fuels that are difficult to replace at this stage with cleaner energies. Thus, the gains in terms of the energy efficiency

125 Decarbonisation is only "almost total" even in the usage phase alone, given the residual "incompressible" gas leaks (fluorinated gases, renewable gases).

France has set itself the programmatic objective of achieving carbon neutrality in the captive fleet segments, which are the State fleet, the port flotilla and the recreational craft fleet. The State also undertakes to set up the refuelling infrastructure and measures necessary to ensure full coverage of the demand for low-carbon maritime fuels for traffic between French ports.

of aircraft are not sufficient to offset the expected growth in traffic: major replacement of fossil fuels with bio-sourced fuel is therefore necessary (sustainable biofuels for aviation).

For maritime transport, levers rely much more on conversion of propulsion systems. Indeed, if clean technologies exist, like hydrogen and electricity, they are currently not really usable by the maritime transport sector because of insufficient engine power. Large ships required very high power compared to fuel cell standards or very powerful storage batteries. On these aspects, technological progresses could be relatively fast. It would thereby enable great breakthroughs in terms of propulsion. A high quantity of hydrogen available will be clearly essential.

For domestic maritime transport, in addition to energy efficiency gains, carbon neutrality must be targeted by allowing refuelling with low-carbon fuels in all French ports and facilitating conversion to other low-carbon technologies (batteries, biofuels, hydrogen, sails).

The approach and actions of the clean mobility development strategy are the outcomes of the Consultative Meetings on mobility and the draft Mobility Law produced by from this listening procedure. The initiative launched in the Consultative Meetings on mobility is an open and contributory step. It was conducted from 19 September to 13 December 2017 and was structured broadly to involve citizens, mobility stakeholders, companies, experts, elected officials, local areas, non-governmental organisations (NGOs) and trade unions. The foundations of mobility have led to work on six themes corresponding to the major challenges to be met:

- Environment: cleaner mobility;
- Digital: better connected mobility;
- Social and regional fragmentation: more solidarity-based mobility;
- Consistency and complementarity of modes: more intermodal mobility;
- Safety and security: safer mobility;
- Governance and financing: more sustainable mobility.

The Consultative Meetings were devoted to passenger mobility and local logistics, but complementary consultation initiatives were launched in autumn 2017, in particular the Infrastructure Guidance Council (COI) tasked with studying funding for major projects – intercity routes, rail and road hubs, major infrastructures for freight – and with making recommendations for the infrastructure planning law. The result of this work is the basis of the future Mobility Law. In rail transport, the government sets up a new organisation of the French rail system via the law for a new “railway pact”. The Government also wants to restore rail freight opportunities, to which this reform will contribute, through the unprecedented investment in the network and the desire to make SNCF more efficient and competitive. The rail freight revival plan will support combined transport, overhaul railway tolls – whose sustained increase (9 to 11% per year) is suffocating freight companies – and invest in freight routes and improve the service offered by SNCF Réseau. On 22 November 2018, Benoit Simian, deputy of Gironde, gave to Elisabeth Borne, Minister in charge of Transport, a parliamentary report dedicated to the greening of the rail transportation system. In order to accelerate the energy transition in rail transport, the government wants to prepare the greening of the rail transportation system by providing for the conversion of the most polluting rolling stock (locomotives, self-propelling trains, heavy plant machinery…) as soon as possible in order to reach the objective of carbon neutrality in 2050. According to this report, hydrogen will be a major lever to succeed this transition.

Steps are being taken in the transportation of goods and logistics. Maritime transport was benefitted from the Consultative Meetings on the Sea Economy in November 2017 and the aviation sector began its consultation process in March 2018 at the launch of the National Conference on Air Transport. The cycling and active mobility plan, the commitment for the development of low-carbon emission areas and the objectives established as part of the strategy committee of the automotive sector are some other examples of actions undertaken with the different stakeholders.

9.5.1. Enabling all areas to benefit from clean mobility and freeing up innovation

The affirmation of the right to mobility is reflected in the search for egalitarian coverage of the country through mobility solutions, in particular by strengthening the integration of the various public transport networks, including accessibility for people with disabilities or those suffering economic and energy poverty. It requires also a strong and continuous vigilance to issues of accessibility to these services, in particular for people with disabilities and for people with economic, social or energetic difficulties which could require specific support tools.

In addition, given the specific characteristics of each territory, innovation through experimentation in new transport solutions remains the best method of developing services that are accessible for everyone, and thereby of reducing the proportion of journeys taken with individual vehicles.

Making clean mobility available to all

Challenges and general orientations

The aim of combating territorial and individual transport inequality can be achieved by ensuring rural zones also benefit from clean mobility solutions. While overall objectives must be the same for everyone and everywhere, the achievement of these goals will require a progressive approach, in order to take into account the specific characteristics of each area and any vulnerable communities. This will involve, for example, considering vehicle renewal cycles, the contribution capacities of territories and households, and currently-available transport services. Specific resources must be dedicated to fragile and isolated communities – those in a state of economic or social vulnerability – in order to facilitate their social inclusion via mobility and avoid the development of a “two-speed” approach to clean mobility.

Even in sparsely-populated areas and among vulnerable communities, clean mobility is based around the preference for active mobility, greener vehicles with shared modes of use, and, more generally, on any and all solutions offering an alternative to individual transport in a polluting vehicle.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Promoting the effective implementation of the mobility competence at the proper scale and nationwide, either at the intercommunal level or at the regional level.

→ Adapting missions of the Transport Organising Authorities (AOM) in order to facilitate the effective implementation of the mobility competence in sparsely populated areas.

→ Strengthening AOMs and Regions’ competences by widening their range of possible actions and services to conduct a policy of sustainable and solidary mobility.

→ Securing AOMs’ resources (the “transport contribution” becomes the “mobility contribution”) for the implementation of their entire mobility policy in particular when they contribute to the development of shared and active mobility or when they set up mobility support for vulnerable people. Enabling city councils to contribute to the financing of regional passenger rail services and train station services.

→ Strengthening the cooperation between Transport Organising Authorities under the leadership of the Region in order to assure a territorial continuity in the daily mobility of the citizens.

→ Strengthening the role of employers and users in the governance of transport systems, by setting up Partner Committees through the AOMs which should be consulted before any substantial change in the mobility policy in order to create conditions for permanent dialogue between the different local stakeholders.

→ Assuring a more inclusive policy particularly for the most vulnerable people by allowing AOMs to organise by themselves mobility services of a social nature, to contribute to their funding or to pay individual direct subsidies for mobility in order to facilitate individual support for vulnerable people in particular concerning employment and training accessibility.

→ Strengthening cooperation between the different public partners in charge of mobility, social affairs or professional insertion to set up support actions for vulnerable people.

→ facilitating public transportation access for disabled people via the establishment of a social pricing for their attendants and via the gathering of harmonised and interoperable data in terms of accessibility of foot path and public transportation regular services.

→ For persons of reduced mobility, guaranteeing access to pre-equipped places or places equipped with charging points for electric mobility scooters.

Other measures to be taken by the Government over the 2019-2023 period

→ Implementing a programme of "Energy Saving Certificates" based on supporting the transition to sustainable mobility for isolated areas or communities with vulnerable economic or social statuses.

→ Systematically integrating the role of transport consulting into the missions of the Public Service Centres.

→ Increasing public awareness of transport modes of use, from a young age through to retirement:

- Including teaching modules on sustainable mobility in school curriculums: reading a public transport network map, use of applications, use and understanding of services on offer (collective transport, car-sharing, etc.), rules for the use of public spaces, cycling lessons, promotion of walking;
- Developing school mobility plans to implement cleaner mobility solutions (walking bus, cycling bus, carpooling, access securing…)
- Adapting the road safety badge and road safety test to increase awareness of all existing modes of transport services, as well as the rules for using public spaces (pavements).

Facilitating experimentation in new mobility solutions

Challenges and general orientations

It is essential that we liberate and support innovation by adapting the regulatory framework in order to make it more flexible and responsive to current developments. This will be achieved notably through a review of the rules on experimentation, improved sharing of information via a dedicated platform, and also greater freedom for public authorities to launch innovative projects.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Constructing the regulatory framework allowing highly-automated vehicles to travel on public roads by 2020-2022.

→ Allowing navigation of autonomous or remotely-controlled rafts and boats.

→ Regulating new transport services (free floating, mopeds, assisted-pedal bicycles, electric scooters, kick scooters, public-hire cars, etc.)

Other measures to be taken by the Government over the 2019-2023 period

→ Supporting local councils in the development of innovative and cleaner transport solutions thanks to project financing from the DSIL (€500M in Local Investment Support Funds allocated to transport), and facilitating experiments and innovative public purchasing thanks to the French Mobility initiative.

→ Accelerating and developing projects of bicycle path creation in local authorities via the national fund "active mobility" (M€ 350 over 7 years)

→ Carrying out wide-scale experiments with autonomous vehicles from 2019 along with the Regions, and monitoring their results via the framework of a consortium-level steering committee led by the Automobile Platform (PFA)[127].

127 Strategic Contract for the Automobile Sector, 22/05/2018.

→ Carrying out prospective studies on new transport plans by the end of 2020, in partnership with local councils, in order to respond to growing transport needs by tapping into technological advances[128].

→ Launching a call for projects for wide-scale experimental initiatives, with a focus on measures encouraging communal or shared mobility.

→ Supporting the creation of a "Logistics and Road Freight Transport" consortium, with a view to testing a pilot blockchain dedicated to the management and securing of data and contracts in the logistics chain.

9.5.2. Managing mobility demand

In order to manage the increase in transport demand, it will be necessary to maintain the implementation of incentivising price signals for the sector:

- Continuing the progression of the carbon component after 2022;
- Internalising external costs when setting prices for urban and long-distance road travel;
- Working to achieve harmonisation of fuel taxation rates at the European level.

It would also be useful to implement measures to manage local traffic, and to support active and shared mobility and new ways of working, as well as the circular economy, local food supply chains, etc.

Reducing the number of journeys taken

Challenges and general orientations

The ecological transition of transport can only be achieved by stemming the continuous increase in demand for transport, and consequently by slowing urban sprawl (which consumes a great deal of natural resources and leads to more journeys being taken).

Urbanisation policies registered in the planning documents, which local authorities are in charge of, have a major impact on soil consumption but also on demand on natural resources and on greenhouse gas emissions.

The legislator has therefore reinforced several times measures in favour of a reduction of soil artificialisation, for the Grenelle Law and recently in the ALUR law.

Hence, the government fosters local authorities to promote a thrifty soil management in order to reduce natural, agricultural and wooded area consumption, to adhere to sustainable planning practices (nature in the city, energy-efficient housing) and to prioritise urban development close to public transport.

In order to reduce the number of journeys taken and to reinforce attractiveness of distressed areas, the State helps some local authorities to reinvest unoccupied downtown shops.

Furthermore, the ELAN law offers several measures to bolster downtown shops and to reduce commercial establishment in city outskirts.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Transforming urban commuting plans (PDUs) into transport plans (PDMs).

→ Strengthening the PDMs while taking into account requirements in terms of active, shared and inclusive transport, as well as measures that will help limit urban sprawl and coordinate transport for school students.

→ Facilitating implementation of parking and traffic policies to promote a cleaner mobility by enabling to update the PDM with greater flexibility.

→ Enabling the AOMs to develop rural transport plans in areas with low population density.

128 Strategic Contract for the Automobile Sector, 22/05/2018.

Other measures to be taken by the Government over the 2019-2023 period

→ Continuing to study tools designed for use by local councils, in order to calculate the effects of urbanisation policy choices on journeys taken.

→ Continuing to study the impact of telecommuting on transport demands.

Encouraging greener behaviour and taking transport issues into account when making consumption choices

Challenges and general orientations

Encouraging the emergence of greener behaviours and supporting commuter transitions will lead to a reduction in journeys taken and/or their environmental impact.

E-commerce represents around 20 to 25% of transport services in cities, despite representing only 8% of consumption. With the number of deliveries increasing by 20% annually, this means that over 100 million additional parcels are being delivered across the nation every year. The product flows caused by e-commerce returns and high rates of failed deliveries (which often require the transporter to make a second trip) are pushing the number of journeys up even further. This highlights the fact that the consumer (and more generally, the purchaser) now has more and more choice regarding the transport of their goods: 24-hour home delivery, express delivery, meeting point, drop-off point, consignment, and instant delivery (1-2 hours). These consumer choices should be more clearly linked to the service option and price involved, in order to raise the purchaser's awareness of their responsibility for the transport solution chosen.

To contain commercial development including e-commerce, the ELAN law introduces a craft and commercial planning programme (DAAC) which is mandatory in the territorial coherence programme (SCOT) in order to better foresee and organise the integration of commercial projects on the territory. It could be made via urban planning with a broad approach of the craft, commercial and logistics activities which have a major impact on land planning and motorised trips.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Progressively rolling out low-emissions zones (LEZ):

- Requiring EPCIs with over 100,000 inhabitants to establish a plan of action to achieve the objective of reducing atmospheric pollutant emissions, and to include a study of the opportunity of establishing an LEZ;
- Imposing the progressive deployment of the LEZs in territories covered by an Atmospheric Protection Plan (PPA);
- Controlling access to LEZs via automated monitoring devices (fixed or mobile).

→ Facilitating installation of free-flow toll stations.

→ Enabling use of video-ticketing and automated fines on restricted roads.

Other measures to be taken by the Government over the 2019-2023 period

Requesting that all advertisements for road transport be accompanied by a message promoting active, shared, clean or public transport.

9.5.3. Developing low-emissions vehicles and delivery infrastructures for alternative fuels, and improving energy efficiency of vehicles nationwide

This Clean Mobility Development Strategy should enable the implementation of the ambitious objectives announced in the Climate Plan: an end to the sale of new greenhouse gas-emitting vehicles by 2040, and carbon-neutral transport by 2050. The gap between the two dates is linked to the time required to renew the vehicle fleet: in order to achieve carbon neutrality, it must be the case that no greenhouse gas-emitting vehicles have been sold in the ten years preceding the target date, in order to leave time for gas-emitting vehicles to be used and to leave the vehicle fleet naturally.

Significant work has been achieved (and must be continued) with all economic stakeholders involved to define and break down objectives for the short-term that are coherent with long-term targets, including in the maritime and aviation sectors.

