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French strategy for energy and climate

Multiannual energy programming (2025-2030, 2031-2035)

November 2024

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Warning: This document was translated by a machine translation tool and may therefore contain inaccuracies.

1. Introduction

WARNING

In this version of the document, the historical data referred to as "today" are the consolidated observed data for the year 2022 (available to date). This information will be updated with data for the year 2023 in a later version of EPP3, once this data is fully available.

A strategy to meet the Challenge of the Century: breaking our dependence on fossil fuels

France's choice, several decades ago, of electrical independence and nuclear power means that today we have a head start in terms of decarbonisation and the competitiveness of our electricity. Over 90% of our production is carbon-free, covering most of our national needs.

In addition to this historic choice, over the last fifteen years our country has made a major effort to develop renewable energies. Over the last ten years, our rate of deployment has been ten points higher than the European average. This development is set to extend to all energy carriers: biomethane, bioliquids, biomass, aerothermal energy, geothermal energy, renewable electricity, etc.

However, as in most major industrialised countries, our energy mix is still dominated by fossil fuels, with oil accounting for 37% and natural gas for 21% of our final energy consumption. For France, this creates a harmful dependency. Both for the climate, because of the consequences in terms of greenhouse gas emissions, but also in economic terms, by putting France and the French people at the mercy of geopolitical and market uncertainties.

France is currently facing a threefold challenge: sovereignty, competitiveness and accelerating the fight against climate change.

In terms of sovereignty, the invasion of Ukraine has shown just how vulnerable we are because of our dependence on imported fossil fuels that are subject to geopolitical uncertainties. The rise of protectionism is also leading to growing competition for control of technologies and supplies for the energy transition (United States, China), whether in terms of strategic raw materials or key components for low-carbon energy technologies. Regaining and building our independence therefore means limiting our dependence on these raw materials and components by multiplying sources of supply and deploying new industrial value chains in France and Europe.

In terms of competitiveness, it has to be said that our current energy mix is leading to a sharp deterioration in our trade deficit (between €25 and €80 billion a year in the 2010s and a fuel import bill of more than €100 billion by 2022), and that it is subjecting our country to the extreme volatility of international markets, due to exogenous events (geopolitical crises, meteorological events, etc.). On the contrary, thanks to the choice of nuclear power in the 1970s, France has benefited from abundant, competitively-priced electricity and has been able to maintain an electro-intensive industry. The challenge is therefore to gradually abandon an energy mix that is unfavourable to our economy. This presupposes preserving and amplifying the link between decarbonisation and the competitiveness of our economy over the long term, by integrating not only the nuclear component, but also renewable energies and flexibility, and by strengthening energy savings through efficiency and sobriety.

Finally, in the fight against climate change, our country, like the rest of the world, is facing a race against time. In the ecological battle, every minute lost adds to the human, economic, social and financial cost of the transition.

This acceleration will require efforts from everyone and transformations throughout our economy (transport, agriculture, industry, buildings and energy. In particular, energy efficiency, the decarbonisation of the energy sector, renewable and recovered heat and the electrification of uses are important levers for decarbonising the various sectors

This threefold political, economic and climate imperative justifies the government's commitment to making France the first major industrial country to move away from fossil fuels. This objective is consistent with the French and European goal of carbon neutrality by 2050.

Moving away from fossil fuels will require an unprecedented effort in our energy history, both in terms of reducing consumption and in terms of energy production. This effort comes at a time when the French energy system will have to be almost entirely renewed over the next thirty years, whether in terms of nuclear facilities, renewable energy capacity, networks or energy consumption flexibility mechanisms (such as load shedding or storage).

The transformation facing France is therefore enormous. The investments required by the energy transition are unprecedented since the first Industrial Revolution, a century and a half ago. And beyond the investment, it is our entire model of society and collective progress that will be turned upside down by the decisions that need to be taken today.

To achieve this, this Multiannual Energy Programme has been drawn up using a method that draws on the lessons learned from past energy programming exercises.

Firstly, the development of the new French energy strategy is based on in-depth dialogue with all stakeholders, through consultation and co-construction phases. It is also based on even more robust scientific and technical foundations, in particular the energy-climate scenario modelling work carried out by the government, but also the "Energy Futures 2050" report by RTE experts, commissioned by the President of the Republic in 2019 and updated last September[1] . In line with the ecological planning approach, the aim of this strategy is to offer long-term visibility, to propose concrete solutions to the French people that take into account their purchasing power and to make the transition an opportunity for the development of sectors and the corresponding jobs, while ensuring technological neutrality in public policy decisions and constantly monitoring the competitiveness of businesses.

France's new energy strategy is also the result of a long process of public participation and consultation, which began in 2021.

In this same spirit of consultation, the implementation of genuine regional planning for renewable energies, which gives local elected representatives a say, marks a break with the centralised management of our energy system to date. Since March 2023 and the enactment of the Renewable Energy Acceleration Act (APER), local authorities have been invited to define acceleration zones within which projects will be encouraged to locate. These zones must be defined in order to offer the potential to accelerate the production of renewable energy, to contribute to solidarity between regions and to securing the energy supply, and also to meet the objective of preventing and controlling the dangers or inconveniences that could result from the siting of renewable energy projects. This system gives operators visibility over the most favourable areas, but also improves the acceptability of projects, thereby speeding them up. In order to ensure that this new mechanism is truly representative of the territories' share of the national target, the Regional Energy Committees, which are the forum for stakeholder consultation at regional level, will be responsible for verifying the consistency between the sum of these acceleration zones and the regional energy production

1 Generation Adequacy Report 2023 Edition - Energy Futures 2050, RTE, September 2023

targets. This concern for decentralisation and public policies that are as close as possible to the regions is also reflected in the fact that the PPE will, for the first time, be rolled out at regional level.

This decision to accelerate and localise the transition is accompanied by a strengthening of the State's management resources to ensure that the French energy strategy is implemented effectively: creation of an interministerial delegation for the new nuclear power plant, mobilisation of the Prefects for the development and acceleration of renewable energies, increase in the number of decentralised staff dedicated to energy issues and a capital increase in the EDF group to give it full control and make it the armed wing of our low-carbon energy policy.

If France is to become the first major industrial country in the world to move away from its dependence on fossil fuels, we need to take resolute action to move away from a predominantly fossil fuel economy to one that is more sober, more efficient and supplied almost entirely by low-carbon energies produced and controlled on our own soil.

That's how this graph works:

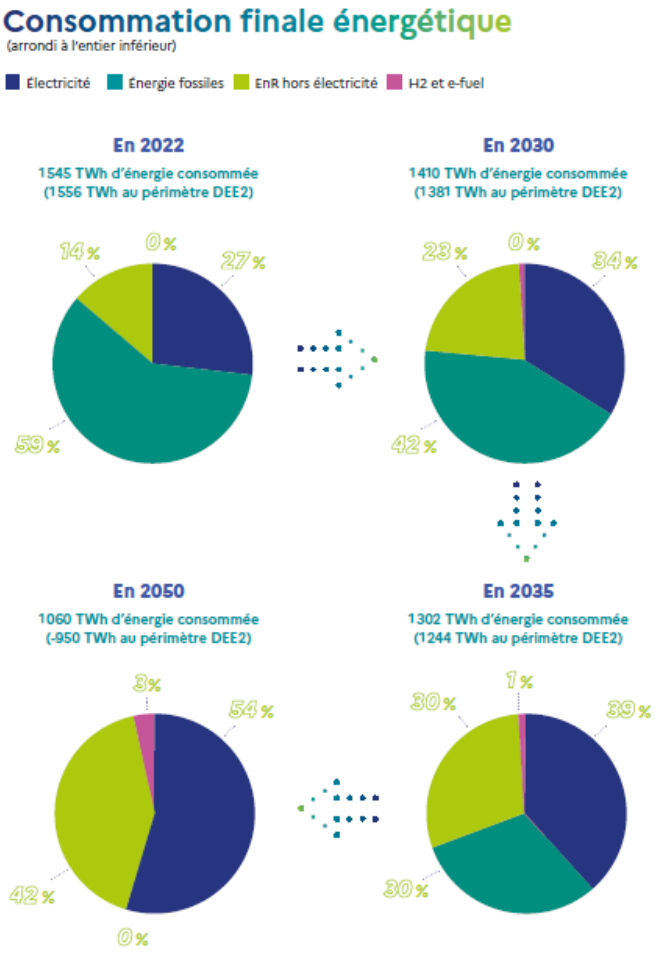


Figure1 Final energy consumption and projections to 2030, 2035 and 2050 (Kyoto scope, excluding international bunkers)[2]

This figure illustrates the transition to low-carbon energy consumption. It shows the final energy consumption projections to date. It should be noted, however, that the models are conservative. In fact, they indirectly incorporate all the public policy measures arising from Directive 2023/1791/EU on energy efficiency (DEE), the individual impact of which is difficult to estimate, and could in fact prove to be additional to other policies (particularly as regards the principle of giving priority to energy efficiency). However, to ensure that we meet our targets in this area (aiming for a -30% reduction by 2030 and a -50% reduction by 2050 in our final energy consumption compared with 2012 levels), it will be necessary to make an additional effort on the basis of additional measures to be consolidated over the coming months.