Developing low-emissions vehicles and improving energy efficiency of vehicles nationwide via the use of alternative fuel markets

Challenges and general orientations

The development of low-emissions vehicles is an essential strategic tool in order to ensure the long-term ecological transition of the transport sector. The Climate Plan adopted in July 2017 set the objective of halting the sale of greenhouse gas-emitting vehicles by 2040. The State is going even further, by setting the objective – in partnership with the automobile sector – to increase the sale of electrical vehicles by a factor of 5, and the sale of low-emissions HGVs by a factor of 15, by 2022 (compared to 2017 levels). These objectives can only be achieved if, over the course of the coming years, the general public are widely exposed to the availability of low-emissions vehicles, and if consumers are able to replace their existing vehicles without worrying about the development of alternative energy sources (batteries, hybrid, hydrogen, gas, etc.). The renewal of the vehicle fleet must be oriented in the short-, medium- and long-term so as to unleash its energy transition and minimise its environmental impact. The measurement of this environmental impact must take into account the full life cycle of vehicles (life cycle analysis). Various forms of price signalling (financing schemes and tariff provisions) should then be used to help steer purchases towards vehicles with better environmental performance levels. For example, two-wheeled vehicles (which are responsible for a quarter of emissions of organic compounds in the road transport sector, for only 2.3% of journeys), are the subject of a study being carried out by the State along with the other stakeholders involved. While it is important for public authorities to respect the principle of technological neutrality, it is also pertinent to recognise that objectives to drastically reduce emissions of greenhouse gases and local atmospheric pollutants can only be achieved alongside major developments in electromobility and hydrogen-fuelled vehicles, which will be the focus of major Government action in the coming years.

The aim now is to accelerate direct electromobility and the hydrogen sector via the creation of a conglomerated sector, notably by actively pursuing the development of a high-performance charging network, and by structuring a progressive approach – designed from a multi-modal perspective – to the use of clean hydrogen transport. Finally, a number of uncertainties remain regarding the use of vehicles and the development of the energy mix, as well as the associated environmental impacts; as such, it will be necessary to develop a steering tool to oversee the evolution of the vehicle fleet. Particular attention must also be paid to the development, production and recycling of batteries.

Box 4: Electric vehicles

The engines used in electric vehicles have the advantage of not releasing pollutants into the air when they are in use. The advantages of electric vehicles in terms of reducing air pollution, especially in cities, are now largely recognised: they enable significant improvements in air quality by reducing concentrations of fine particles and nitrogen oxide, which are among the pollutants emitted by combustion-engine vehicles. Electric vehicles are also characterised by positive levels of energy efficiency, and, depending on the mode of production for the electricity used, reductions in greenhouse gas emissions.

As regards France, in late 2017 the Foundation for Nature and Mankind (FNH) and the European Climate Foundation (ECF) published a prospective study on the environmental impacts of electric vehicles, not only during the life cycles of the vehicles themselves, but also during the life cycle of their batteries, taking into account potential ways they might be used. In order to carry out this study, FNH and ECF solicited input from both public sector operators (including ADEME) and private companies, as well as five NGOs. This study confirmed that electric vehicles are an asset in the fight against climate change – an asset bolstered by the reduction in greenhouse gas emissions in electricity production. Electric vehicles therefore constitute a major axis of France's clean mobility policies.

The vehicle production stage, including batteries, is responsible for a significant proportion of environmental impact (in particular due to the extraction and processing of mineral resources used in batteries). Nevertheless, effective measures exist to reduce this impact, such as improvements in production methods or technological advances in the batteries and their uses.

The development of the electric vehicle sector therefore requires continued:

- Structuring of the recycling sector for batteries no longer in use, in order to recover their resources (particularly rare metals);
- Integration into the electrical network: the increased popularity of electrical vehicles will increase consumption of electricity and affect daily use rates; their batteries can also contribute to balancing supply and demand within the network.

Within the framework of its "provisional reports", RTE has analysed the potential impacts of the future development of electric vehicles on the national metropolitan electrical network. These studies show that the expected growth in the number of electric vehicles is compatible with planned developments to the network and electricity production levels for the year 2035.

During a transition period, vehicles running on LPG would help ensure a reduction in greenhouse gas emissions. The replacement of fossil fuels with biofuels (especially 2nd generation biofuels) will also contribute to the development of low-emissions vehicles.

The development of clean propulsion methods should also be encouraged for heavy vehicles. Natural gas vehicles currently constitute the most robust alternative to diesel vehicles; electric engine and hydrogen-fuelled cars, currently under development, will help to supplement this supply, notably for fleets of buses and coaches, which are developing rapidly, as well as for urban logistics (light goods vehicles). Natural gas has immediate benefits in terms of air pollution, as it causes much fewer harmful emissions. In time, this technology could enable the use of biogas, which has a neutral effect on the carbon cycle. The maturation of advanced biofuel technology is essential in order to ensure the replacement of diesel fuels in remaining thermal engine types.

Box 5: Biofuels

The incorporation rate of 1st-generation biofuels is currently 7%. Predictions show this level will not be surpassed between 2023 and 2028. The growth of the bio-sourced share in fuels is therefore exclusively obtained through the development of advanced biofuels.

Advanced biofuels are obtained via the transformation of lignocellulose contained within agricultural residue (hay) and wood, or in plant matter from dedicated biofuel crops (short rotation coppice). More generally, inputs that may be used include agricultural residues, waste (household, municipal or industrial), plant waste and residues, straw, manure and sewage sludge, livestock effluents, algae, waste and residues from forestry, pulp residues, wood, and renewable fuels of non-organic origin.

By 2028, the incorporation rate of advanced biofuels in the petrol sector should be 3.8%, and 3.2% in the diesel sector.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Maintaining the bonus-penalty scheme in order to encourage the purchase of vehicles with lower emissions rates and support sales of electric vehicles (battery and hydrogen).

- annual drop in the penalty induction threshold to 3 grams of CO_2 per kilometre in 2019, to be pursued after the end of the new WLTP testing cycle (*Worldwide-Harmonised Light Vehicles Test Procedure*);
- Maintenance of bonuses at a high level, while also progressively integrating technological gains and greener modes of use.
- Extension of the conversion bonus in order to keep on the replacement of a large amount of old vehicles with new or second-hand vehicles with lesser emissions: the bonus will be doubled in 2019 for 20% of the households in the lowest income group and for non-taxable workers which have long distances to travel. It will be upgraded in order to make conversion to electrical or rechargeable hybrid vehicles more attractive.

→ Adapting all tools used for the greening of light vehicles so they may be applied to two- and three-wheel vehicles.

→ Encouraging the acquisition of vehicles using alternative fuels by prolonging the over-amortisation scheme for natural gas HGVs until 2021, and extending it to all low-emissions technologies (electricity and hydrogen).

→ Strengthening monitoring efforts in order to guarantee adherence to emissions standards:

  - Establishment of a department with national authority tasked with market surveillance for vehicles and parts;
  - Strengthening of inspections aiming to prevent fraudulent behaviour by users of heavy vehicles.

Other measures to be taken by the Government over the 2019-2023 period

→ Supporting ambitious European standards in terms of the reduction of greenhouse gas emissions for heavy vehicles, under the third segment of the Clean Mobility Package presented by the European Commission in May 2018.

→ Helping establish French and European industrial supply of batteries (focusing on fourth-generation batteries).

→ Updating prospective studies on the impact of changes in the automobile sector on jobs and job skills.

→ Continuing State actions against sectors illegally processing end-of-life vehicles (ELV), and implementing measures to incentivise the re-use of end-of-life products and promote the recycling of materials.

→ Developing, by September 2019, an application to provide consumers with all the information they might need regarding support measures available for the purchase of electric vehicles, the availability of charging infrastructures, and useful services for owners of electric vehicles.

→ Implementing annual monitoring of the voluntary commitment to recycling plastics used in automobiles.

→ Monitoring the operational performance of the collection and processing service for end-of-life vehicles (ELV) in overseas territories.

→ Pursuing studies to make taxation more favourable towards ultra-low emission vehicles.

Deployment of alternative fuel distribution infrastructures

Challenges and general orientations

The establishment and maintenance of a charging and refuelling network infrastructure is a major challenge in the development of alternative fuels[129]. The structure of the distribution network must be adapted to each fuel type:

- Electric charging is structured around home charging points and public charging points;
- Hydrogen charging points are structured via an approach based on captive fleets and local networks;
- The CNG distribution network will be developed in the interests of European transport;
- The LPG distribution grid is already structured and in use.

Box 6: Diversification of energy types used

The current Clean Mobility Development Strategy concentrates on evolving modes of transport, vehicle engines and directly-associated energy infrastructures (energy distribution infrastructures for vehicles specifically designed to use these energy sources).

Evolutionary changes in the production of energy types (liquid fuels, gas fuels, hydrogen, electricity) and the composition of fuels, upstream of the transport sector, are covered by the Multi-Year Energy Programme itself.

These evolutionary changes will also have a significant influence on the environmental impact of transport types. In certain cases, improvements may be envisaged with relatively little change to engine behaviour and logistics, initially involving existing energy carriers (as in the case of incorporating liquid biofuels into petrol products, for example). In other cases, a comprehensive transformation of engine types and infrastructures will be necessary, supplemented by changes in the methods used for energy production (as is the case with the development of electric or hydrogen-powered vehicles, for example).

Today, road transport almost exclusively consumes petrol-based fossil energies. This type of energy is a major source of greenhouse gas emissions. In order to meet the “carbon neutrality” objective set for 2050, road transport must replace oil-based products with:

- Energy sourced from biomass: biofuels or biogas;

- Decarbonised electricity.

The challenge for our programmes (the Multi-Year Energy Programme and Clean Mobility Development Strategy) is to simultaneously develop new, non-carbon-based energies and new types of engines and associated logistical infrastructures (including electrical charging points).

129 Appendix 2.3 provides guideline information on the deployment of charging points for alternative fuels for various timeframe objectives.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Before 2022, deploying charging points nationwide for electric vehicles:

- Raising to 75% the maximum level of subsidisation (via public electricity use rates) of the cost of connection to electric charging infrastructures open to the public;
- Providing for effective installation of at least one charging point in 2025 for all public car parks with more than 20 parking spaces and car parks of non-residential buildings;
- Providing for pre-fitting of all parking spaces of residential buildings to facilitate subsequent charging point installation. Parking spaces of non-residential buildings should also be partly pre-fitted;
- Simplifying the "right to charge" for legal or natural persons using an interior or exterior parking space in their collective residence, giving them the right to install (at their own expense) vehicle charging points in the parking structures connected to their buildings[130].

→ Accelerating the deployment of CNG:

- Sustaining production of biomethane for methane charging points to supply vehicles (buses, trucks) in order to develop direct local usage, particularly in areas removed from the gas network;
- Facilitating supply and connection of CNG stations to natural gas networks;

Other measures to be taken by the Government over the 2019-2023 period

→ Initiating the development of hydrogen as a tool for decarbonised transport, as outlined in the Hydrogen Plan adopted in 2018:

- Deploying regional hydrogen mobility ecosystems, which will supplement those based on "all battery" electrification, notably for modes of use that require rapid charging times, operation over wide areas, and heavy goods transport:
  - 5000 light commercial vehicles and 200 heavy vehicles (buses, trucks, 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 2000 heavy vehicles and 400 to 1000 stations by 2028;
- Supporting, thanks to the Future Investments Programme (PIA) – via existing calls for projects or calls for expression of interest on hydrogen – the development of French heavy/highly autonomous vehicles powered by hydrogen (trucks, buses, boats, trains, etc.), the associated components chain, and competitive systems for the production and storage of decarbonised and sustainable hydrogen;
- Defining, via a ministerial order, the applicable regulation for hydrogen installations in service stations, combining safety, clear understanding of rules, and ability to integrate hydrogen into standard service stations.

→ Revising the legislative and regulatory framework for oversight of electrical charging points by 2023

→ Encouraging the development of electric charging stations via Energy Transition Tax Credits (CITE) and mobilisation of Energy Saving Certificates (CEE).

→ Installing electrical charging stations on motorways and national roads, securing contracts between infrastructure administrators and operators of charging stations.

130 ELAN ruling

→ Freezing the rate of interior tax on petroleum products (TICPE) for CNG at its current level (€5.8/100m^3) from 2018 to 2022;

→ Creating 100 new CNG supply stations over the next four years nationwide, along with the operational launch of over 2100 vehicles thanks to State support; Pursuing these efforts with a new call for tenders launched in 2018.

→ Facilitating the deployment of natural gas for vehicles by revisiting safety regulations (in service stations, for example).

→ Ensuring coherence between the number of vehicles using alternative fuels in circulation and the number/regional breakdown of charging or refuelling infrastructures open to the public.

→ Studying the implementation of a traceability system for decarbonised and/or renewable hydrogen.

→ Providing for a totally decarbonised rail transport sector in order to go beyond the electrification potential, in particular in conducting the first experimentation of hydrogen train in France by 2022.

Promoting low-emissions maritime and river transport

Challenges and general orientations

Maritime and waterway activities are also affected by the prospect of carbon-neutral vehicle propulsion by 2050, and the associated reduction in atmospheric pollution. Most vessels providing international transport links are powered by heavy fuel oil, which is cheap but highly polluting. As such, international maritime transport contributes up to 2.6% of global CO_2 emissions, and constitutes a significant source of atmospheric pollution (sulphur oxides, nitrogen oxides and fine particles) within high-concentration activity zones (large ports, straits). In Marseille, emissions of atmospheric pollutants linked to maritime transport represent around 20% of nitrogen oxide emissions (NOx) and 70% of sulphur oxide emissions (SOx).

The scope of action here is limited, as a unilateral regulatory approach would discourage traffic from stopping at national ports, causing changes to shipping lanes and resulting in a loss of traffic without any positive impact on emissions. At the national level (draft Mobility Law), the government could take action on two axes to promote this transition:

- By fixing a conversion target to carbon-free propulsion engines in 2050 concerning the "captive fleet": state-owned ships, ships owned by seaport services, recreation boats;
- By assuring supply facility development and necessary measures in line with the carbon-free energy demand concerning traffic between French harbours.

Any regulatory changes can therefore only be applied on an international scale via the further extension of measures already taken by the IMO, and under the framework of its decarbonisation strategy adopted in April 2018, which is based on three strategic pillars:

- Strengthening requirements pertaining to the Energy Efficiency Design Index (EEDI) applicable to new vessels;
- Reducing CO_2 emissions from transport activity, on average for all international maritime transport, by at least 40% by 2030, and pursuing measures taken in order to achieve 70% by 2050 (compared to 2008 levels);
- Reaching peak GHG emissions from international maritime transport as quickly as possible, and reducing the total volume of annual GHG emissions by at least 50% by 2050 (compared to 2008 levels), while also pursuing action in order to progressively eliminate emissions altogether.