[2] NB 1: The figures in this figure, particularly for 2050, are based on provisional modelling. NB 2: Part of the final energy is consumed in the form of heat sold (mainly via heating networks). It has been decided here to break this down into its renewable and fossil fuel components. Electricity is almost completely decarbonised by 2030, 2035 and 2050

1.1. Multiannual energy planning

1.1.1. The nature of multiannual energy programming

The multi-annual energy programme (PPE) sets out the State's energy priorities for mainland France, excluding Corsica, over the next 10 years, divided into two 5-year periods. Every 5 years, the multi-annual energy programme is updated: the second 5-year period is revised and a subsequent 5-year period is added.

The EPP 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, and then by the law of 8 November 2019 on energy and climate. The PPE must contain sections on:

- security of supply ;
- improving energy efficiency and reducing primary energy consumption, particularly fossil fuels;
- developing the use of renewable and recovered energy sources;
- the balanced development of networks, energy storage and conversion, and energy demand management, in particular to encourage local energy production, the development of smart grids and self-generation;
- preserving the purchasing power of consumers and the competitiveness of energy prices;
- assessing the need for professional skills in the energy field and adapting training to these needs.

This multi-annual energy plan covers the two successive periods 2025-2030 and 2031-2035. The first period therefore covers 6 years, in order to ensure consistency with the objectives of the various regulations and the European objectives, most of which have 2030 as a central deadline

This multiannual energy plan is made up of :

- a decree defining the main energy objectives and priorities for action;
- this report, which is annexed to the decree;
- a summary of the orientations and actions of the EPP.

In accordance with the French Environment Code, the PPE has been subjected to an environmental assessment.

1.1.2. Legal scope of multiannual energy planning

Strategies and planning documents that include energy guidelines must be compatible with the guidelines set out in the multi-annual energy plan.

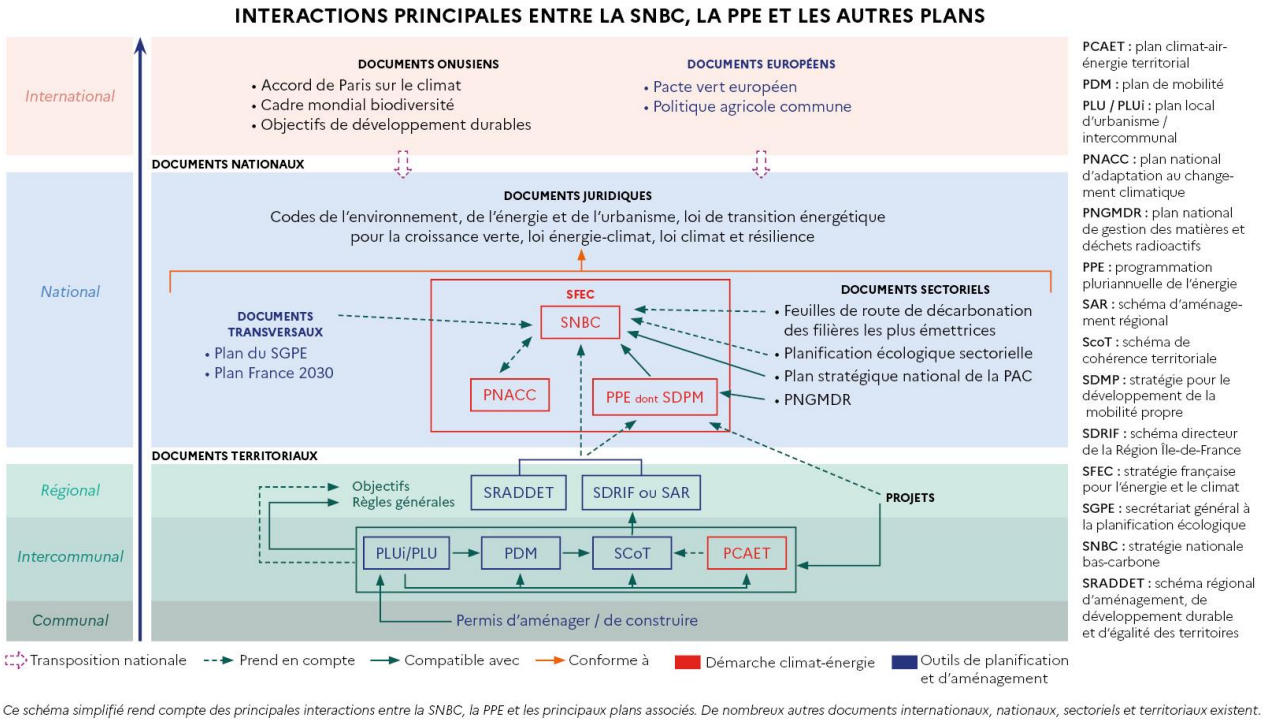
The normative scope of :

- setting quantitative targets for the launch of calls for tenders for electricity production facilities (particularly renewable energy), for capacity to reduce electricity consumption, or for investment to enable biomethane to be injected into gas networks;
- the definition of the guidelines with which the authorisation to operate new electricity generation facilities, as well as EDF's strategic plan provided for in article L311-5-7 of the Energy Code, must be compatible;

- defining the level of security of supply for the French energy system, by setting the failure criterion used to assess the balance between electricity supply and demand, or the criterion for the security of supply of natural gas and the storage facilities that must be kept in operation.

1.1.3. Linking multiannual energy programming with other planning documents

The multi-annual energy programme is linked to various national plans, programmes and strategies that provide an operational framework for its priorities for action. The figure below illustrates this relationship.



Ce schéma simplifié rend compte des principales interactions entre la SNBC, la PPE et les principaux plans associés. De nombreux autres documents internationaux, nationaux, sectoriels et territoriaux existent.

Figure2 Relationship between the EPP and other national planning documents

1.2. Process for drawing up the PPE

Scientific planning, based a comprehensive model of our energy future

The development of France's energy and climate strategy is based on **extensive prospective modelling work.** As part of this, the DGEC is building an energy and climate scenario aimed at describing a target trajectory for reducing greenhouse gas emissions until the targets set for 2030 and carbon neutrality in 2050 are reached.

This work is not a forecasting exercise, but a comprehensive and integrated planning exercise: the aim is for the State to propose, from among the various possible trajectories, a target scenario that meets the challenges expressed upstream, and that coordinates the various sectoral objectives by taking into account all the physical, social, economic and environmental constraints.

The modelling exercise is completed by a specific check to ensure that the results are consistent with each other ("looping"). For each time horizon, and for each of the energy vectors, it is necessary to check that the resources match the needs that emerge from the target scenario, to check its economic impact and acceptability, and to confirm the overall stability and robustness of the model, based on the work of the government and all the stakeholders (e.g. RTE's "Energy Futures 2050" study, etc.).

Some of the balancing points are particularly tricky, for example checking that electricity supply and demand are in balance, which involves fine-tuning the balance at every hour of the year on the basis of available resources and changes in electricity demand, or checking the biomass resource and its mobilisation, given the diversity of forms of biomass and their economic stakes, which are interwoven in an agricultural economy undergoing profound change (agricultural crisis and retirement of almost one farmer in two in 10 years).

The trajectories presented in this document are based on available projections to date and reflect the structural changes required between now and 2035 to achieve our objectives. However, these elements will continue to be re-evaluated and refined in the light of new knowledge about each of the levers to ensure that the long-term trajectory is in line with our objectives.

Work based on public debate and consultation with all stakeholders

The government has chosen to place public debate at the heart of the energy-climate planning exercise. Ecological planning sets general objectives, trajectories, levers for action and financial resources to support the players involved. The government's aim is to ensure that these objectives are implemented on the ground, through projects that are fair, realistic and desirable for all French people. In order to respond effectively to these challenges, identify the social impact of the proposed measures and provide solutions, the development of the French energy strategy is based on extensive consultation and dialogue with a wide range of stakeholders (business representatives, employee representatives, associations, local authorities, NGOs, citizens), which has been underway since October 2021.

In this context, **the State has** :

- **Involve all the stakeholders** (scientists, economic players, the State, local authorities, associations, etc.) through a dedicated committee and sector experts via workshops and working groups (WG) to discuss the initial hypotheses and levers to be mobilised;
- **Involve citizens** through consultation phases designed to gather their views on the country's climate and energy policy;
- **Supported economic players** in the sectors with the highest emissions in identifying the decarbonisation levers available to them and translating them into operational decarbonisation roadmaps (Article 301 of the French Climate and Resilience Act3 , roadmaps of the National Industry Council's strategic sector committees4 , roadmaps of the 50 industrial sites with the highest emissions, etc.).

In particular, the government has chosen to launch an unprecedented exercise in citizen dialogue on our energy future, with organisation of a consultation entitled "Our energy future is being decided now", from October 2022 to February 2023 under the aegis of the Commission Nationale du Débat

3 https://www.ecologie.gouv.fr/feuilles-route-decarbonation-des-filieres-plus-emettrices

4 https://www.conseil-national-industrie.gouv.fr/decouvrez-19-csf

Public (CNDP). As part of this consultation process, the opinions of a "Youth Forum" were gathered, an exercise unprecedented in Europe, with 200 young people drawn at random from all over the country, including the French overseas territories.

In addition, as part of the ecological planning desired by the President of the Republic and on the initiative of the Minister for Energy Transition, 7 working groups were set up in May 2023 to update our country's energy and climate strategy. These groups, led by members of parliament and local elected representatives and involving all the stakeholders concerned (professional federations, social partners, experts, environmental and consumer associations, etc.), were tasked with sharing the constraints that our country is going to face in the context of the various challenges that lie ahead, making a diagnosis and identifying courses of action. They submitted their conclusions in September 2023[5] . These proposals have fed into the preparation of the current multi-annual energy programme.

Work based on all energy vectors, from production to the end consumer

The PPE for the next ten years aims to decarbonise the French energy system in its entirety, at every link in the chain, from the production or import of energy, right through to the end consumer, by integrating the entire transport, distribution and storage chain. At the same time, it includes all energy carriers, whether electricity, heat, gas or solid or liquid fuels. It is only by embracing all our energy uses and all energy carriers that we can prepare to replace fossil fuels wherever they are found.

The overall reduction and decarbonisation of energy consumption, in particular through the electrification of energy uses, should make it possible to initiate an accelerated process of phasing out fossil fuels (see Figure 4 below) thanks to an increase in the production of low-carbon energies (see Figure 3 below). At the same time, it has to deal with major constraints, particularly in terms of the physical capacity of natural resources for biomass production and the associated environmental issues, as well as the challenges facing the electricity sector, with strong growth in electricity consumption, skills and industrial capacity that need to be adapted, and grid stability that must be guaranteed at all times.

This transition imposed on the energy system will require, for the electricity system in particular, the development of a range of decarbonised flexibilities (storage, load shedding, interconnections, decarbonised thermal energy, etc.) to encourage consumption to be shifted outside periods of tension. It will also be necessary to adapt oil and gas infrastructures.

[5] https://www.ecologie.gouv.fr/dossier-presse-travaux-preparation-strategie-francaise-energie-climat-restitution-des-groupes

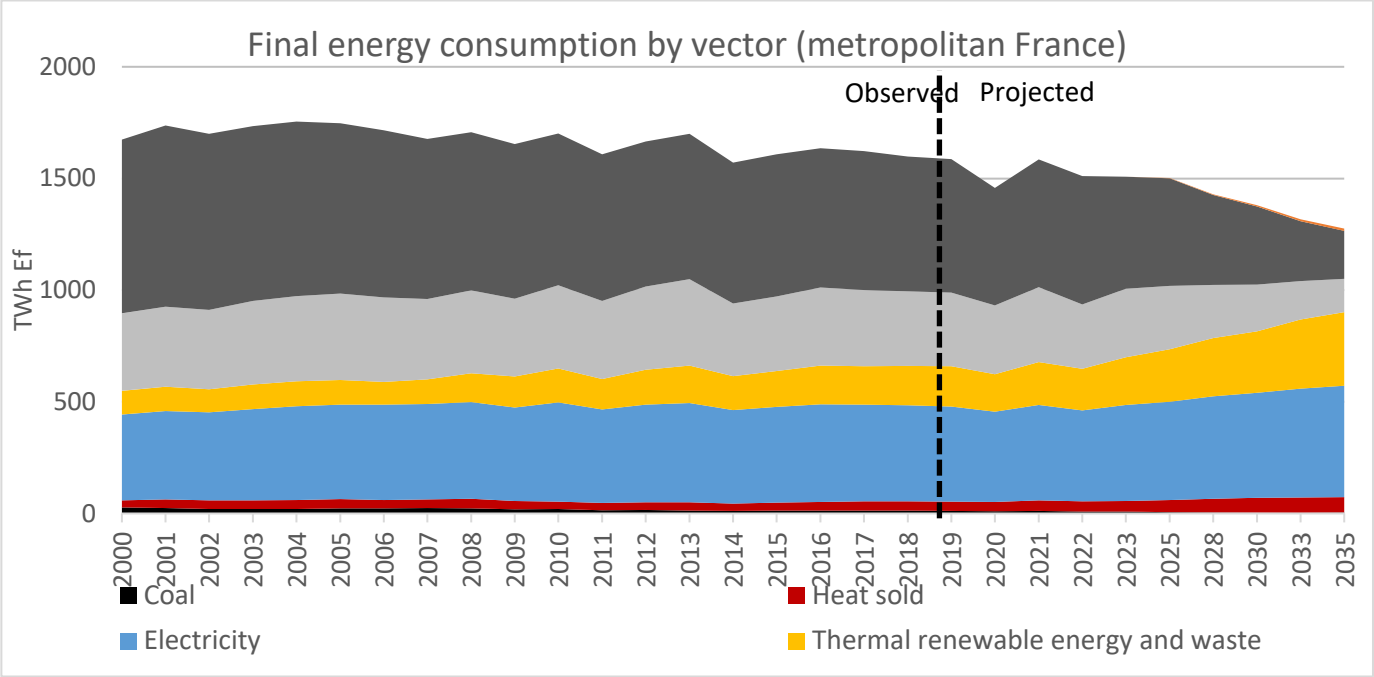


Figure3 Evolution of the actual energy mix (2000-2022) and projection of final energy consumption up to 2035 (SDES, May 2024; DGEC modelling, excluding international bunkers)