Concerning inland navigation, France sets the same objective to reach a carbon-free fleet by 2050 (draft Mobility Law). Regarding specific constraints of the navigation inland sector and especially the long ship lifespans, starting energy transition of the fleet from 2020 will be necessary to decarbonise navigation inland by 2050 via appropriate solutions for each type of ships (freight transport, passenger transport, inland fishery, ships contributing to sovereign missions like maintenance, police, rescue).

Intentions of the State regarding clean mobility – Proposed regulatory changes

→ Implementation of ecological criteria for new vessels outfitting lighthouses and beacons, as well as patrol boats operated by the Ministry for Ecological and Solidary Transition:

- NOx: Application of Tier III, even outside emissions inspection zones (NECA);
- Definition of an energy yield objective;
- Implementation of systems for the reduction of fine particle emissions;
- Use of innovative propulsion systems such as LNG or CNG, hybrid batteries/diesel/electric, H_2 fuel batteries.

→ Adapting the regulatory framework regarding construction and equipment rules for inland waterway vessels to enable alternative motorisation engines (currently, only fuel, LNG and fully electrical engines are allowed).

Other measures to be taken by the Government over the 2019-2023 period

→ Supporting the development of electric charging points and CNG in maritime and river ports.

→ Providing financial support for the river transport sector via an engine upgrade scheme worth €8M over five years (2018-2022), in order to improve the environmental performance of riverboat fleets.

→ Making a particular effort to renovate and modernise waterways.

→ Providing financial support for the development of alternative ship motorisation engines via an extra depreciation measure with effect from the 1th of January 2019.

→ Presenting a proposal to the IMO to create a low-emissions zone (ECA) in the Mediterranean, and promoting effective measures for the limitation of CO_2 emissions based on the decarbonisation strategy adopted in April.

→ Accelerating merchant vessel replacement with an extra depreciation measure in favour of ships with a carbon-free or LNG propulsion or with marine equipment enabling an improvement of their air emissions.

Concerning inland navigation, all measures contributing to ecological and energy transition will be subject to a "pact for inland navigation greening" which will identify commitments of all stakeholders: government, economic operators, waterway and port installation managers…

Limiting the impact or air transport on climate change

Challenges and general orientations

As part of the bundle of measures decided upon by the ICAO in order to limit the impact of this mode of transport on climate change, the air transport sector is pursuing its efforts to reduce emissions at the source, in particular via the creation of a CO_2 standard for reactors, optimisation of aviation navigation procedures and infrastructures, and the deployment of sustainable biofuels. The industry is also behind an ambitious emissions offsetting programme.

Box 7: Air transport and market measures

In order to help combat climate change, the aviation sector has focused on market measures: first, by signing up in 2012 to the European Emissions Trading Scheme (EU ETS), and secondly by establishing a carbon offsetting and reduction scheme for international aviation (CORSIA), applicable from 2021.

Air transport is currently the only mode of transport to have adopted the ETS at the European level. This mechanism enables aviation emissions thresholds to be set for flights within the European economic zone. For every tonne of CO2 emitted by these flights, companies are required to return an emissions allowance. A portion of these allowances are freely allocated (in 2017, this portion represented roughly half of allowances due for return by French companies); the remaining portion is acquired, either on the market or via bidding. All profits generated by the sale of allowances are paid into the budget of the National Housing Agency (ANAh). Finally, it should be noted that while the price of allowances remained low for some time, the cost will rise to €25 in September 2018, which will have a significant financial impact on airlines.

The CORSIA was approved by the ICAO in 2016, and will guarantee neutral growth in terms of greenhouse gas emissions from 2020 onwards. The strategy decided upon by the ICAO is to offset emissions levels that surpass average annual emissions levels observed in 2019 and 2020. An initial launch phase between 2021 and 2026 should enable coverage of 70% of international emissions (links between countries will be voluntarily established from 2021 under the CORSIA scheme). The second phase will begin in 2027 and will enable coverage of all emissions, excluding those linked to countries which are exempt or non-signatories (in particular, this refers to countries accounting for less than 0.5% of global passenger-kilometres). Air transport is the first economic sector to have established this type of measure on a global scale.

Intentions of the State for clean mobility

→ Pursuing the objective to reduce greenhouse gas emissions from air transport sector by supporting the deployment of aviation biofuels, with a development objective of 4% by 2030.

→ Supporting the implementation of distribution channels for aviation biofuels, integrated within the mass logistical infrastructures for aviation fuels.

Aviation biofuels

Supplementing continuous technological progress, operational improvements and market measures such as CORSIA, the air transport sector should throw its weight into the deployment of innovative and sustainable biofuels in order to respond to climate issues and reduce its carbon footprint. These biofuels constitute a strategic advantage for the reduction of net emissions in a growing economic sector – one which has only a limited number of energy alternatives. These bio-sourced fuels can also come from the circular economy, enabling carbon savings of up to 90% over the course of their life cycle. Some of these fuels can even be incorporated into fossil fuels to a rate of up to 50%, representing an immediate and significant reduction in emissions.

Considerable progress has been made in this field in recent years, notably in terms of the performance and certification of aviation biofuels; operational readiness has now been achieved for these fuels. The roadmap drawn up by ANCRE (National Alliance for Coordination of Energy Research) has evaluated the potential of French sectors to produce aviation biofuels. At the global level, six aviation biofuel sectors have received ASTM certification (American Society for Testing and Materials), and been identified as renewable and sustainable alternatives to fossil-based aviation fuels. Other innovative sectors are currently being studied, with varying levels of feasibility and certification timelines, confirming the extent of technological possibilities. Certified aviation biofuel production technologies enable the production of molecules very similar to those present in kerosene, and totally compatible in terms of use. The use of these biofuels does not require any adjustments to aircraft or airport infrastructures.

In order to encourage the emergence of a French aviation biofuels sector, at the end of 2017, the State, Air France, Airbus, Safran, Suez and Total all signed up to the "Commitment to Green Growth" (ECV), aiming to study the feasibility of deploying a French production and distribution sector for sustainable aviation biofuels. Its conclusions will be delivered by the end of the first semester of 2019.

9.5.4. Favouring modal shift for passenger transport

Today, 80% of journeys are made in personal vehicles, most of which are used to transport only one person. In order to reduce the impact of transport on the environment and limit transport costs, one of the main challenges is to promote cleaner journey types wherever possible, notably via alternatives to the use of personal vehicles and an increase in shared modes of transport.

Developing multi-modal transport options

Challenges and general orientations

The availability of multi-modal transport must be developed in order to provide individuals with alternatives to the use of personal vehicles, and therefore to shift from an imposed method of transport to one that is chosen. In order to do so, it is necessary to supplement the provision of alternative modes of transport with new information technologies: creation of new types of services (autonomous, connected, shared) and new ways of accessing these services (integrated information and ticketing systems). However, care must be taken to ensure sufficient access to multi-modal information while also guaranteeing the safety of users' personal data.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Accelerating open access to data on multi-modal information, while also carefully monitoring data management and appropriate use.

→ Widening the list of open data to include real-time data, and drawing up a financial compensation scheme for users of this data in the event that its availability comes at a significant cost.

→ Offering every individual (public or private) the possibility of establishing a multi-modal transport service by allowing access to the digital marketplace for the sale and reservation of local journeys.

→ Requiring certain operators to produce and publish accessibility data.

→ Strengthening and securing the social responsibility of digital connection platforms.

→ Strengthening intermodality between the different services thanks to a better coordination between the offers of the different public stakeholders.

Other measures to be taken by the Government over the 2019-2023 period

→ Launching a call for projects on Mobility as a Service (MaaS), with a view to encouraging the shared achievement of a small number of large-scale projects.

Increasing the proportion of active modes of transport in daily commutes

Challenges and general orientations

The importance of walking and cycling, especially in cities but also in rural areas, should be reconsidered, along with the inherent safety issues that go along with these modes of transport. These two active modes could represent significant proportions of modal shift in cities. The national strategy for clean mobility aims to make walking account for 25% of journeys and to give cycling a modal share of 12.5% by 2030. The State has also set the objective of increasing the modal share of cycling from 2.7% to 9% by 2024[131]. These values should be considered as the minimum thresholds to achieve: it is undoubtedly possible to achieve even more through investment on a reasonable scale, while also ensuring full satisfaction for citizens.

131 Press release of 20 July 2018 on "clean mobility" measures of the Mobility Law.

Walking is an essential part of every journey, and can increase the scope of public transport options on the condition that the route to and from transport stops is sufficiently accessible. Cycling, meanwhile, has seen a significant increase in use due to the development of electric bicycles, which increases the range of bicycle journeys, and also removes certain obstacles to cycling (physical fitness, fear of fatigue, ability to cycle up hills). The extension of journey lengths enabled by electric bicycles also strengthens the suitability of cycling in sparsely-populated zones. The opportunity presented by electric bicycles must be seized by implementing quality cycle routes on a wider scale, laying out cycling paths and creating secure parking areas for bicycles, notably in hub areas for intermodal connections.

Increasing the use of bicycle transport can only be achieved by successfully managing road safety risks in towns and cities, where traffic speed is a key factor, and by working to combat bicycle theft. The confederation of different modes of transport (walking, cycling, new types of personal vehicles and cars) should be achieved in a safe, pacific way.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ establishing a "sustainable mobility credit" for employees from public and private sectors in order to pay back the cost of commuting between home and work by bicycle on a flat-rate basis up to 400 €/year. The government will generalise this "sustainable mobility credit" for public employees by 2020 up to 200€/year.

→ Ensuring safe cycling practices in order to encourage the use of bicycle transport:

- Taking active mobility into account in planning documents (PDUs, SRADDETs, etc.);
- Installing secure parking infrastructures for bicycles in certain buildings or parking annexes, as well as in train stations and multi-modal transport hubs;
- Attributing and displaying a unique identifier on every bicycle sold, and recording these registration numbers in a national database using a secure procedure, in order to combat the theft, fencing and illegal re-sale of bicycles.

Other measures to be taken by the Government over the 2019-2023 period

→ Implementation of the Cycling and Active Mobility Plan:

- Promoting trainings to cycle safely. By 2022, a generalised implementation of these trainings will enable youths to be admitted to the first year of high school to cycle autonomously and safely;
- Including cycling in the fiscal kilometric allowances in order to pay off employees' travel expenses which are made for professional purpose with a personal bicycle;
- Creation of a national "active mobility" fund worth €350M, aiming to support, accelerate and amplify projects for the creation of structured cycle routes in local areas. Launch of a call for projects aiming to link up gaps in cycle routes in 2019;
- Supporting local councils, notably in medium-sized towns, in the definition of their cycling policies, following on from the "Vélo et Territoires (Bicycles and Territories)" call for projects launched by ADEME on 14 September 2018;
- Simplifying the legal status of green pathways, in order to facilitate cohabitation of transport modes and enable the creation of new green pathways;
- Ensuring nationwide implementation of bicycle waiting spaces at traffic lights, as of 1 January 2019;
- Developing two-way systems for bicycles on all urban roads in major cities;
- Authorising cyclists to install non-dazzling lighting systems;
- Experimenting with allowing cyclists to ride side-by-side in zones with a speed limit of

30km/h;

- Requiring heavy vehicles to be equipped with systems to detect the presence of vulnerable road users;
- Implementing a plan of action to combat bicycle theft (bicycle marking, equipping train stations and connection hubs with secure parking spaces, installation of bicycle parking spaces within buildings);
- Mobilising energy saving certificates for secure parking spaces;
- Supporting the purchase of electric-assisted bicycles via the use of energy savings certificates;
- Supporting enterprises making fleets of bicycles available via tax deductions;
- Publication of an NF industrial standard for utility bicycles.

Developing collective, shared and collaborative modes of transport

Challenges and general orientations

Mass public transport is the backbone of urban transport in large cities, and an essential tool in the development of cleaner everyday transport. The development and modernisation of these modes of transport should remain a priority for public authorities. They should be made more attractive and more reliable, with improved environmental performance and connections to new transport developments and active modes. In order to achieve this, several measures are being put forward, involving regulatory changes, financial support measures for local councils, and educational outreach.

While the use of cars is falling in densely-populated zones with high-performance public transport options, car journeys remain indispensable in less urban areas. The aim therefore should not be to do away with cars altogether, but to optimise their use and encourage more suitable, shared forms of car journeys, along with improvements in the ecological performance of the vehicles themselves.

Shared mobility services over short distances and in areas not covered by public transport networks must be sufficiently developed to constitute a credible service, without overlooking the regulatory issues covering the car-sharing and carpooling markets. They enable more efficient use of assets (the vehicles and the infrastructure that supports them), and thereby lessen the environmental impact of transport for a higher number of passenger-kilometres (total energy consumed and emissions released during the construction, use and recycling of the vehicles). The sharing concept also leads to a decrease in the overall cost of transport, via an increase in fixed costs but a reduction in marginal costs. Car-sharing also enables an acceleration in the renewal of the vehicle fleet, due to the more intensive use of the vehicles being shared.

Each of these solutions constitutes a transport bundle, with each mode of transport retaining its own scope of suitability (walking, cycling, public transport, low-emissions vehicles, car-sharing, carpooling, etc.). Via the progressive assimilation of viable alternative options, this approach could encourage certain households to go car-free – particularly residents of cities. The AOMs must develop their central role by offering service packages within their local transit areas, integrating public transport, shared vehicles, active modes of travel and other transport services.

Finally, the development of these solutions also helps initiate the learning curve for “service vehicles”, which are a prelude to autonomous and shared vehicles – both likely to cause profound changes to our use of cars and transport in general. These changes will help limit the impacts of transport on the environment and health by reducing road accidents, congestion and fuel consumption.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

Implementing a “Sustainable Transport Credit” for employees in the public and private sectors.

Clarifying the definition of carpooling in the Transport Code.

Enabling AOMs to intervene in shared mobility and authorising road operators and policing bodies to bestow advantages on shared modes of transport:

- Allowing AOMs to organise a public carpooling service or to financially support private carpooling services;
- Giving local councils the ability to reserve parking spaces;
- Pursuing the development of road lanes reserved for certain vehicle categories or modes of use, in order to encourage shared mobility and clean mobility options.

Investing €1.2Bn over ten years to support clean and shared mobility (calls for projects).

Other measures to be taken by the Government over the 2019-2023 period

Updating the "car-sharing" certification that enables local councils to give preferential treatment to these vehicles, in order to include new technical possibilities such as car-sharing systems that do not require registration or pick up/drop off stations.

Launching a call for programmes as part of the Energy Savings Certificates (CEE) scheme, to enable the development of energy-saving mobility solutions: carpooling, cycling mobility tools (including secure parking areas), financial support for vulnerable households in order to facilitate their use of energy-saving mobility options.

Leading a fourth call for projects for the dedicated public transport lanes (TCSP) and sustainable mobility, notably by continuing to open up access to priority urban areas (QPV).

9.5.5. Promoting modals shift and freight transport efficiency

The ability to develop high-performance, sustainable end-to-end logistics chains – from mass transport to urban logistics – is vital for both France's import/export strategy and the economy. Measures will therefore need to be put in place to support the development of logistics models at both the national and local level.

Streamlining urban logistics and increasing the load fill rate of freight transport vehicles

Challenges and general orientations

Urban logistics only represent a portion of the logistics chain, but face a number of challenges in terms of the modernisation and optimisation of infrastructures, vehicles and software tools, as well as worker protection issues linked to digital delivery platforms and regulatory clarifications.

Following a period of logistical periurbanisation, it is now essential to (re)locate facilities in the heart of urban areas, closer to the areas in which products will be consumed. This involves planning and finding room to manoeuvre in terms of real estate for logistics buildings and access to waterways, and creating synergies between passenger and freight transport.

It is also necessary to support the greening of this sector, and to re-jig logistics for the digital age. Technological advances and the development of e-commerce are creating an ever-more connected environment, leading to larger amounts of data and information flows, which are a current and future source of wealth for companies. The use of this data as a new resource has led to the emergence of new business models and opportunities for public action. Working with blockchains, new operators are not hesitating to shake up traditional transport sectors, tackling challenges such as the optimisation of vehicles and routes, or operational performance. The challenges associated with the collection, transport and processing of logistical information, as well as the protection of the interests of the State, companies and citizens using these logistics systems, are significant. The following orientations are being proposed:

- Managing data effectively to revamp the logistics sector and increase vehicle load rates;
- Making purchasers aware of the environmental impact of the transport option they have chosen, and incentivising them to implement action plans aiming to reduce emissions across the entire logistics chain induced by their company's commercial activity;
- Promoting the development of alternative fuels (NVG, biofuels, electricity, hydrogen);

- Deriving maximum value from efforts agreed to regarding sustainable logistics in public ordering.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Defining and regulating co-transport of packages in order to support the development of this new service, enabling individuals to transport another person's package during their journey.

→ Taking urban logistics into account in planning documents (local urbanisation plan, regional development, sustainable development and regional equality plan, etc.).

→ Regulating the activity of digital intermediary platforms, which connect freight-holding clients with public road freight transport companies, by defining the conditions for the creation and operation of these platforms, as well as methods for identifying infractions and penalties to be handed out when this occurs.

Other measures to be taken by the Government over the 2019-2023 period

→ Monitoring the launch of the Corporate and Social Responsibility reference base for logistics:

- Supporting companies involved in the logistics sector, particularly small businesses and intermediate enterprises, within their overall approach to corporate responsibility;
- Facilitating exchanges between purchasers and logistical service providers, particularly during the call for bids phase.

→ Monitoring the implementation of charters for sustainable logistics in cities, at an inter-municipal level:

- Providing a "national framework for sustainable logistics in cities' charters" for local councils, in order to encourage towns and cities to make voluntary commitments in this sector, in partnership with private operators. Creation of a logistics toolbox for local councils;
- Supporting local councils during the implementation of the "national framework" at the inter-municipal level (support programme delivered within the framework of the energy savings certificates scheme);
- Providing financial support for local councils implementing urban logistics actions, which enable them to achieve energy savings (standardised actions within the framework of the energy savings certificates scheme).

→ Encouraging charter companies to implement action plans to reduce emissions of atmospheric pollutants and greenhouse gases associated with the freight they generate.

Developing bulk transport modes for freight

Challenges and general orientations

French policies for the development of infrastructures and service operations (notably freight) should be connected to those in other European countries: these include the establishment of European freight corridors, support for port freight policies, development of projects in partnership with the EU (particularly cross-border projects), and the mobilisation of European funds.

The dynamic strength of the French economy and its logistical performance levels stems from the country's connection to Europe, ensuring that goods are circulated in the most fluid and economic way possible.

Public policy must evolve, at the very least, with regard to the two extremities of the logistics chain: improving the competitiveness of maritime entry ports and their terrestrial access routes, and effective management of the explosion in final distribution flow rates.

Intentions of the State regarding clean mobility – legislative proposals, including proposals for the draft Mobility Law

→ Increasing investments in mass transport infrastructures:

- €3.6Bn over ten years to renew the existing rail network;

- €530M between 2018 and 2022 in the waterways network;
- €2.6Bn over ten years to desaturate urban rail hubs;
- €2.3Bn over ten years to support the development of ports, as well as their rail and river/canal connections with the surrounding area.

Other measures to be taken by the Government over the 2019-2023 period

→ Transforming the economic model for ports in order to bolster the recovery of maritime traffic by major maritime ports.

→ Improving competitivity of logistics chains and recovering market share by providing greater clarity regarding the governance and digital transition of the key port areas of the Seine, Mediterranean-Rhone-Saone and the North (CIMER).

→ Making all methods of CCS (Cargo Community System) operations interoperable with one another at the national level, and opening them up to all relevant operators under attractive conditions within the framework of the Union Customs Contract.

→ Designing and distributing innovations enabling the reduction of polluting emissions from waterway vessels (freight transport, passenger transport, inland fishery, ships contributing to sovereign missions like maintenance, police, rescue)):

- Identifying innovations and fostering cooperation so that operators conduct collaborative projects (transfer of innovation, sharing of costs, pooling request of exemption from the rules);
- Implementing an approach of ship electrification by modulating energy generation so that it can be adapted over the ship lifespan;
- Examining requests of exemption from the rules to enable innovative motorisation engines and to allow them nation-wide or only for specific areas in compliance with the article D4220-4 of transport code (decree "limited area") and to support evolutions of the European standard laying down technical requirements ES-TRIN as part of the European Committee for drawing up standards in the field of inland navigation (CESNI) in order to promote innovative ship motorisation engines at European level;
- Assisting with engine replacement or upgrade projects. At the French level, the Modernisation and Innovation Assistance Plan (PAMI), led by the VNF, is currently being ratified by the European Commission, and will enable financial support for engine replacement/upgrade projects;
- Mobilising existing calls for proposals at national and European levels to support innovations in the inland navigation sector;
- As part of an inland navigation inter-branch organisation (if created), developing R&D on energy transition, supporting and conducting projects which facilitates cooperations between operators.

→ Initiating a study to objectively assess the quality of service offered by SNCF Réseau.

-- Overseeing the improvement of information regarding network characteristics made available by SNCF Réseau to rail operators.

→ Initiating a reflective process on the reference bases and assessment procedures used for Exceptional Transport Notices, as well as gauge design reference bases.

→ Pursuing the development of rail motorway services.

→ Revitalising direct connections between factories/logistics facilities and the national network.

→ Initiating a prospective study on the capacities of trans-shipment facilities for modes of combined transport.

→ Maintaining assistance for the operation of regular combined transport services in order to promote the use of rail, river and maritime modes of transport for the movement of freight:

- Reaffirming the principle of support for the development of regular combined transport services offering an alternative solution to end-to-end road freight transport;
- Submitting new support measures to replace the existing ones.

→ Pursuing efforts already undertaken to boost capillary freight routes:

- Supporting the consultation approach between SNCF Réseau and stakeholders;
- Broadening sources of financing;
- Maintaining State financial efforts to provide important drive progress;
- Optimising costs of infrastructure upgrading and maintenance.

Appendix 1. Review of the SDMP, 2016-2018

Measures involved

- Managing mobility demand

Certain actions have been completed or are currently in operation: supporting the implementation of regional mobility plans, studies commissioned by the CEREMA on rural and peri-urban mobility, management of peak journey times, raising awareness of mobility options based on household location, and experiments with on-demand transport. Several studies are in their final stages, and others are waiting to be launched – such as the assessment of mobility needs in relation to the ageing of the population. Other actions focusing on small businesses or vulnerable sections of the population have not yet been solidified.

- Development of low-emissions vehicles

This measure essentially involves regulatory actions, which have been completed in accordance with planned timeframes: support for electric mobility and hydrogen via Article 37 of the LTECV regarding the replacement and upgrading of public fleets, publication of a National Atmospheric Emissions Reduction Plan (PREPA), application of new European regulations on non-road vehicles, and inclusion of motorised electric two-wheeled vehicles in the ecological bonus scheme.

Actions pertaining to the safety of parking and charging points for electric vehicles, as well as the re-use of batteries, have not yet been rolled out. Following the COP21, the SDMP also plans to launch a global call for projects with the aim of placing an electric car on the market with a price tag of less than €7000.

- Development of the alternative fuels market and deployment of corresponding infrastructures

Four out of five regulatory actions have been achieved:

  - Government order of 10 April 2017 establishing lists of biofuels and double counting processes;
  - Publication of a national framework for alternative fuels (CANCA) on 7 February 2017;
  - Decree no. 2017-26 of 12 January 2017 on charging facilities for electric vehicles;
  - Modification of Government orders defining technical specifications of fuels, in order to add a display standard – for vehicles and pumps – designed to inform consumers on the compatibility of their vehicles with the fuels being supplied.

The last action (which has been sanctioned but not delivered) concerns proposals for a re-launch of the specialised support programme aimed at local councils for electrical charging networks.

- Optimisation of existing vehicles and networks

All actions within this measure have either been completed or are underway. The “CO_2 Objective: Committed Transporters” programme has been in place since 2016. Local charters for sustainable urban logistics have been signed by six volunteer district councils, and nationwide roll-out is planned for 2018. The prospective study on the challenges, obstacles and opportunities for logistical partnerships and shared platforms has been delivered. The CEREMA published a report on 7 February 2018 on lessons drawn from the experiment of lowering the speed limit from 90 to 80km/h, and the Prime Minister announced the implementation of the measure, effective from the beginning of the same year.

- Improvement of modal shifts

Actions here involve the development of reports, some of which have been completed, such as the development review for the inter-urban bus market and its impact on mobility choices, and another on the call for collective transport projects in December 2014. The report on the “breathable cities” call for projects is being compiled, and will be completed in late 2019. As this report examines the bicycle-kilometres compensation scheme for agents of ministries responsible for sustainable development and their public establishments, the review process has not yet been initiated – as not enough time has elapsed to obtain a measured view of the scheme (which began on 1 September 2016).

The action regarding port spaces is highly specific, involving measures to standardise the costs of handling shipping containers between various transport modes linking ports with inland facilities, notably in favour of river/canal transport. For the moment, only one such initiative has been successfully established, at the Dunkirk port.

- Development of collaborative modes of transport

This action combines a number of studies currently being carried out by the CEREMA. The study examining feedback and best practices gleaned from free-hire car services has been completed. Others are currently in progress.

Review of Thematic Strategies

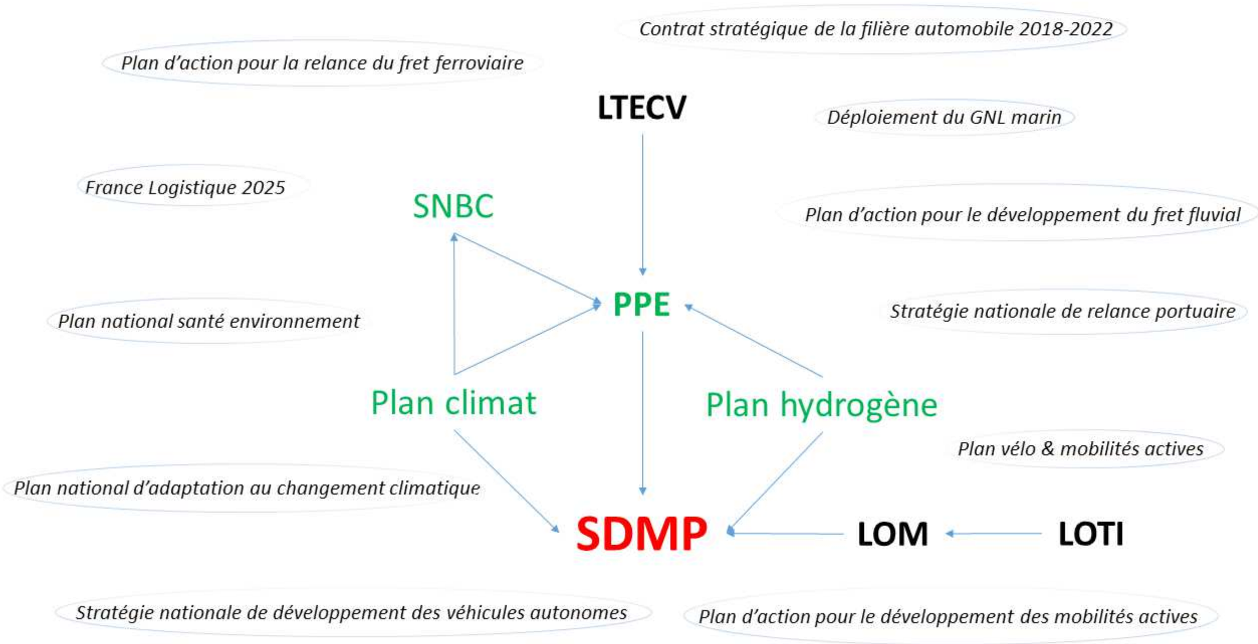
The thematic strategies are currently at varying stages of completion. The draft national strategy for experimentation and development of automated vehicles was presented to the public on 14 May 2018, while the French Institute of Transport Science and Technology and Network Development (IFSTTAR) is working on the development of energy-positive roads.

Global overview

Out of a total of 12 studies to be launched under the SDMP, three have been completed, six are underway and two are in their final stages. Three studies have not yet been launched. Among the 26 actions to be implemented as part of the strategy, 13 have been completed, eight are underway and five have not yet been launched.

Most of these actions are underway or complete, but their levels of achievement are varied and the monitoring indicators are sometimes difficult to define.

Appendix 2. Overview of existing strategies and plans of action



Appendix 3. Navigational guidelines on electrical charging points

The development of electric mobility will require the provision of a network of charging points, with sufficient density and quantity to cover all types of user needs. This is a condition essential to the success of electric vehicles, as the absence of a high-performance charging network would be a huge psychological barrier to the purchase of these vehicles.

Under the terms of the strategic contract for the automobile sector, the Government has committed to guaranteeing a ratio of one charging station for every ten vehicles in circulation, i.e. a total of 100,000 public charging stations by 2022 if the sector reaches its objectives. When applying this overall ratio, the preferred method involves taking into account the need for public charging stations based on the type of habitat or mobility involved. This document aims to put forward an assessment of the demand for low-powered and semi-accelerated charging stations based on their geographical location; in particular, this approach helps to identify zones in which demand will be highest.