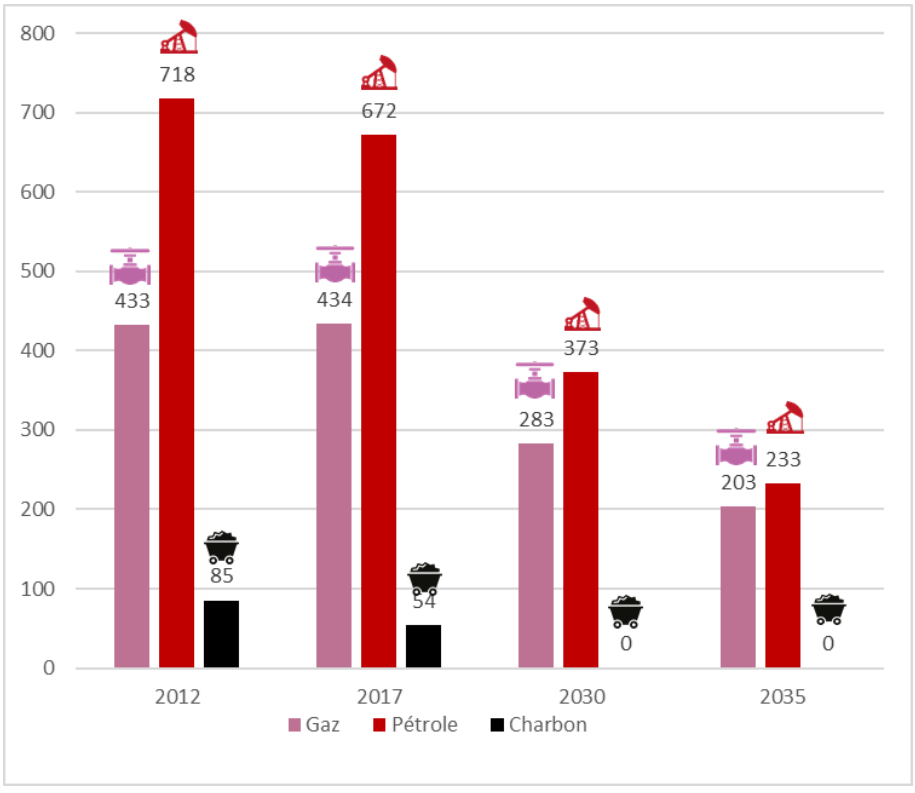


Figure4 Change in primary fossil fuel consumption for energy uses compared with 2012 (DGEC modelling, excluding non-energy uses)

1.3 Objectives to be achieved by the PPE

1.3.1. The international framework for combating climate change

Climate change requires countries around the world to work together. On this scale, the fight against climate change is guided by the United Nations Framework Convention on Climate Change (UNFCCC) adopted in 1992.

In 2015, world leaders agreed to ambitious targets in the fight against climate change: to **keep the rise in the global average temperature well below 2° C above pre-industrial levels and to continue action to limit the rise in temperatures to 1.5°** C. **This is the Paris Agreement**.

This agreement, drawn up under the French Presidency, **deals in a balanced way with the two facets of climate action**, namely mitigation - i.e. efforts to reduce greenhouse gas emissions - and the adaptation of societies to existing climate change.

Achieving these targets will require **immediate, rapid and far-reaching action to reduce GHG emissions** and **achieve global GHG neutrality**[6] (zero net emissions) **by around 2050**.

1.3.2. The European framework

The **regulation "establishing the framework for achieving climate neutrality", known as the "European Climate Act",** is the cornerstone of the European Union's climate ambitions. It enshrines in European law the principle of climate neutrality by 2050 and sets out intermediate milestones for reducing greenhouse gas emissions.

By 2030, the European Union has set itself (article 4 of the above-mentioned regulation) the objective of **reducing its greenhouse gas emissions by -55% net by 2030 compared with 1990** (compared with -40% gross previously included in the European Union's first nationally determined contribution (2015 NDC)).

A number of European laws and objectives have been revised to reflect these objectives, including :

- The revised European Effort Sharing Regulation (ESR)[7] , which aligns Member States' targets for reducing GHG emissions from the transport, buildings, agriculture and waste sectors with the new European target for 2030;
- The European regulation on land use, land-use change and forestry (LULUCF)[8] , which sets out the efforts that France will have to make in terms of forest management, strengthening long-lasting uses for wood from French forests, carbon storage in

6 Carbon neutrality or climate neutrality is understood as a balance between GHG emissions and GHG absorptions by ecosystems managed by human beings (forests, agricultural soils) and by technological processes (carbon capture and storage or reuse).

7 Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual reductions of greenhouse gas emissions by Member States from 2021 to 2030 contributing to climate action to meet their commitments under the Paris Agreement and amending Regulation (EU) No 525/2013

8 Regulation (EU) 2023/839 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/841 as regards scope, simplification of reporting and compliance rules, and setting of Member States' targets for 2030, and Regulation (EU) 2018/1999 as regards improved monitoring, reporting, progress monitoring and review.

agricultural land (e.g. preservation of meadows, hedges, etc.) and reducing the artificialization of land.

- Directive 2023/1791/EU on energy efficiency (DEE)[9] , which determines the efforts that France will have to make to reduce its energy consumption.
- Directive (EU) 2023/2413 on the promotion of energy from renewable sources, known as the "RED III Directive", which sets out the efforts that France will have to make in terms of renewable energy production.
- Directives (EU) 2023/95810 and (EU) 2023/95911 , which revise the EU Emissions Trading Scheme (EU ETS, the European carbon market) to make it more environmentally ambitious.

In addition, the European Union (EU) and France, individually, have committed to the Global Methane Pledge (GMP), an initiative launched at COP 26. The commitment made under the Global Methane Pledge is collective in nature, with GMP signatories pledging to work together to reduce global methane emissions by 30% between 2020 and 2030 . [12]

The guidelines set out in the EPP are part of this framework.

1.3.3. The national framework

France has developed a number of tools to guide its policy on combating the greenhouse effect and the energy transition. These are the National Low Carbon Strategy and the Multiannual Energy Programme. These two documents are closely linked**: while the purpose of the SNBC is to define the long-term mitigation roadmap for all sectors** (including energy production and conversion), the **PPE provides a precise description of the energy policy guidelines for the next ten years and, in particular, translates our ambitions in terms of reducing our consumption and developing low-carbon energy production methods and green industrial sectors,** with an operational aim for the State's action. The projection made by the SNBC up to 2050 is a possible trajectory for achieving France's objectives in terms of reducing greenhouse gas emissions.

The purpose of these documents is to define the collective transition path that will enable France to achieve its climate and energy objectives (see section 1.5).

9 Article 4 of Directive 2023/1791/EU on energy efficiency sets a European target for 2030 of a maximum final energy consumption of 763 Mtoe and a maximum primary energy consumption of 992.5 Mtoe. These targets aim to reduce energy consumption by at least 11. in 2030 compared with the projections in the EU's 2020 reference scenario.

10 Directive (EU) 2023/958 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC as regards the contribution of aviation to the emission reduction objective of all sectors of the economy of the Union and the appropriate implementation of a global market mechanism

11 Directive (EU) 2023/959 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 on the establishment and operation of a market stability reserve for the greenhouse gas emission allowance trading scheme of the Union

12 France reduced its methane emissions by 20% between 1990 and 2020.

1.3.4. Achieving carbon neutrality by 2050 and the challenges for the energy sector

In July 2017, France set itself the target of **becoming "carbon neutral" by 2050**[13] , in line with its commitment under the Paris Agreement. Achieving this target is a challenge that the reference scenario chosen by the French government for the SNBC 3 will have to meet.

Energy has a key role to play on the road to carbon neutrality, since by 2022 the share of greenhouse gas emissions due to energy use will represent 73% .[14]

The evolution of natural and technological sinks will be decisive in achieving carbon neutrality. However, the natural sink has fallen sharply in recent years as a result of a major forestry crisis, and there is a great deal of uncertainty as to how the sink will evolve as a function of the climate[15] . Against this backdrop, France's climate strategy could involve **a number of technologies for absorbing greenhouse gas emissions**[16] to achieve carbon neutrality, in support of sectors that have no other alternatives, but the development of these technologies will remain limited by 2050. In view of these factors, it is crucial to aim to mobilise all emitting sectors **to reduce residual as much as possible by 2050**

The EPP sets out guidelines for the period 2030-2035, with a view to initiating the structural changes needed to decarbonise the sector and achieve carbon neutrality by 2050.

In this timeframe, ecological planning must also ensure that it fully meets **the challenges of "closing the loop" in the scenario, including matching energy supply and demand over the long term.**

Generation of energy that does not emit greenhouse gases by 2050

By 2050, no energy should come from fossil fuels. This means that there will essentially be four sources of energy:

1. Renewable heat other than biomass: geothermal, solar thermal, heat pumps;
2. Biomass: wood and solid recovered fuels, biofuels, biogas. Given the constraints on the resource, it will be necessary to take into account the efficiency with which biomass is used and converted into the various vectors, as well as the capacity of the sectors to use these different vectors;
3. Recovered energy: using waste heat from industry and recovering energy in situ;
4. Non-carbon electricity produced by renewable energies (hydro, wind, photovoltaic, marine, geothermal, wood, biogas) or nuclear, which can also be used to produce hydrogen or decarbonised synthetic fuels.