The analyses presented in this report have been compiled based on the National Survey of Transport and Travel (ENTD), which was carried out in 2008. During this survey, journeys taken by 10,177 vehicles were recorded over a one-week period. The conclusions drawn below are postulated on a scenario in which all these vehicles become electric, and require charging stations. As such, this hypothesis will need to be adapted in order to be applied to a deployment phase, during which it may transpire that the supply of charging stations already outstrips demand, or that additional public services will be necessary in order to compensate for the lack of availability of domestic charging points (especially in apartment buildings). Based on the data from this survey, the changing needs of each of these vehicles have been simulated for the week-long period during which they were observed.

Stationary charging

A certain proportion of drivers will be able to charge their vehicles at home using a low-powered socket (3.5 to 7kW). A certain number of wallbox-type devices are already widely available in commercial outlets. These devices can also be installed in private parking areas in collective residences, or in covered parking bays. For drivers having installed these devices, charging will usually be done overnight, and requirements in terms of public stations are limited. A useful starting point, therefore, would be knowing how many vehicles are likely to be permanently parked in public spaces, as public charging points will be essential for all these users.

The National Survey of Transport and Travel included a question on the usual type of parking space used by each vehicle. The response fields described where vehicles were usually parked during the day and at night, enabling the deduction of the number of vehicles that would not have access to a private charging station if they were electric.

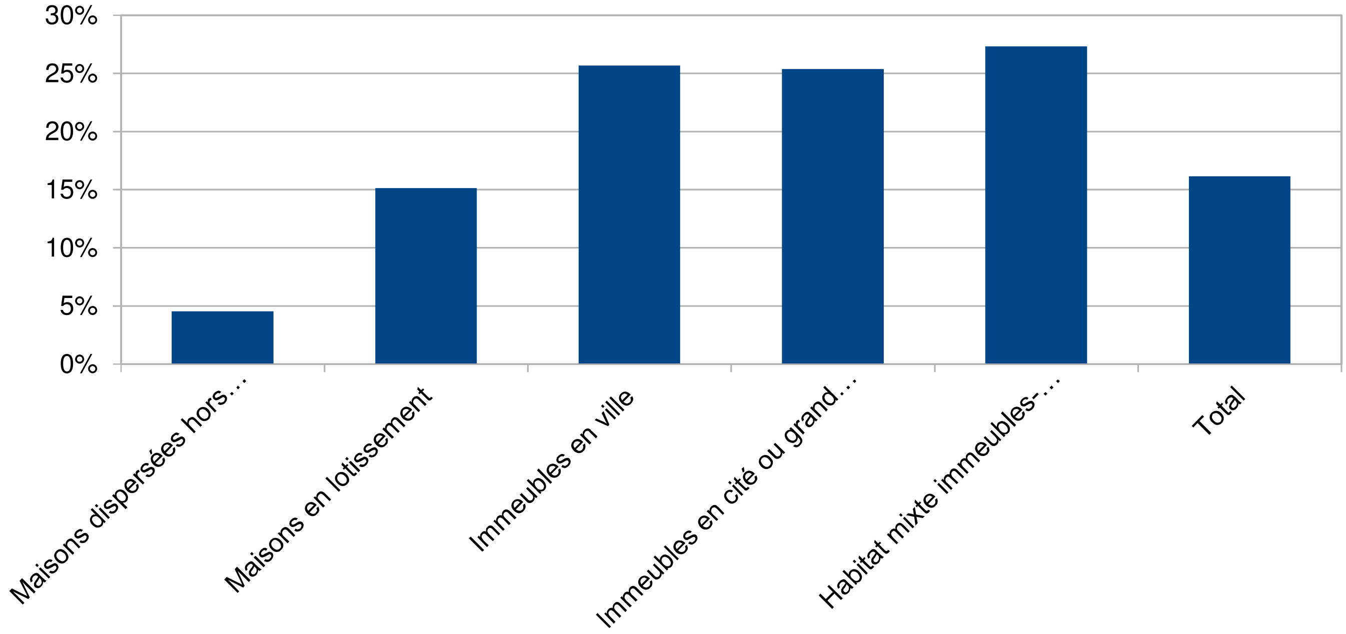


Figure 1: Requirements of vehicles parked on public roads, per type of habitat (share of number of vehicles)

At the national level, 16% of vehicles were permanently parked on public roads and would not have access to a private charging point either during the day or at night. These vehicles therefore could not be electrified without the sufficient presence of charging points in public areas. The type of habitat involved has a significant bearing on this ratio: only 5% of vehicles are parked on public roads outside urban areas, while this figure rises to 25% where buildings are present.

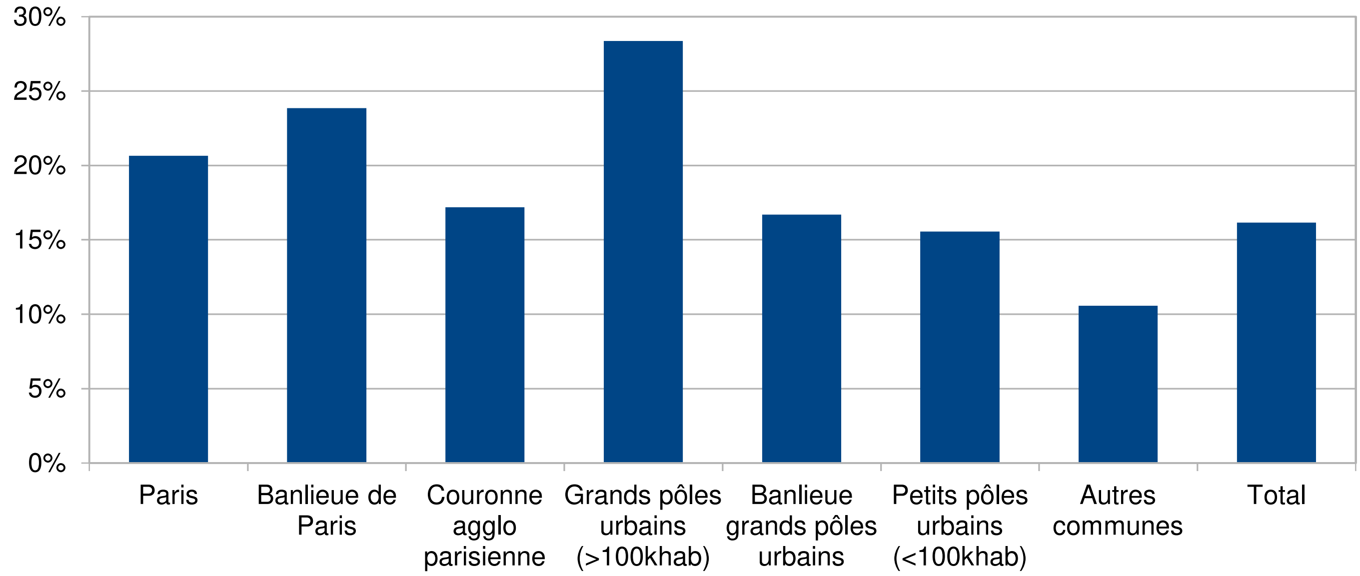


Figure 2: Requirements of vehicles parked on public roads, per type of area (share of number of vehicles)

Demand from vehicles parked in public spaces represented 21% of vehicles in Paris, but 24% in suburban Paris, and 28% in major urban areas (centres of urban areas with over 100,000 inhabitants). It applied to only 11% of vehicles in rural communities.

Simulation principles

For each of the 10,177 vehicles sampled by the ENTD, charging needs over the course of one week were simulated based on data from vehicle logbooks. The survey was carried out over two visits: during the first visit, a household vehicle being surveyed was picked at random and a logbook was provided to record the vehicle's journeys. The second visit took place at the end of the week, and allowed the surveyors to collect the data on the journeys taken.

The same sequence of journeys was considered for an electric vehicle with autonomous range of 200km, at an energy consumption rate of 15kWh/100km. This vehicle would have three options for electrical charging:

- A low-powered charging socket (up to 7kW), which could be installed in the home;
- A moderate-power charging point (between 7 and 22kW);
- A high-powered charging point (over 50kW), where no other option was available.

In order to encourage drivers to develop rationalised habits for the use of charging stations, the pricing structure would include a fixed rate for the connection, and a price rate that was proportional to the amount of time for which the vehicle occupied the charging point. The simulations were based on the following price index, with amounts having been adapted so as to minimise total needs and ensure financing for charging stations.

Type of charging[132]	Power	Cost of charging	Comments
Low power	7kW	€0.31 + €0.17/hr	Free if charged at home or in a covered parking bay
Moderate power	22kW	€0.50 + €0.18/hr	-
High power	50kW	€10 + €5/hr	Disincentivising price index (charging reserved for long journeys)

The price indexes indicated above only concern the price of the charging service; the cost of electricity can be priced separately without any additional impact in terms of charging choices.

For simulation requirements, certain restrictions were placed on the conditions of charging:

- The charging time invoiced corresponds to the total amount of stationary time between two journeys;
- Only full charging is possible.

This final condition enables a simulation, for each vehicle logbook, of the combination of connections, which limits the total cost for the user. The simulation uses a dynamic programming algorithm, aggregating results in order to determine the total number of connections per hourly interval in a typical week. The need for charging stations is therefore equal to the maximum number of simultaneous connections over the course of a typical week.

This approach was applied per category of residential area for slow charging, and at the national level for moderate charging power. The need for high-powered charging should be subject to specific data processing, as the results were not decisive in the sample observed.

In order to take into account limitations in the process of matching vehicles to charging points on a local scale, and to ensure the permanent availability of public charging points, it will necessary to plan on installing a number of stations that is slightly higher than the maximum identified requirements. Otherwise, the time spent searching for an available charging point will become prohibitive, and drivers will not be guaranteed to find an available station near to their destination. A ratio of 1.25 has therefore been applied to the number of low-powered charging stations, and a ratio of 1.5 to the number of moderate-powered stations.

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132 It should be noted that the eventual categorisation will need to cover all power levels. This will mean categorizing charging levels between 22 and 50kW, as the "moderate" level currently designates power levels of between 7 to 22kW. The specification could become:

- Low: ≤7kW
- Normal: 7 - 22kW
- Moderate: 22 - 50kW
- High: >50kW

Additional scenarios

In addition to the central scenario described above, two supplementary scenarios have been studied:

- A scenario including a flat rate for slow charging, in which the price index does not depend on the time spent at the charging point;
- A scenario in which vehicles' autonomous range is extended to 400 kilometres (instead of 200km): this is the vehicles' practical range, i.e. after deduction of the amount of power drivers feel they must reserve in order to avoid breaking down.

The price index for the use of charging points has been changed in both of these scenarios. In each case, the prices and times have been adjusted so as to reduce, as far as possible, the need for charging stations.

Type of charging	Central scenario	Flat rate for slow charging	Autonomous range 400km
Low power	€0.31 + €0.17/hr	€2.00	€0.21 + €0.22/h
Moderate power	€0.50 + €0.18/hr	€1.01 + €0.45/hr	€0.65 + €0.20/hr
High power	€10 + €5/hr		

Simulation results

In the central scenario, around 2.2 million charging stations are needed to cover the needs of all vehicles (excluding moderate-powered charging). This corresponds to a ratio of 6.5 stations per 100 vehicles.

The breakdown of charging needs is not uniform across the country. Regarding low-powered charging, the ratio necessary to cover all needs rises from four stations per 100 vehicles in rural zones to 11 stations per 100 vehicles in large urban areas. The national average is 5.7 stations per 100 vehicles, to which we may add 0.8 stations per 100 vehicles for moderate-powered charging.

In case of a flat rate for low-powered charging, drivers are not incentivised to shorten their charging times, and the need for financial balance would require the adoption of higher price indexes. Total requirements in terms of charging stations are higher, corresponding to 6.9 stations for every 100 vehicles.

The number of low- and moderate-powered charging stations necessary is not very sensitive to vehicle autonomy levels. When autonomous range rises from 200 to 400km, requirements fall by 12%, giving a ratio of 5.8 stations per 100 vehicles. However, needs in terms of high-powered charging decrease in a more significant fashion.

Type of residential area	Central scenario	Flat rate for low-powered charging	Autonomous range 400km
Paris	49,000	49,000	49,000
Suburban Paris	204,000	210,000	202,000
Paris hinterland	55,000	61,000	53,000
Large urban areas (>100k inhabitants)	495,000	551,000	455,000
Suburbs of large urban areas	300,000	308,000	290,000
Small urban areas (<100k inhabitants)	194,000	207,000	157,000
Other areas	618,000	666,000	490,000
Total low-powered charging	1,915,000	2,052,000	1,695,000
Moderate-powered charging	269,000	248,000	230,000
Total charging stations	2,185,000	2,300,000	1,924,000

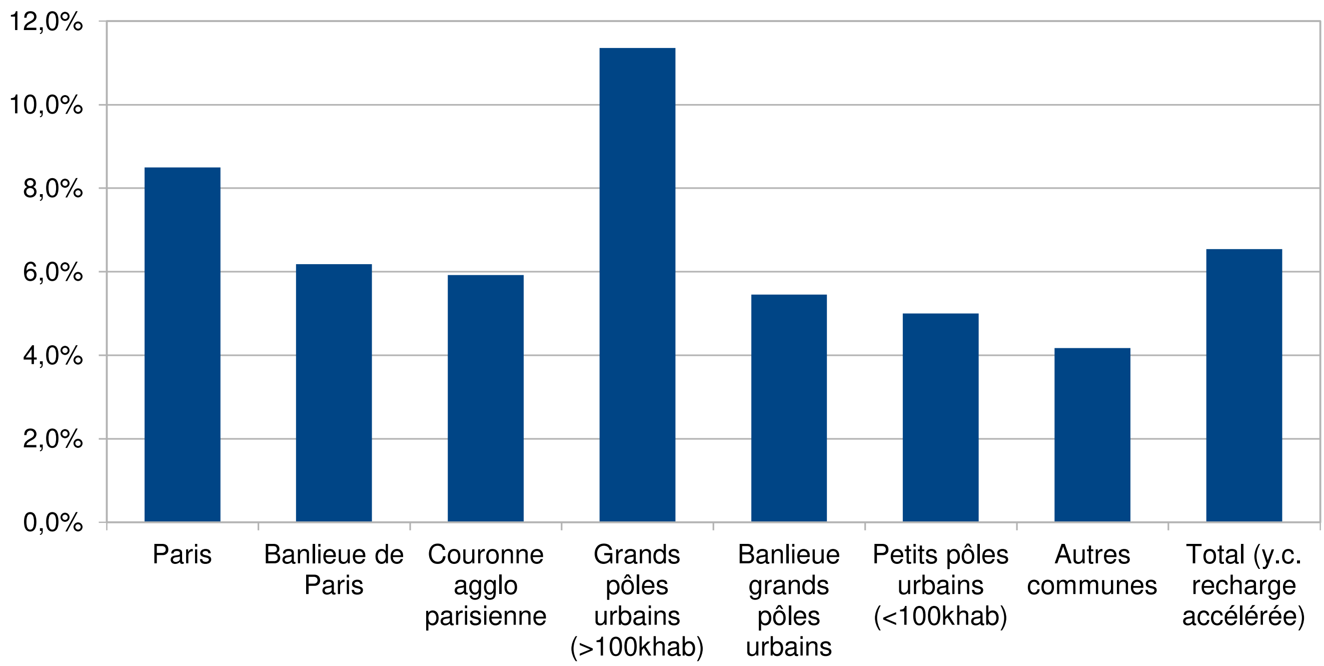

Figure 3: Number of low-powered charging stations necessary to cover all needs (ratios based on number of vehicles, category of residential area, and central scenario)

Price rates for the use of public charging stations presented in this document have been adjusted so as to ensure balance between investment costs and revenues. The investment cost considered is €4000 for a low-powered charging point and €6000 for a high-powered charging point, with a cost update after ten years at a rate of 8%. The price rates are taken from an optimisation algorithm which minimises total investments, while retaining a financial balance for public charging stations.

Appendix 4. Estimation of infrastructure needs for CNG refuelling

This addendum aims to estimate the number of CNG refuelling stations needed by 2023 and 2028 in order to meet the requirements of the vehicle fleet envisaged in the Clean Mobility Development Strategy (SDMP), itself an appendix of the Multi-Year Energy Programme (MYEP).

To ascertain the size of the CNG refuelling infrastructure needed, several criteria had to be verified:

- An energy threshold: the total quantity of energy distributed by refuelling stations must be able to meet vehicle demand, with a reasonable rate of occupation for refuelling stations in order to avoid queues;
- Effective network density: stations must be spread across the country in such a way as to ensure that vehicles do not have to travel long distances in order to reach a station;
- A station profitability threshold: there must be a minimum number of vehicles enabling stations to turn a profit, so that distribution costs do not heavily penalise the cost of CNG.

The effective network density criterion was examined as part of the development of the CANCA objectives. This examination has led to an estimated requirement of at least 140 refuelling stations to ensure effective national coverage.

Energy analysis

The CNG fleet being considered is indicated in the SDMP as:

	2017	2023	2028
LCV	8200	40,000	110,000
HGV	1350	25,000	60,000

Based on the energy performance objectives indicated in the SDMP, and assuming a constant rate of annual kilometres covered per vehicle as well as the breakdown between various types of heavy vehicles, the total demand for the CNG fleet, expressed in tonnes of CNG, is estimated at:

	2017	2023	2028
TOTAL CNG demand (in tonnes)	63,000	420,000	910,000
of which LCV (CNG)	8000	34,000	82,000
of which HGV			
of which tractors (LNG)	10,000	173,000	400,000
of which trucks <19t (CNG)	2000	39,000	85,000
of which trucks >19t (CNG)	4000	110,000	250,000
of which buses/coaches (CNG)	37,000	64,000	90,000

Buses and coaches are considered as being primarily fuelled via a nocturnal refuelling system in reserved depots. They are therefore not considered in the next section of this exercise, which aims to provide an estimate of the number of stations open to the public. For other types of vehicles considered, we have assumed the following autonomous ranges per type of vehicle, expressed in km:

	2017	2023	2028
LCV	300	350	400
HGV			
of which tractors (LNG)	1500	1550	1600
of which trucks <19t (CNG)	400	450	500
of which trucks >19t (CNG)	400	450	500

Supposing that each fill-up fills 80% of the tank, this gives us the following number of fill-ups:

	2017	2023	2028
LCV (CNG)	550,000	1,800,000	5,600,000
HGV			
LNG tractors	30,000	600,000	1,500,000
Trucks <19t CNG	30,000	450,000	970,000
Trucks >19t CNG	70,000	1,300,000	2,900,000

In this approach, the estimated refuelling time for an LCV is 5 minutes, and 10 minutes for a heavy vehicle.

All tractors are considered as fuelled by LNG, using refuelling stations located along the TEN-E. Trucks weighing >19t are fuelled by CNG and refuel at stations located along the TEN-E. Trucks weighing less than <19t and LCVs refuel in urban areas away from the TEN-E, according to values defined in the CANCA.

Stations along the TEN-E are designed for high flow rates, equipped with four pumps (source: AFGNV, either two CNG and two LNG, or four CNG), and for which we estimate fill-ups to be carried out over a timeframe of 4hr/day/pump (equivalent to current diesel stations). A higher occupancy rate for stations will sometimes lead to the formation of unreasonable queues.

Stations in urban zones are designed to refuel local vehicle fleets, and are equipped with CNG; all fill-ups are carried out over a timeframe of 4hr/day/pump in order to avoid queues.

In these conditions the maximum annual capacity for stations, in number of fill-ups, is:

	2017	2023	2028
TEN-E CNG	35,040	35,040	35,040
CNG urban area	32,440	32,440	32,440
TEN-E LNG	35,040	35,040	17,520

The number of stations necessary to supply all fill-ups is therefore:

	2017	2023	2028
TEN-E CNG	2	36	83
CNG urban area	18	85	202
TEN-E LNG	1	17	41
TOTAL:	23	138	325

This approach gives a higher number of stations than the CANCA method; the criterion of total energy quantity to be supplied within a reasonable waiting time at stations therefore indicates the dimensions of the CNG infrastructure to be deployed.

Economic analysis

The profitability thresholds for stations have been estimated based on the hypotheses presented in the table below:

	Stations in urban areas	**TEN-E stations**
Investment expenditure	€500,000.00	€1,000,000.00
Annual operating cost	€20,000	€30,000
Margin	€0.15/kg	
Update rate	10%	
Period	Ten years	
Profitability threshold	600 tonnes/year	1150 tonnes/year

Based on previously-determined energy needs, we can deduce the maximum number of profitable CNG stations for the 2023 and 2028 timeframes.

	Stations in urban areas		**TEN-E stations**	
	2023	2028	2023	2028
Total demand (tonnes/year)	73,000	167,000	282,000	652,000
Maximum number of profitable stations	122	278	245	567

In conclusion, the two analyses carried out allow us to obtain the following value range regarding the number of CNG supply stations:

	2023		**2028**	
	Urban area	TEN-E	Urban area	TEN-E
Result of energy analysis	85	53	202	124
	Total: 138		Total: 326	
Result of economic analysis	122	245	278	567
	Total: 367		Total: 845	

The energy approach gives the lower value of around 140 stations in 2023 and 330 stations in 2028. This threshold value represents, according to the hypotheses, the minimum number of stations capable of meeting energy needs without unreasonable waiting times at stations. It should be noted that the number of stations is highly sensitive to the use characteristics of the refuelling pumps: time taken by each vehicle to fill up, number of pumps per station, amount of time pumps are in use daily.

The energy approach gives the higher value of around 370 stations in 2023 and 850 stations in 2028. This upper value represents, with regard to the hypotheses indicated, the maximum number of stations that could be profitable. This number of stations is highly sensitive to the margins achieved by the station per kilogram of NVG sold, and also, in particular, to supply costs. Connecting these stations to the natural gas transport network (hitherto reserved for industrial use and gas distributors) would enable a notable reduction in supply costs.

10

The Ponant Islands, non-interconnected with the mainland

10. The Ponant Islands, non-interconnected with the mainland

Article L.141-5 (IV) of the Energy Code stipulates that *Zones that are not connected to the continental metropolitan grid, with the exception of Saint-Martin, Saint-Barthélemy and the zones mentioned in paragraph I of this Article, are addressed in an appendix to the Multi-Year Energy Programme referred to in Article L. 141-1, in accordance with the procedures laid down by the decree referred to in Article L. 141-6.*"Accordingly, the Ponant Islands that are inhabited all year round, but which are not interconnected – i.e. the islands of Ouessant, Molène, Sein and Chausey – are addressed in an appendix to the national MYEP covering 2019-2023 and 2024-2028.

These islands have a special energy configuration because:

- In terms of mobility, Chausey, Molène and Sein are almost vehicle-free – there are only three or four vehicles, used for emergency services, to provide transport for people, and for refuse collection. On Ouessant, the situation is different – there are about 400 vehicles year-round and double that number in summer.
- Heating is mainly electricity-based, representing 72% of homes on Molène, 73% on Ouessant, 80% on Sein and 100% on Chausey. Fuel oil is not used much – 23% on Molène (28 dwellings), 20% on Ouessant (90 dwellings) and 10% on Sein (13 dwellings). The other dwellings are heated with wood.

Electricity is therefore fundamental to these islands, especially as they are not connected to the mainland power grid and must produce their own electricity.

10.1. Evaluation of actions undertaken since 2016 as of 31 May 2018

As of 31 May 2018, the evaluation of the first actions undertaken was positive and encouraging: 1659MWh electricity savings (compared to a target of 750MWh) and 217MWh of energy produce from renewable sources. That represents a 563m3 saving in fuel oil consumption. The carbon footprint of Ouessant, Sein and Molène has made major improvements: carbon dioxide emissions have fallen by 22.9%.

10.1.1. Demand management

For many years, several initiatives have yielded significant gains in demand management, including:

A Public Interest Programme (programme d'Intérêt Général (PIG)) for housing renovation on the islands of Ouessant, Molène and Sein, in partnership with the ANAH (French Housing Improvement Agency), the department of Finistère, the Region of Brittany, the ADEME (French Environment and Energy Management Agency) and EDF, provided funding for 156 projects between 2012 and 2017.

The 2015-2020 partnering agreement between the Ponant Islands Association, the State, and the Region sets out activities relating to:

Energy efficiency in community property with the aim of improving the energy performance of the existing infrastructure;

Public lighting with the installation of LEDs.

The "Local Energy Loop" (BEL) launched by the Brittany region in 2015 for the islands of Sein, Molène and Ouessant. These three islands are engaged in an energy transition approach with energy management projects (distribution of LED lights, incentives for the replacement of cold appliances, hydro-efficient kits), energy production from renewable sources, energy management and storage;

The “Positive Energy for Green Growth Territories” (TEPCV) project, sponsored by the Ponant Islands Association, particularly on behalf of Molène, Ouessant and Sein. The objective is to continue and extend the actions taken to control energy demand over three years (distribution of LEDs, hydro-savings kits, incentives to replace refrigeration appliances), in buildings (energy improvement in public buildings), clean energies (local renewable energy production, self-consumption, charging stations for 100% renewable electric vehicles) and public lighting (LED replacement);

On Chausey, during summer 2017, a campaign involving the distribution of over 400 light bulbs and water economisers reached 80% of homes.

10.1.2. Development of renewable energies

In 2016, the islands of Ouessant, Sein and Molène mobilised, through the MYEP and with the support of the State, to accelerate their energy transition with a dual objective:

- A 30% reduction in their greenhouse gas emissions within three years;
- Achieving a energy mix of 100% renewable energies by 2030.

In addition to the demand management measures using the instruments mentioned above, this MYEP also sets ambitious targets for renewable energies with projects representing a total of 2200MWh / year:

- Power generation from a tidal farm coupled to storage on Ouessant. This project lays the foundations of an energy solution for isolated networks, which can be reproduced for export;
- Following the study of the photovoltaic potential of the municipal property for the three islands in the Iroise Sea, conducted in early 2015, projects to install photovoltaic panels on roofs in order to dedicate part of the production to recharging community electric vehicles (self-consumption) or the public lighting network;
- Project in the operational study phase including the long-term installation of wind turbines on the island of Sein. This project may evolve based on the contribution of photovoltaics.

The recent start-up dates of the facilities mean that representative figures for the year are not available. However, initial projections suggest that renewable energies will represent 10% of the mix in Sein and between 5% and 10% in Ouessant in 2018.

Currently, the development of renewable energy projects is based on over-the-counter contracts agreed with EDF SEI under the control of the CRE (French Energy Regulator), within the limits of the objectives of this MYEP. In order to facilitate project planning, the Ponant Islands Association has proposed to help individuals and to regroup the smallest projects so that they can be studied by the CRE based on a standardised grid.

10.1.3. Managing the supply-demand balance

The goal is to achieve a multi-energy system coupled with storage solutions, with the aim of reducing (or even eliminating) the consumption of fuel oil. The use of storage should be optimised by effectively coupling the reinforcement of network infrastructures with finer coordination of each element of the value chain. Thus, a smart power grid will make upstream correlation and optimisation possible for the production phases (modelling of solar capture, adjustment of production to suit needs, etc.), storage / depletion phases (optimisation of energy transfers between production points and storage points, etc.), then, ultimately, energy use and consumption phases (e.g. installation of smart meters to improve the real-time responsiveness of the low voltage power grid). This smart management should make it possible to manage the renewable electricity injected into the grid at any given moment while enabling energy to be transferred between production time and use time (to respond to need, smooth peaks, compensate for the intermittency of some renewable generation).

To meet this goal:

- Storage facilities have been installed in Sein and Ouessant to absorb intermittent renewable generation well beyond the 30% limit;
- Management systems for the different components of the power system have been implemented (storage, groups, renewables, consumption). These Energy Management Systems (EMS), which have already been deployed on Sein and Ouessant, make it possible to optimise the operation of the electricity system and maximise the share of renewable energies;
- The deployment of Linky has facilitated the establishment of fixed off-peak hours and will allow off-

peak hours to be set based on renewable production, helping to maintain the balance between supply and demand.

This smart grids' ambition is supported, in particular, by the following programmes:

- INTERREG Transmanche (ICE), supported on Ouessant for innovation in smart management of tidal power generation and storage;
- SMILE (smart ideas to link energies) rolled out by the Brittany and Pays de la Loire regions, provides a "green islands" component, supported on Yeu and Ouessant for the development of smart grids.

10.2. The specific framework for equalisation in non-interconnected zones (NIZ)

Due to the specific constraints of the NIZs, electricity generation costs are much higher than in mainland France. Consequently, regulated sales tariffs are insufficient to pay for electricity generation in these zones. To ensure national tariff equalisation, compensation of cost overruns is necessary. This is calculated by the Energy Regulation Commission (CRE) and forms part of the State budget.