13 This objective was then enshrined in the Energy Code (Article L. 100-4) by Law no. 2019-1147 of 8 November 2019 on energy and the climate.

14 Citepa, UNFCCC format, March 2024

15 In 2022, the LULUCF (Land Use, Land Use Change and Forestry) sector will absorb 18 Mt CO_2e (Citepa, Secten 2024). In the SNBC 2, sinks were estimated at 82 Mt CO_2e in 2050, including 67 Mt CO_2e stored by natural sinks (35 Mt $CO_{(2)}$e by forests, 21 Mt $CO_{(2)}$e by wood products and 11 Mt CO_2e by other land) and 15 Mt CO_2e by technological sinks.

16 technologies for the capture and storage of carbon of biogenic origin (bioenergy carbon capture and storage - BECCS), which come from energy production or the industrial sector and make it possible to capture biogenic emissions and then store them in deep geological layers or technologies for the direct capture of CO_2 from the air (Direct Air Capture - DAC), which make it possible to remove $CO_{(2)\ from}$ the atmosphere, which can then be stored in a geological layer.

Loop constraints

Some uses can be met by using several energy carriers. In other cases, the energy sources are not perfectly interchangeable, even if the possibilities for substitution are evolving over time: for a long time, oil was the only energy source to power cars, whereas today electricity can also be used. Some uses are still captive: only electricity can power electrical and electronic equipment.

Thus, the French Climate and Energy Strategy aims to have, at each time step, a decarbonised energy consumption that is less than or equal to the anticipated production, in order to ensure that the scenario "closes the loop". This involves estimating available production on the basis of a number of assumptions (particularly in the agricultural and forestry sectors for biomass), and comparing them with anticipated consumption in the various sectors. If the loop is not respected, we need to consider the reductions in consumption as well as the energy vector substitutions that can be made, and as a last resort, import capacities.

1.4. Summary of the second PPE

The PPE 2 is monitored periodically. The latest version of the monitoring indicators is available at the following link: https://www.economie.gouv.fr/actualites/publication-des-indicateurs-de-suivi-2022-de-la-programmation-pluriannuelle-de-lenergie

Reducing energy consumption

The 2nd multiannual energy programme (PPE 2) set a target for final energy consumption in mainland France (excluding international bunkers) of 1,528 TWh in 2023. In 2018 and 2022, this energy consumption amounted to 1,614 TWh and 1,559 TWh respectively[17] . Although the indicators for 2023 are not yet available, and given the increased level of ambition in terms of reducing energy consumption in the 3rd multi-annual energy programme (PPE 3), a major acceleration in the effort to achieve energy efficiency and sobriety will be necessary. The target set by the PPE 2 was to reduce primary consumption of petroleum products by 19% in 2023 compared with 2012. By 2022, the reduction will have reached 17.2%.

The fall in consumption has been driven by an active energy efficiency policy in the building, transport and industry sectors.

In the building sector, the creation of MaPrimeRenov' in January 2020 made energy renovation more accessible to those on the lowest incomes. Since then, 2 million homes have been renovated, including more than 210,000 comprehensive renovations, mobilising €8.6 billion in aid.

France Rénov', the public home renovation service, was launched on 1st January 2022 to make it easier to renovate homes for energy efficiency by providing more information and supporting households at every stage of their projects. More than 570 France Rénov' advice centres and 2,5500 advisors are now available throughout France, thanks to the efforts of the government and local authorities, which are helping to fund the scheme.

[17] Updating of EPP monitoring indicators (2022 indicators):
https://www.economie.gouv.fr/files/files/2024/2024_01_22_Publication_Indicateurs_Definitifs_PPE.pdf

In the field of transport, thanks to an active policy of support for the acquisition of clean vehicles through ecological bonuses and the conversion bonus, and tax penalties on the most emitting vehicles, the number of electric private vehicles (including rechargeable hybrids) has grown considerably. The number of electrified light vehicles (electric and plug-in hybrids) on the road will exceed 1,500,000 by the end of 2023. These vehicles now make up a quarter of the market, and 100% electric vehicles accounted for more than 19% of registrations in September 2023. Over this period, almost one million electric vehicle purchase bonuses and more than 450,000 conversion bonuses have been paid out since 2020.

At the same time, the French government has organised the development of an electric battery industry for vehicles as part of the joint Major European Interest Project dedicated to batteries, which has led to the emergence of 4 electric gigafactory projects in France. Greater attention has been paid to the resilience of the supply of critical raw materials for their production at European level (Critical Raw Materials Act), and strict criteria on the life-cycle carbon impact of batteries have been laid down as part of the battery regulation negotiated under the French Presidency of the EU and adopted by the European Union on 10 July 2023.

In line with this electrification of the vehicle fleet, the number of charging points has been rising sharply since 2020. With the strong support of the French government, some 1,310,000 charging points are currently open to the public, spread across the country. In addition, there are almost 21.7 million home and business charging points. This makes France one of the three best-equipped countries in Europe, along with the Netherlands and Germany, in terms of both the number and density of charging points.

As a central mechanism for public action on energy efficiency, the Energy Savings Certificates (EWCs) scheme has grown in importance throughout the period. The fourth period of the CEE scheme (2018-2021) was based on increased obligations (2,133 TWhc, including at least 533 TWhc for households in fuel poverty) compared with the third period, meaning that more energy-saving actions will have to be financed by obligated players. The scope of the scheme has been extended to the industrial sector and to installations subject to the European Union Emissions Trading Scheme. The targets for the fifth period (2022-2025) have been strengthened compared with the fourth period (obligation increased to 3,100 TWhc over 4 years, including 1,130 TWhc for households in fuel poverty). In addition, this fifth period provides for greater efficiency in the system.

As part of a drive to reduce energy consumption and promote less energy-intensive modes of consumption, France has also resolutely supported European policy on the eco-design and energy labelling of energy-related products throughout the period. It is scrupulously monitoring the implementation of successive work programmes, and is currently working on the 2022-2024 programme. The 2022-2024 work programme includes 38 reviews of existing measures, which will save an additional 170 TWh per year across Europe. Priorities include the revision of provisions concerning heating and cooling appliances and the development of energy labels.

In industry, the government's decarbonisation policy is based on decarbonisation roadmaps for the highest-emission sectors (metallurgy, heavy chemicals, cement) and has been supported by the France Relance plan, which has helped over 200 industrial sites to reduce their CO_2 emissions by around 4 million tonnes a year. In addition, support for deep decarbonisation is being rolled out as part of the France Relance plan and the national strategy for the development of low-carbon hydrogen, with almost €9 billion in public support.

More recently, on 6 October 2022, the French government presented its first energy efficiency plan, based on work carried out in ten sectors of activity and involving more than 300 federations. The aim of the plan was to reduce energy consumption by 10% compared with the end of 2019.

This mobilisation has produced unprecedented results. Over a twelve-month period (1 August 2022 to 31 July 2023), France reduced its combined electricity and gas consumption by 12% - after adjusting for weather effects and for all types of consumer, including those less exposed to the volatility of energy prices. This reduction in consumption, which has had no impact on growth, has enabled France to reduce its greenhouse gas emissions by 8.5% in the last quarter of 2022 and by 4.3% in the first half of 2023.

Developing renewable energies

The share of renewable energies in final energy consumption has increased by 3.1 TWh compared with 2022, reaching a total of 193.4 TWh, putting us on a par with our European partners of a similar size, particularly Germany (20.4%). This reflects the success of the government's efforts to accelerate the deployment of renewable energies.

The EPP targets for onshore wind power and photovoltaics have not been met. In the case of photovoltaic solar power, 1,373 MW of new capacity was connected in the first half of 2023, compared with 1,093 MW in the first half of 2022. Solar photovoltaic capacity reached 17.5 GW in mainland France (18 GW for the whole of France) at the end of the first half of 2023, compared with the 18.9 GW forecast in the EPP. For onshore wind power, as at 30 June 2023, the total installed capacity in mainland France was 22.5 GW, including 21.6 GW of onshore wind power, slightly below the 23.2 GW target set in the EPP. **The main reason for this is the long lead times involved in appraising applications** (often compounded by disputes over the authorisation granted). In the case of onshore wind power, there are numerous difficulties, including aeronautical and military constraints that restrict the development of projects, and sometimes difficulties with local acceptability. For photovoltaics, the current regulatory and legislative framework is increasingly restricting the development of ground-based projects, which may also explain the difficulties in achieving targets. Numerous measures have been put in place and are currently being rolled out to achieve the objectives of EPP3.