In the Ponant NIZs, the cost of production is almost exclusively linked to investments in thermal and fuel oil power plants used to produce electricity. So, the average cost of the electricity generated on these islands is highly sensitive to fluctuations in the price of fuel oil.

		Sein	Ouessant	Molène	Chausey	Average
2014	**Variable cost**	205	226	216	237	222
	Full production cost	250	441	260	972	415
2017	**Variable cost**	160	140	138	113	141
	Full production cost	205	404	204	714	371

Table 1: Evolution of electricity production costs (€ / MWh) on the non-interconnected Ponant islands

10.3. Ouessant

10.3.1. The situation in 2017

Ouessant occupies 15.58km², has 893 inhabitants and 1050 customers, and consumed 6.2GWh in 2017. The power demand in 2017 fluctuated between 300kW and 2MW. Residential consumption accounts for 69% of consumption and can be explained by the importance of electric heating. Summer tourism creates peak consumption at midday, related to restaurants.

As discussed in the first part of the document, actions to reduce power consumption were started a decade ago, involving a range of agencies (Ponant Islands Association, ADEME, State, Region, Department , EDF): overhaul of public lighting, distribution of LED bulbs, replacement of energy-consuming cold appliances and building energy efficiency improvements, as part of the Public Interest Programme.

Until 2016, power was entirely provided by oil-fired generator groups. Since then, renewable energies have been developed:

- Photovoltaics with three plants of a total installed capacity of 60kW: one of 54kW, hosted on a community building by the Finistère Energy Union in 2017 and the other two of 3kW each owned by private individuals.
- A marine turbine (D10) developed by Sabella, with 250kW of injection capacity, has been connected and has undergone trials. It is currently being serviced, with a return to the sea being scheduled for September 2018.

For the moment, the renewable share of the energy mix remains very low at approximately 1% (around 7% when the tidal turbine is back in service). These installations are expected to produce around 400MWh in a full year.

In accordance with the first Multi-Year Energy Programme, EDF SEI has launched three actions, which are now fully operational, for the network integration of new facilities based on intermittent renewable energy:

- A storage system (based on 1MW / 500kWh Li-ion batteries);
- An infrastructure for management of arbitration between the various generation sources, to maximise the renewable share. The system is now in place and can absorb a much larger share of renewable energy.
- The modulation of off-peak hours by the deployment of Linky meters, already fitted for 96% of the island's customers. Individual customers were divided into ten batches defined based on annual mean power extraction, how long they spend on the island and the degree of coordination of their off-peak consumption, in order to smooth the load curve and thus reduce the number of start-ups and increase the performance of the generator sets. The graph below illustrates how the load curve is smoothed:

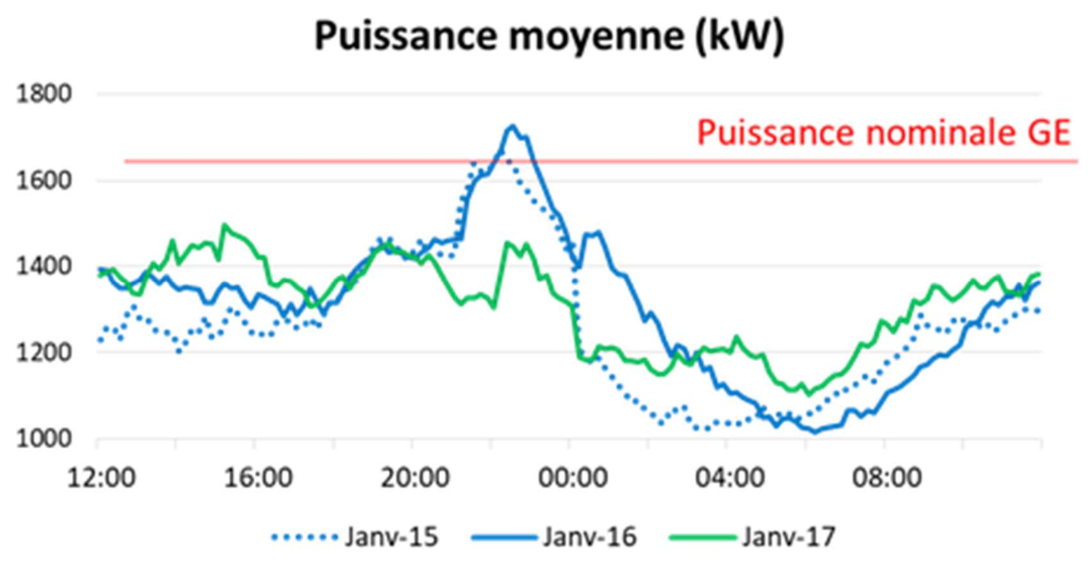

Figure 1: Capped winter peaks

10.3.2. Objectives for the 2019-2023 and 2024-2029 periods

Demand management actions need to be continued:

- Renovation of the infrastructure in place to reduce the electrical consumption of buildings and extensions for professionals. The goal is to reach a rate of 30 applications processed per year;
- New LED distribution campaigns, information / awareness raising for inhabitants and involvement in the energy transition;

These initiatives should lead to a 1GWh reduction in annual consumption from 2023 (without taking account of the development of Electric Vehicles). Carbon-free electric mobility covering 2- and 4-wheeled vehicles on the island will be the subject of a special study.

The development of renewable energies must be expanded and diversified with:

- An increase in installed photovoltaic capacity, particularly on the roofs of public buildings, which are still largely underused. Four such projects, for a total of 150kW, are planned by 2023. Additionally, a photovoltaic plant project, partly for agricultural greenhouses, with a total capacity of between 500kW and 1.5MW, is planned for 2020, subject to administrative permits. The development of photovoltaic power for private customers will also be subject to a quantitative and architectural acceptability study to estimate the potential, given solar potential and the architectural constraints;

- The development of wind power, given the very high quality of the island's wind resources. The commissioning of a 900kW wind turbine is planned for 2021, subject to obtaining the necessary administrative authorisations;
- The development of tidal energy with the commissioning of two additional turbines with an individual capacity of between 500kW and 1MW;
- The use of biomass remains an open question. While the feasibility of a wood energy sector is incompatible with the island's air and pedoclimatic conditions, a study of the energy potential of fermentables (reuse of household waste, green waste) and the potential of the vegetation cover requiring heritage management (maintenance of heathland) appears necessary. A study will be conducted to evaluate the potentials and possibilities of technological solutions adapted to the available volumes and biomasses, taking account of the possibilities of pooling with Molène (same shipping line). This will also involve evaluating the feasibility and cost of mobilising biomass in Ouessant's energy mix.

In terms of management of intermittency and coordination of uses:

- The current size of the battery (1MW / 500kWh) is able to absorb up to 500kW of additional photovoltaic capacity. The commissioning of the wind turbine and tidal turbines will lead to an increase in storage capacity (of around 2MW / 2MWh) in order to limit the capping of renewable production;
- The deployment of Linky will enable peak hours to be modelled on the operating ranges of renewables, in line with the implemented off-peak hours time lag. An experiment on the alignment of peak hours with tide times will be implemented in some homes as soon as the D10 tidal turbine is put back in place (from September 2018);
- Drivable electric vehicle charging facilities will be interfaced with the grid coordination system.

In the context of a 100% renewably powered island by 2030, coordination, flexibility and storage systems will be adapted and subject to analyses:

- Study of new flexibilities, particularly at the level of usage coordination, through Linky;
- Study of medium-term storage solutions (e.g. hydrogen) in order to move towards 100% renewable energy;
- "Vehicle-to-Grid" (V2G) implementation study;
- Ongoing demand management initiatives.

The objectives of the Ouessant MAEP for 2019-2023 and 2024-2028 are set as follows:

	2018	2023 (1)	2028 (1)
MDE		-1GWh	-1.5GWh
PV	56kW	0.5 to 1.5MW (2)	1.5MW
Wind	0kW	900kW	900kW
Tidal	250kW	1 to 2MW (2)	1 to 2MW
Biomass	0kW	0kW	100kW
Storage	1MW / 500kWh	2MW / 2MWh (2)	2MW / 6MWh
Share of renewables in energy mix	10%	65%	75%

(1) Total installed capacity

(2) The photovoltaic objective will be adjusted based on the power of the new installed tidal turbines: 1.5MW for two x 500kW tidal turbines or 500kW for two x 1MW tidal turbines

10.4. Molène

10.4.1. The situation in 2017

Molène occupies 0.72km², has 186 inhabitants and 323 customers, and consumed 1.2GWh in 2017. Power demand in 2017 fluctuated between 50kW and 400MW. Residential consumption represents 69% of consumption with a peak between 20:00 and 23:00, between dinner time and the time when water heaters switch on. Molène has two peculiarities:

- A less significant difference than on the other islands in power consumption between low season and summer, due to tourism;
- More significant daily consumption variations than on the other islands.

As discussed in the first part of the document, actions to reduce power consumption were started a decade ago, involving a range of agencies (Ponant Islands Association, ADEME, State, Region, Department , EDF): overhaul of public lighting, distribution of LED bulbs, replacement of energy-consuming cold appliances and building energy efficiency improvements, as part of the Public Interest Programme.

A study of photovoltaic resources commissioned by the Ponant Islands Association in 2015 identified several potential projects on community buildings. To date, no pholtovoltaic generation has been installed. The energy mix currently remains 100% thermal.

No storage or coordination system has yet been deployed, pending the implementation of plants based on renewable energy. The deployment of Linky meters began in 2016 and 90% of customers now have them installed.

10.4.2. Objectives for the 2019-2023 and 2024-2029 periods

Demand management initiatives must be continued:

- Renovation of the infrastructure in place to reduce the electrical consumption of buildings and extensions for professionals. The goal is to reach a rate of ten applications processed per year;

- New LED distribution campaigns, information / awareness raising for inhabitants and involvement in the energy transition;

These efforts should reduce annual consumption by 200MWh from 2023.

The development of renewable energies shall start with:

- In 2018-2019, a photovoltaic installation will be commissioned on the roof of the EDF-SEI power plant with a battery storage system, to supply all public lighting points;
- A 250kW photovoltaic installation in the area of the impluvium, hosted by the Finistère Energy Union (SDEF) is planned for connection in 2020;
- Studies of photovoltaic resources conducted in 2015 may lead to the development of projects on community buildings. Resources are estimated at 50kWc;
- The development of photovoltaic power for private customers will also be subject to a quantitative and architectural acceptability study to estimate the potential, given solar potential and architectural constraints;
- A study of wind resources shall be carried out to identify wind power potential on the island.

In terms of management of intermittency and coordination of uses:

- The implementation of differentiated off-peak hours, made possible with the deployment of Linky, will enable power demand to be limited and, simultaneously with the development of renewable energies, will enable off-peak hours, community uses (such as the water treatment system) and renewable production to be harmonised.
- Like the architecture implemented on the islands of Sein and Ouessant – which today means that Sein can operate several hours per day with exclusively renewable power generation – the development of renewable energy will be accompanied by the establishment of a Li-ion battery storage system connected to a coordination system to maximise the share of renewables in the energy mix.

In the context of a 100% renewably powered island by 2030, coordination, flexibility and storage systems will be adapted and subject to analyses:

- Increase in battery storage capacity in order to integrate additional renewable power generation;
- Study of new flexibilities, particularly at the level of usage coordination, through Linky;
- Study of medium-term storage solutions (e.g. hydrogen) in order to move towards 100% renewable energy;
- Ongoing demand management initiatives.

The objectives of the Molène MAEP for 2019-2023 and 2024-2028 are set as follows:

	2018	2023 (1)	2028 (1)
MDE		-0.2MWh	-0.3MWh
PV	0kW	300kW	750kW
Storage	0	300kW / 300kWh	300kW / 300kWh (2)
Share of renewables in energy mix	0%	30%	90.00%

(1) Total installed capacity

(2) To which the hydrogen demonstrator, if any, would be added.

10.5. Sein

10.5.1. The situation in 2017

Sein occupies 0.58km², has 215 inhabitants and 300 customers, and consumed 1.5GWh in 2017. Average power demand in 2017 fluctuated between 50kW and 500kW. Residential consumption represents 64% of consumption and is explained by the importance of electric heating, with a peak between 20:00 and 23:00, between dinner time and the time when water heaters switch on. Large numbers of summer tourists create peak consumption at midday, related to restaurants.

As discussed in the first part of the document, actions to reduce power consumption were started a decade ago, involving a range of agencies (Ponant Islands Association, ADEME, State, Region, Department , EDF): overhaul of public lighting, distribution of LED bulbs, replacement of energy-consuming cold appliances and building energy efficiency improvements, as part of the Public Interest Programme.

Until 2016, electricity production was provided by three fuel-oil generator groups with a total capacity of 810kVA and three photovoltaic installations with a total installed capacity of 14.6kW. Since then, renewable energies have been developed:

- Five photovoltaic installations were commissioned between 2017 and 2018 by the Finistère Energy and Equipment Union (Hatchery, Maritime Station, Nautical Centre and Fire Station) and by Finistère Habitat (15kW in self-consumption). When these are added to the pre-existing installations, the total installed capacity reaches 139kW;
- Two small vertical self-consumption wind turbines with a total capacity of 7kW were installed in 2017 by Finistère Habitat.

In a full year, these facilities should produce about 190MWh / year, or just over 10% of consumption.

In accordance with the first Multi-Year Energy Programme, EDF SEI has launched three actions for the network integration of new facilities based on intermittent renewable energy:

- A storage system (based on 200kVA / 180kWh Li-ion batteries);
- An infrastructure for innovative management of arbitration between the various generation sources, to maximise the renewable share. Additionally, an interface between the reverse osmosis unit supplying the freshwater network (whose power can reach 40kW) and the coordination infrastructure will be put in place in June 2018. This infrastructure will make it possible to operate the reverse osmosis system during periods of renewable power production;
- Finally, the deployment of Linky meters began in 2016 and 83% of customers now have them installed.

All of these actions already make it possible, when the conditions are fulfilled (high photovoltaic power, sufficiently loaded storage system, low consumption), to turn off the diesel units:

- In 2017, the thermal power plant was shut down for approximately 90 hours;
- In May 2018, the commissioning of an additional 35kW of photovoltaic installations (facilities at the ferry terminal and the fire station) made it possible to extend the operating life without the thermal groups: A total of 96 hours in May 2018, in particular the week of 21 May, with several days at around ten hours per day.

Note that photovoltaic capacity injected into the network may exceed the demanded capacity at times.

10.5.2. Objectives for the 2019-2023 and 2024-2029 periods

Demand management initiatives must be continued:

- Renovation of the infrastructure in place to reduce the electrical consumption of buildings and extensions for professionals. The goal is to reach a rate of ten applications processed per year;
- New campaigns for distribution of LEDs and replacement of energy-consuming appliances.