The first step in the above-mentioned efforts is to simplify the administrative procedures for setting up new renewable electricity generation facilities: Law no. 2023-175 of 10 March 2023 on accelerating the production of renewable energy (APER) provides for various measures to accelerate the development of renewable energy, and its implementing regulations have been in force since 10 March 2023. It defines agrivoltaics and provides a framework for its development. At the same time, it provides a framework for the development of ground-mounted photovoltaic systems in natural, agricultural and forestry areas, and strengthens the solarisation obligations for car parks and buildings previously introduced by the Climate & Resilience Act. Finally, in line with European legislation, it recognises that renewable energy projects must meet an imperative requirement of overriding public interest, which will make it possible to secure exemptions for protected species granted to project developers. This effort is also being made at local level, through the mobilisation of all the parties involved, both the decentralised government departments responsible for supporting and examining projects and the local authorities involved in the local planning of acceleration zones and the regionalisation of renewable energy objectives, as provided for in article 15 of the APER law.

Several recent reforms have accelerated the development of offshore wind power, although the 2023 target has not yet been reached. The 2020 law on the acceleration and simplification of public action (ASAP) has made it possible to:

- To bring forward the administrative phases of pre-selecting candidates for offshore wind power tenders, in parallel with the public debates. This will speed up the competitive tendering process by several months without reducing the level of public participation;
- To pool public debates on offshore wind projects within the same coastline. This will improve planning for offshore wind farms, while giving the public greater visibility;
- To give the Conseil d'Etat jurisdiction to rule in the first and last instance on appeals against offshore wind farm projects. This provision will shorten the time required for appeals by at least two years.

The APER Act of 2023 made it possible to :

- To pool the public debates on offshore wind energy and those on the revision of strategic coastal documents, with a view to more integrated planning;
- Anticipate offshore connections independently of the tendering process.

Finally, the APER law and decrees 2023-1419 of 29 December 2023 and 2023-1209 of 19 December 2023 have clarified and simplified the authorisation regime for offshore wind projects, particularly in the exclusive economic zone (EEZ).

So, while the target of 2.4 GW of installed capacity by 2023 set by the EPP has not been reached due to long periods of authorisation, appeals and delays in work on the projects in the first two offshore wind tenders, the aforementioned reforms should make it possible to speed up the development of future wind farms. It should also be noted that the French government has launched all the offshore wind tenders provided for in the current EPP (AO3 to 9), representing more than 7.5 GW, and that the current planning work should make it possible to identify areas for the allocation of a further 15.5 GW over the next 10 years, with a view to achieving 45 GW in service by 2050.

At present, 3 projects totalling 1.5 GW have been commissioned: the 480 MW St Nazaire wind farm was commissioned in 2022, and the Fécamp and Saint Brieuc wind farms in May 2024. In 2025, the Courseulles-sur-Mer and Yeu-Noirmoutier projects will also be commissioned. Finally, the Dieppe-Le Tréport project will be commissioned in 2026.

In the case of **renewable heat**, the target for production by heat pumps by 2023 has been met and even exceeded (+27% compared with the production target), but not those for biomass (77% of the target achieved), solar thermal (89% of the target achieved) and deliveries of renewable and recovered heat and heat networks (67% of the target achieved).

Despite a budget for the Heat Fund that has been increased since 2018, the context of tax incentives has not made it possible to differentiate sufficiently between low-carbon energies and fossil fuels for heat production, making it difficult to drive sufficient momentum to achieve the objectives of the EPP in this area. As a result, at the start of the period, the rate of development of heating was almost half that forecast in the EPP. The Fonds Chaleur budget for 2022 has been increased to €520 million in order to tackle the energy crisis and, in particular, to speed up the deployment of heating

networks, the main vector for renewable heat. It has been further increased to €595 million in 2023 to cope with the significant increase in new district heating network projects.

As part of the stimulus plan, the government has also introduced ambitious and proactive support for decarbonisation of industry, available from 2020 and continued in 2021 and 2022 for a total of €1.2 billion over the period 2020-2022. A very strong momentum on renewable heat projects was observed in 2022.

As far as **biomass** is concerned, the context of EPP3 has changed since EPP2. Wood-energy and biomass resources in general have become limiting factors, which is why the objectives of the new EPP have been revised downwards. In addition, the development of wood energy will be subject to compliance with the prioritisation of uses on the one hand and the principle of cascade use of the RED III directive on the other.

As for **solar thermal energy**, the previous EPP foresaw a revival of the sector through the development of large-scale installations in industry and on heating networks, and outlined growth prospects for individual and collective housing. The years 2021 and 2022 were marked in mainland France by a recovery in the solar thermal market and the development of GISTs with glazed collectors, supported by a dedicated call for projects under ADEME's Heat Fund. This momentum is set to accelerate sharply over the next few years, with a view to achieving 6 TWh of solar thermal heat consumption by 2030 and 10 TWh by 2035. Meeting this challenge - by multiplying by 4 the number of collectors installed in the individual and collective sectors and reaching 1 million m^2 of collectors installed per year under GIST - will require a sustained effort in terms of industrial capacity, installation and operation, not forgetting the regulatory and financial aspects.

Deliveries of renewable and recovered heat, linked to the development of heating networks, have continued to increase steadily, but at a rate that is insufficient to meet the objectives of the EPP2. In fact, despite the advantage of a more stable and predictable price for the heat delivered over the long term, district heating networks were hit hard by competition from gas prices for several years, before the energy crisis created a great deal of enthusiasm for new projects. However, these projects must be allowed to get off the ground if they are to have a full impact, and this is subject to the condition that public support is not eroded, which could jeopardise this momentum.

With regard to hydroelectricity, the second EPP aimed to increase installed hydroelectric capacity in mainland France by around 200 MW by 2023 (i.e. 25.7 GW), and by 900 MW to 1,200 MW by 2028 (i.e. from 26.4 to 26.7 GW). **Targets The EPP2 target of 25.7 GW of installed hydropower capacity was reached in 2023**. A number of measures have been taken since the adoption of EPP 2 to support the development of the sector and increase installed capacity, taking into account all the issues at stake, particularly the environmental ones.

This includes economic support for facilities authorised on the basis of **a tariff decree** (the State provides support for electricity production based on the characteristics of the facility and the investment required) or via **a call for tenders**. A tariff order supporting the development and renovation of hydroelectric facilities of less than 1 MW was issued in 2016. This aid scheme, known as H16, is open until 2026 and has supported 65 MW. In addition, 3 calls for tenders spread over 7 periods have been implemented since 2016, resulting in the competitive selection of 64 winners representing around 150 MW for facilities of less than 4.5 MW.

For hydroelectric concessions, in addition to the work carried out spontaneously by the concessionaires under their concession contract or which may have been the subject of specific riders, the Energy and Climate Law of 8 November 2019 opened up the possibility of carrying out power increases by declaration, under certain conditions. This possibility, specified in the law on accelerating the production of renewable energies of 10 March 2023, meant that by [1]September 2024, almost **60 MW of power increases** could be approved under hydroelectric concessions.

More specifically, **the Compagnie Nationale du Rhône concession was extended** by the law of 28 February 2022 on the development of the Rhône until 2041. This extension made it possible to include five-year investment plans and an additional works programme in the specifications appended to the law. The five-year investment plans include a section on developing the production of hydroelectric power or other sources of energy, and will be used to build a new 8 MW small hydroelectric scheme and to carry out a study of the residual hydroelectric potential on the Rhône as a whole. The additional works programme includes increasing the capacity of the Montélimar power station and building 6 small hydroelectric power stations coupled with fish passes.

A number of complementary measures have also been studied, such as support for the renovation of facilities with a capacity of between 1 and 4.5 MW.