These efforts should reduce annual consumption by 300MWh from 2023.

The development of renewable energies must continue and shall focus on two priorities:

- Photovoltaic development: resources on community buildings are approaching saturation, so the installable capacity on individual houses shall undergo a quantitative and architectural acceptability study;
- The wind power output on the island is exceptional, with a load factor higher than 3000 hours / year measured via a mast installed on the island in 2015/2016. A 250kW project is currently being investigated by the State services.

These two initiatives should make it possible to reach 60% of renewable energy.

In terms of intermittency management and coordination of uses:

- The implementation of mobile off-peak hours modeled on the operating ranges of renewables. This coordination will encourage a shift in demand in order to minimise capping of renewable production;
- The management of the reverse osmosis unit by the coordination infrastructure of the system. This infrastructure will make it possible to operate the reverse osmosis system during periods of renewable power production;
- Combined with the use of flexibilities, the current energy sizing of the battery should be sufficient to absorb renewable power production by 2023, including wind power.

In the context of a 100% renewably powered island by 2030, coordination, flexibility and storage systems will be adapted and subject to analyses:

- Ongoing demand management initiatives;
- In a first analysis, the development of renewable power will mainly be based on photovoltaic and wind power. Depending on the success of the first wind installation, the 2023-2030 period will be an opportunity to boost wind capacity. Depending on the resources and the architectural feasibility of photovoltaics on previously studied single dwellings, an implementation phase will aim for 100% renewable power;
- The potential and feasibility of marine energies (wave, tidal, etc.) will be studied, with the aim of diversifying the means of production while controlling costs;
- Increase in battery storage capacity in order to integrate additional renewable power generation;
- Study of new flexibilities, particularly at the level of usage coordination, through Linky;
- Study of medium-term storage solutions (e.g. hydrogen) in order to move towards 100% renewable energy;

The objectives of the Sein MAEP for 2019-2023 and 2024-2028 are set as follows:

	2018	2023 (1)	2028 (1)
MDE		-0.3MWh	-0.5MWh
PV	139kW	150kW	250kW
Wind	7kW	250kW	500kW
Storage	200kW / 180kWh	200kW / 500kWh	200kW / 1MWh
Share of renewables in energy mix	10%	60%	75%

(1) Total installed capacity

10.6. Chausey

10.6.1. The situation in 2017

Chausey (0.65km²) refers to both the archipelago and the Grande Île (0.45km²), which is the only inhabited island (11 inhabitants year-round and 123 customers). In 2017, Chausey consumed nearly 500MWh. Power demand varies between 20 and 250kW and shows significant seasonal variability: only about ten people live on the island during the winter but there is a major influx of tourists during the summer holidays and high tide periods (approximately 200,000 visitors a year).

Two demand management initiatives were launched in 2017:

- An Energy Demand Control Agreement (MDE) signed in July 2017 between EDF SEI and Granville City Council provides for business incentives for MDE actions;
- In August 2017, EDF, the Channel Energy Union (SDEM) and Granville City Council carried out a joint operation with the inhabitants of the island for the supply of LEDs, efficient tap nozzles and shower heads, distribution of more than 400 LED bulbs and water economisers for 80% of homes.

The electricity mix is currently 100% thermal. No renewable facilities have been installed on the island. Studies of photovoltaic resources were conducted by the Channel Energy Union. The conclusions presented to the City Council at the end of June 2018 show a total potential exceeding current demand. This potential must now be analysed against environmental criteria.

No storage or coordination system has yet been put in place. The deployment of Linky meters began in 2016 and all active customers now have them installed.

10.6.2. Objectives for the 2019-2023 and 2024-2029 periods

The objective is to launch the transition today in order to approach a 100% renewable mix on the island by 2030.

Discussions are underway with the Ponant Islands Association and EDF SEI about the implementation of a residential programme aimed at providing financial assistance for thermal renovation works on buildings (replacement of windows, insulation, etc.). In addition, as part of the MDE agreement signed with Granville City Council in 2017, operating agreements such as renovation of public lighting, further distributions of LEDs, installation of heat pumps to heat permanently occupied premises or replacement of energy-intensive appliances are being studied. It is estimated that consumption will descend from 502MWh in 2017 to 450MWh in 2023 and 400MWh in 2028.

Several renewable energy sources are being considered for Chausey:

- Photovoltaic is the simplest source to implement with an estimated load factor of around 1100 hours / year;
- A small wind turbine would supply significant capacity due to weather conditions on the island. However, deployment possibilities on the island are very limited;
- Furthermore, studies must be conducted to assess the resources and the feasibility of other renewable energies, including marine (tidal, etc.).

The ongoing study into solar photovoltaics shows significant potential, which would enable the goal of 100% renewable energy in the energy mix to be achieved, with a linked storage system or systems. These facilities will have an impact on the environment, which will be described in studies and shared during the public inquiry (necessary for any installation of more than 3kW). These studies will also highlight positive externalities serving public interest (gradual cessation of generator groups, removal of pollution risks, food security, etc.).

In terms of intermittency management and coordination of uses:

- The implementation of differentiated off-peak hours, made possible with the deployment of Linky, will enable power demand to be limited and, simultaneously with the development of renewable energies, will enable off-peak hours, community uses (such as the water treatment system) to be harmonised with renewable production intervals.

- A storage system using batteries connected to a centralised coordination system will maximise the share of renewable energies in the energy mix;
- The battery system will be complemented by a hydrogen storage system. The usefulness of hydrogen storage must be evaluated. The solution would include an electrolyser, a hydrogen storage tank and a fuel cell. The capacities of the electrolyser and the fuel cell would be around 50kVA. The system would be installed centrally or in a permanently occupied building to supply certain homes autonomously and thus reduce the power demand on the network during the week, which is a period of fewer visits to the island. In both cases, this hydrogen system would be interfaced with the coordination system of the island's electrical system.

Photovoltaic production combined with a dual storage system by battery and hydrogen would allow load shedding for about 16 hours per day, thus limiting the operation of thermal groups.

In the context of a 100% renewably powered island by 2030, coordination, flexibility and storage systems will be adapted and subject to analyses:

- Ongoing demand management actions, in line with the achievements of the 2018-2023 period;
- Based on resources and the architectural feasibility of the disseminated development of photovoltaics, enhanced installed capacities will be put in place in order to approach 100% renewable energy;
- The conclusions of the study of resources will also determine the feasibility of a wind turbine;
- Studies of the feasibility of other renewable energies, particularly marine (tidal, wave, etc.) will be conducted.
- Increase in battery storage capacity in order to integrate additional renewable power generation;
- Study of new flexibilities, particularly at the level of usage coordination, through Linky;
- Study of medium-term storage solutions (e.g. hydrogen) in order to move towards 100% renewable energy;

The objectives of the Chausey MAEP for 2019-2023 and 2024-2028 are set as follows:

	2018	2023 (1)	2028 (1)
MDE		-0.05MWh	-0.1MWh
PV	0	250kW	400kW
Storage	0	200kW / 300kWh (2)	200kW / 300kWh (2)
Share of renewables in energy mix	0%	50%	65%

(1) Total installed capacity

(2) To which the hydrogen demonstrator, if any, would be added.

11

Monitoring indicators

11. MYEP monitoring indicators

The following indicators will be monitored each year. A report will be produced and presented to the National Council for Ecological Transition in September of year n+1 to report on year n. The indicators will be presented in a table showing changes in the indicator since 2015 and recalling the objectives set by the MYEP for the 2023 and 2028 timeframes.

	Indicator	Scope	Unit	Source	2015	2016	2017	2023	2028
	Control of energy demand and reduction of fossil energy consumption								
1	**End-use energy consumption excluding international bunkers**	Metropolitan France	TWh	SDES	1641	1629	1644	1543	1420
2	**Primary energy consumption excluding international bunkers**	Metropolitan France	TWh	SDES	2798	2865	2911	/	/
3	**Primary energy consumption of fossil fuels**	Metropolitan France	TWh	SDES	1382	1355	1412	1151	942
4	**Primary energy consumption of coal**	Mainland France	TWh	SDES	107	100	110	47	27
5	**Primary energy consumption of petroleum products**	Mainland France	TWh	SDES	845	810	843	699	565
6	**Primary energy consumption of natural gas**	Mainland France	TWh	SDES	430	445	459	406	349
	Promoting renewable energies								
7	**Renewable energy share in end-use energy consumption**	France	%	SDES	15.1	16	16.30%	25%	34 to 38%

Renewable and recovered heat and cold

	Indicator	Scope	Unit	Source	2015	2016	2017	2023	2028
8	**Renewable heat and cold production**	France	TWh	SDES	141	155	154	196	218 to 247
9	**Biomass**	Metropolitan France	TWh	SDES	106	117	114	145	157 to 169
10	**Heat pumps**	Metropolitan France	TWh	SDES	21	25	28	39	44 to 54
11	**Low and medium geothermal energy**	Metropolitan France	TWh	SDES	2	2	2	3	4 to 5
12	**Solar thermal energy**	Metropolitan France	TWh	SDES	1	1	1	2	2 to 3
13	**Amount of renewable and recovered heating and cooling delivered by heating and cooling networks**	France	TWh	SDES	10	11	ND	25	31 to 36

Renewable liquid fuels

14	**Share of advanced biofuels included in petrol**	Mainland France	%	TGAP (Pollution tax) Customs	0.3	0.3	0.3	1.8	3.8
15	**Share of advanced biofuels included in diesel**	Mainland France	%	TGAP (Pollution tax) Customs	0.35	0.35	0.35	0.85	3.2

Renewable gas

16	**Renewable gas share in end-use gas consumption**	Metropolitan France	%	SDES	0.5	0.6	0.7	2	9 to 13
17	**Biogas injected into networks**	Mainland France	TWh	SDES	0.07	0.19	0.37	6	14 to 22

Renewable electricity

18	**Share of renewable electricity in consumption**	France	%	SDES	18.8	19.3	20	35%	48 to 52%
19	**Share of renewable electricity in production**	France	%	SDES	15.9	17.5	11.06	27%	36%
20	**Hydroelectricity**	Mainland France	GW	SDES	25.5	25.5	25.6	25.7 to 25.9	26.4 to 26.7
21	**Land wind power**	Mainland France	GW	SDES	10.3	11.5	13.2	24.6	34.1 to 35.6
22	**Photovoltaics**	Mainland France	GW	SDES	6.6	7.2	8.1	20.6	35.6 to 44.5
23	**Electricity from wood**	Mainland France	MW	SDES	423	591	NA	800	800
24	**Electricity from methanisation**	Mainland France	MW	SDES	94	111	140	207	340 to 410
25	**Offshore wind**	Mainland France	MW	SDES	0	0	0	1500	2500 to 3000
26	**Marine energies (floating wind turbines, tidal turbines, etc.)**	Mainland France	MW	SDES	240	240	240		750
27	**Geothermal electricity**	Mainland France	MW	SDES	0	2	2	2	2

Security of supply

Electricity

	Indicator	Scope	Unit	Source	2015	2016	2017	2023	2028
28	**Electricity supply security**	Mainland France	Time	RTE	00:30	00:45 to 02:30		/	/
29	**Development of electric curtailment capacities 2018 and 2023**	Mainland France	GW	RTE	3.7	3.1		/	/
30	**Electricity interconnection rate**	France	%	RTE	13.5%	13.1%		/	/
31	**Share of power generation from nuclear**	France	%	SDES	75.9	71.7	71.6	67	59

Gas

32	**Gas supply security**	Mainland France	%	DGEC	107	102	101	/	/

Petrol

33	**Service stations**	Mainland France	Number	DGEC	10,765	10,478	10,377	/	/

Sustainable mobility

34	**Energy consumption by the transport sector**	Mainland France	TWh	SDES	509	509	Nd	/	/
35	**Share of renewable energy consumed by the transport sector**	France	%	SDES	8.2	8.6	9.1	/	/

	Indicator	Scope	Unit	Source	2015	2016	2017	2023	2028
36	**BioNGV consumption**	Mainland France	TWh	SDES	0.03	0.06		/	/
37	**Registrations of private electric vehicles**	Mainland France	Annual number	SDES	100,599	143,309	165,135	/	/
Energy poverty									
38	**Housing assisted by the ANAH due to energy poverty**	Mainland France	Number	ANAH	49,706	40,726	52.266	75,000	/
39	**Volume of operations benefitting from precariousness ESCs**	Mainland France	TWh	DGEC	/	174.3	/	/	/
40	**Households receiving energy cheques**	Mainland France	M	DGEC	/	0.17	0.17	4	4
Macroeconomic indicators									
41	**GHG emissions from energy production**	Metropolitan France	Mt CO_2eq	CITEPA	46.5	50	54.6	/	/
42	**Energy bill**	France	€Bn_{2017}	SDES	39.67	31.42	38.59	/	/
43	**Jobs in renewable energy and energy efficiency**	France	Number	ADEME	323,510	334,290	NA	/	/
44	**Annual charges for public electricity service (excluding equalisation)**	France	€M	CRE	/	4974.1		/	/

Some methodological details

Indicators 1 to 5: These report on energy consumption excluding non-energy uses.

Indicators 14 and 15: For the petrol and diesel sectors, the percentage of biofuels is equal to the ratio between the energy quantity of biofuels physically incorporated in the sector and total physical energy consumption of the sector. There is no double counting.

Indicator 16: This is the ratio of (injected biogas + biogas used to produce electricity + biogas used to provide heat) / (gas primary energy consumption).

The amounts of biomethane directly used in the vehicles are disregarded.

Indicators 20 to 27: The cumulative capacities in service.

Indicator 28: Annual expectation of disruption due to supply-demand imbalance for the following year.

Indicator 29: Tariff Curtailment Capacities + Curtailment Blocks Exchange Notification + Adjustment Mechanisms + Calls to Tender + Rapid and Complementary Reserves contracted for the Year.

Indicator 30: Export capacity as defined by RTE divided by total installed production capacity.

Indicator 32: Share of the natural gas storage capacity obligation covered by underground natural gas storage capacities of other modulation instruments.

Indicator 43: Sum of FTE jobs for renewable energy, FTE jobs in improved energy efficiency in buildings (Total of markets) and FTE jobs in energy efficiency in the transport sector.

Source: Markets and jobs related to energy efficiency and renewable energies, ADEME: direct or indirect jobs clearly identified.

Indicator 44: Expenditure amount allocated to support for renewable energies, cogeneration and expansion of curtailments over the calendar year.

Ministère de la Transition
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Hôtel de Roquelaure
246 boulevard Saint-Germain
75007 Paris

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