The objectives relating to the development of hydroelectricity also include targets for the **deployment of pumped-storage energy transfer stations (STEP**), which are facilities that allow electricity to be stored by pumping/turbining between two lakes at different altitudes. The PPE 2 set the objective of initiating steps to develop STEP **with a potential of 1.5 GW**, with a view to commissioning the facilities between 2030 and 2035. With this in mind, a public consultation was launched in the spring of 2023 to determine the economic framework conducive to the development of WWTPs and the possible need for public support. This work is continuing, and could be implemented during the award procedure for the new concession for the Lacs Blanc et Noir WWTP in the Haut-Rhin region, for which an award procedure is being prepared. In addition, in January 2024, an amendment to the Saut-Mortier concession approved the new project for a STEP with a pumping capacity of 18 MW, making it possible to develop the energy flexibility of the Ain hydroelectric chain (450 MW) and better reconcile the uses of water resources.

However, the legal uncertainty surrounding the renewal of hydroelectric concessions and the ongoing discussions with the European Commission mean that there is some uncertainty as to whether the objectives for the hydroelectric sector for 2028 and 2035 **will be met**, whether in terms of increasing hydroelectric capacity or developing WWTPs. Indeed, in the absence of concession renewals, the largest investments in modernisation, power increases or development of pumping capacity between two existing lakes cannot be made. In the short and medium term, the resolution of the pre-litigation issues surrounding the renewal of hydroelectric concessions is therefore essential if hydroelectric objectives are to be achieved.

Since 2022, the production of biomethane injected into gas networks has exceeded the target of 6 TWh set by the PPE 2 for 2023, with an injected volume of 7.0 TWh in 2022 and 9.1 TWh in 2023, compared with 0.7 TWh in 2018. At the same time, the national fleet of biomethane production facilities has expanded rapidly, rising from 76 units at the end of 2018 to 652 units at the end of 2023.

This strong development of the biomethane sector has been largely supported by the regulated feed-in tariff system, which has operated as an open window since it was introduced in 2011. However, despite the increasing maturity of the industry, the expected fall in production costs has

not been observed, which led the government to organise a consultation with the industry at the end of 2010 on a review of the tariff framework and to obtain commitments from the main players to optimise the costs of methanisation. The announcement in 2019 of a new, less attractive tariff decree, incorporating in particular an automatic degression coefficient for the tariff, and henceforth reserved for small-scale facilities producing less than 25 GWh per year, led to a rush of feed-in tariff contracts being signed before the decree was published on 23 November 2020. The commissioning of the new facilities benefiting from these contracts, which generally took place 2 years after the contracts were signed, meant that by 2022 the 2023 target for biomethane production set out in the PPE 2 had already been exceeded.

However, momentum for new projects slowed sharply after 2020, and given the need to revive the sector, which has also been facing significant inflation since the end of 2021, it was decided to increase the feed-in tariff in 2023. The latest tariff decree of 10 June 2023 made the tariff more attractive by introducing indexation to the cost of electricity supply - which rose sharply as a result of the energy crisis in 2022 - and by retroactively cancelling the effects of the automatic degressivity introduced at the end of 2020.

In addition, since facilities generating more than 25 GWh per year have no longer been eligible for the regulated tariff since 2020, a new budgetary system of purchase obligation following a call for tenders was introduced to support the development of large-capacity facilities, with the launch of an initial call for tenders at the end of 2022. However, this tender had to be suspended due to the risk that it would not be successful, and was relaunched at the end of 2023 following an increase in the ceiling tariff. The first bid submission period took place in February 2024.

Overall, the government's support for biomethane injection means that the industry is now on a trajectory that is compatible with achieving the PPE 2's top target for 2028, set at 22 TWh. In budgetary terms, however, the faster-than-expected development of the industry, at a higher-than-expected average production cost, means that the government's commitment under the feed-in tariff for the period 2019-2028 needs to be significantly increased, from €9.7 billion to €17 billion.

At the same time, the 2021 "climate and resilience" law introduced the biogas production certificate (CPB) scheme, the application details of which have been set out in two decrees and an order. This extra-budgetary scheme, which can be likened to a market mechanism, will be a major growth driver for biomethane production from 2026 onwards. It requires natural gas suppliers to return a quantity of certificates to the government each year, based on an overall trajectory for the incorporation of biomethane and the volume of gas delivered to their customers in the sectors subject to the scheme, i.e. the residential and tertiary sectors. Suppliers will be able to fulfil their obligation to return CPBs by producing biomethane themselves or by acquiring these certificates from third-party producers.

The creation of this system, which will automatically pass on part of the extra cost of producing biomethane injected into gas networks to end consumers, is designed to meet the ambitious targets set out in the EPP for 2030, while limiting the impact of support for the biomethane sector on public finances.

The targets for **advanced biofuels** set out in the PPE 2, i.e. 1.2% in petrol and 0.4% in diesel, have been achieved and are part of a trajectory for the use of renewable energy in line with European regulations to aim for 15% renewable energy in the road and rail sectors by 2030. The methodology is currently being revised to aim for a 14.5% reduction in the carbon intensity of energy used by

transport as a whole by 2030, giving preference to alternative fuels with greater potential for reducing emissions.

In 2022 and 2023, after more than 15 years of public support for the emergence of renewable energies, most of these have become competitive in France. They generated €6.5 billion in additional net revenue, including €6.2 billion for onshore wind power in 2022 and 2023.

Nuclear power development

While acknowledging the key role of nuclear energy in the French energy mix and its decarbonisation, the EPP2 opened up a number of options as to the place of nuclear energy in our country.

The "Energy Futures 2050" work entrusted to RTE has confirmed the merits of electricity mix options based on the massive development of renewable energies, the continued operation of existing nuclear power plants as far as is technically and economically possible - without considering further closures - and the launch of a new nuclear power programme.

It was in this spirit that the President of the French Republic, in his Belfort speech, set out the political guidelines for making this choice for the country: following the public debate and the work carried out by the working groups, the present Strategy is intended to ratify this choice. The objectives of the PPE 2 are therefore no longer relevant.

In terms of phasing out fossil fuels

The aim of the EPP was to move away from fossil fuels, and its targets for reducing primary fossil fuel energy consumption by 2023 have been met. In fact, between 2015 and 2023, primary energy consumption of fossil fuels fell by 17%, from 1,208 TWh to 1,006 TWh in 2023, according to the forecasts, making it possible to achieve the EPP target of 1,005 TWh.

Firstly, as mentioned above, the overall reduction in energy consumption contributes to the objectives of reducing fossil fuel consumption.

In addition, in housing and transport, the efforts to convert the road vehicle fleet through conversion bonuses and incentives, and the efforts to renovate energy and transform heat production methods, confirmed in the revision of the energy regulations for new buildings (RE2020), have started to reduce consumption and paved the way for this strategy, making it possible to scale up the phase-out of fossil fuels in the main everyday uses of French people's lives. A detailed analysis of the measures that have reduced fossil fuel consumption in the transport sector is provided in Appendix 2 of the SDMP

In terms of production, this EPP confirms the closure of power plants that run exclusively on coal, with the aim of phasing out the use of coal for energy purposes by 2027. These plants will require support for employees and local communities: the government has ensured that vocational training measures for the employees concerned have already been put in place.

1.5. The trajectory structuring the EPP

The scenario taken into account in this EPP is structured so that the evolution of the various parameters making up the EPP, from energy production to energy consumption, makes it possible to achieve the objectives set at European level, to successfully move away from fossil fuels, and to have sufficient decarbonised energy to meet our needs.

The measures detailed explicitly in this document will have to be supplemented by additional measures to achieve all the objectives by 2030.

CENTRAL SCENARIO

	2022	2030	2035
OUTPU FOSSILS	60% OF FINAL FOSSIL FUEL ENERGY CONSUMED	42% OF FINAL FOSSIL FUEL ENERGY CONSUMED	29% OF FINAL FOSSIL FUEL ENERGY CONSUMED
CARBON-FREE ELECTRICITY GENERATION	390 TWh	At least 560 TWh	At least 640 TWh
RELANCE NUCLEAR ENERGY	56 reactors 279 TWh	57 reactors in service 360 TWh *(400 TWh "managerial ambition" of EDF)*	
PHOTOVOLTAIC	16 GW 19 TWh	54-60 GW *~65 TWh*	75-100 GW *~93 TWh*
ONSHORE WIND	21 GW 38 TWh	33-35 GW *~64 TWh*	40-45 GW *~80 TWh*
OFFSHORE WIND ENERGY	0.6 GW 1 TWh	4 GW *~14 TWh*	18 GW *~70 TWh*
HYDRO-ELECTRICITY	26 GW (with STEP)	26 GW (with STEP) *~54 TWh (excluding STEP)*	29 GW (with STEP) *~54TWh (excluding STEP)*

	43 TWh[18] (excluding STEP)		
RENEWABLE AND RECOVERED HEAT AND COOLING	172 TWh heat 1 TWh cooling delivered by networks	276-326 TWh heat 2 TWh cooling delivered by networks	330-419 TWh 2.5 - 3 TWh cooling delivered by networks
BIOGA	17.7 including 7 TWh injected into natural gas networks	50 including 44 TWh injected into natural gas networks (i.e. around 15% of biogas injected into gas networks)	50-85 TWh
BIOFUELS	38.5 TWh	Between 50 and 55 TWh	Between 70 and 90 TWh
HYDROGEN (*installed electrolysis capacity*)	0 GW	Up to 6.5 GW *(9-19 TWh$_{(bcf)}$)*	Up to 10 GW *(16-40TWh$_{(bhp}$*
FINAL ENERGY CONSUMPTION	1556 TWh	1243 TWh	APPROXIMATELY 1100 TWh

[18] This value is not representative given the exceptionally hot and dry conditions in 2022, which was the lowest year for hydroelectric generation since 1976. By way of illustration, the values for 2021 and 2023 were between 54 and 59 TWh.

•2. Improving energy efficiency and reducing fossil fuel consumption

This section presents trends in energy consumption in France and analyses the determinants of consumption trends in order to identify the public policy levers available to the State to reduce consumption.

The projections for consumption in 2030 and 2035 are based on a scenario that incorporates the public policy measures described in this section, within the limits of the modelling capacity available.

Macro-economic assumptions

A scenario has been drawn up based on the macroeconomic parameters considered most likely to evolve.

Population

The population change framework used is the INSEE central demographic change scenario updated in 2021. This scenario is preferred to the Eurostat scenario proposed by the Commission because it reflects more accurately the recent demographic trends observed in France.

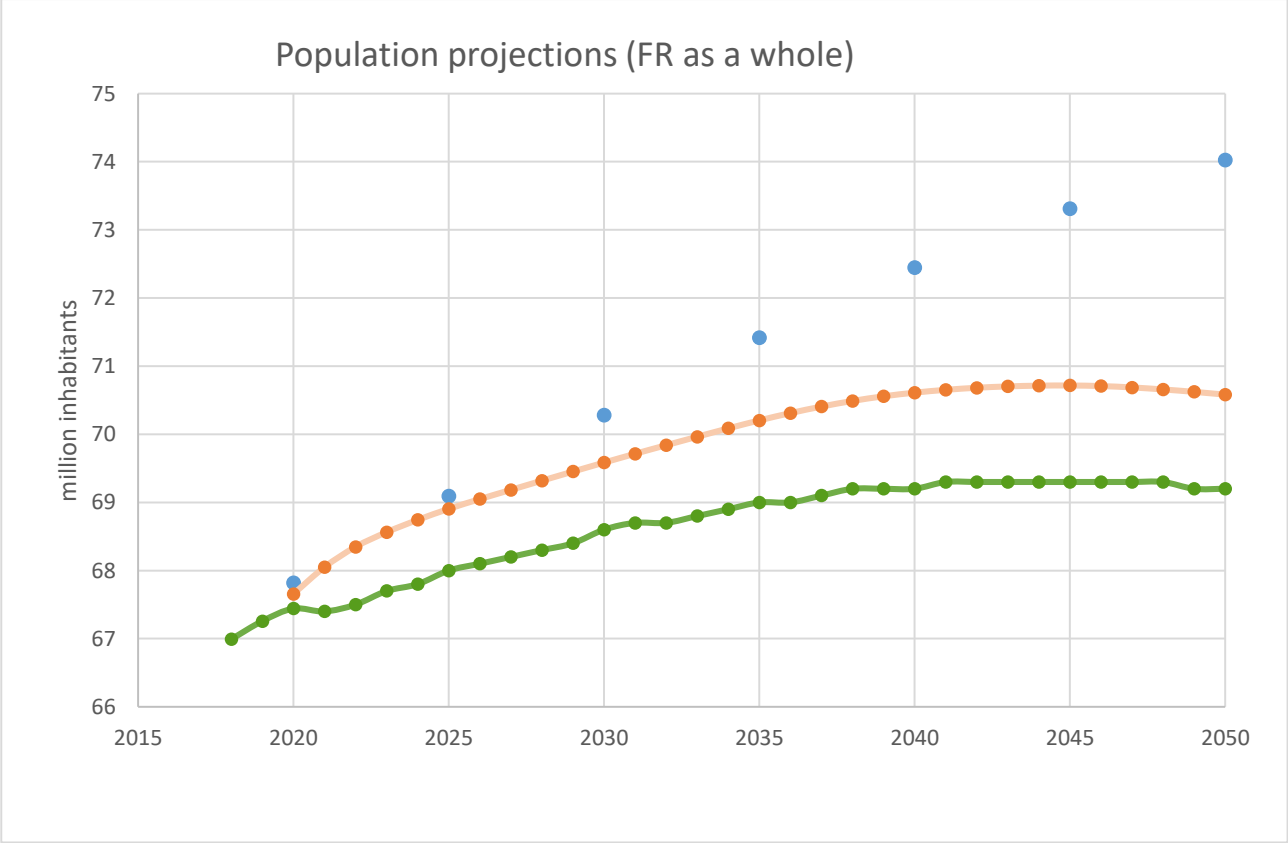


Figure5 . Population trends in the different scenarios (hexagon + DROM). Blue: EPP 2; Orange: European Commission; Green: INSEE central scenario, used for EPP 3.

Energy prices

The price framework for imported energy is that of the European Commission, which applies to all the Member States' reports.

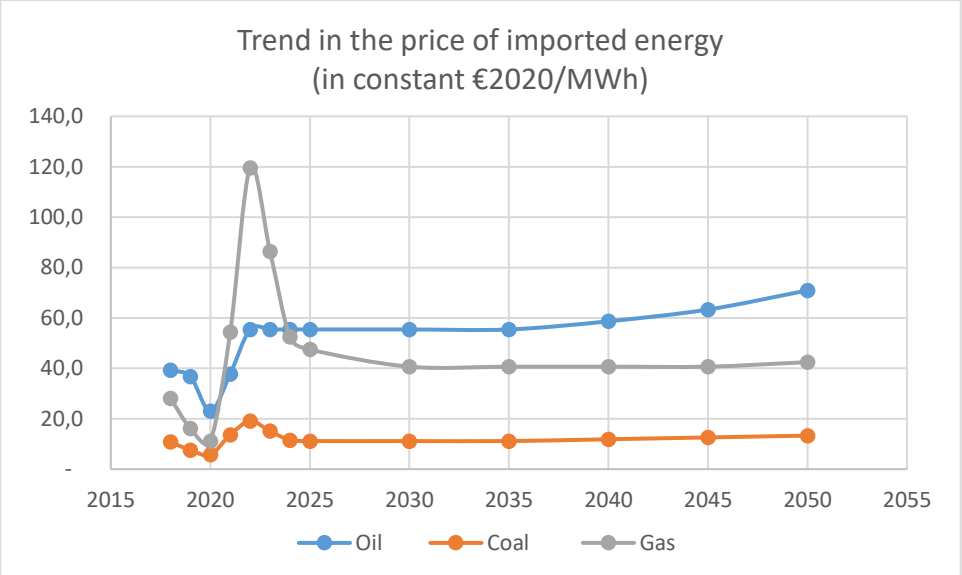


Figure6 . Evolution of imported energy prices - European Commission scenario for the March 2023 scenarios

Energy prices are projected taking into account these imported energy prices as well as network and distribution costs.

Taxation

In projection, the energy excise duties for oil and gas are those in force on 1st January 2024.

The tax rate taken into account is the standard statutory rate.

Economic growth

The GDP growth assumptions are based on the framework provided by the European Commission (framework assumptions provided by the European Commission to all Member States each year to ensure consistency and comparability of national scenarios). As the population assumption has not been included in the Commission's framework, the figures have been adjusted so as to maintain identical GDP/capita growth, and to include the population growth of the INSEE 2021 scenario.

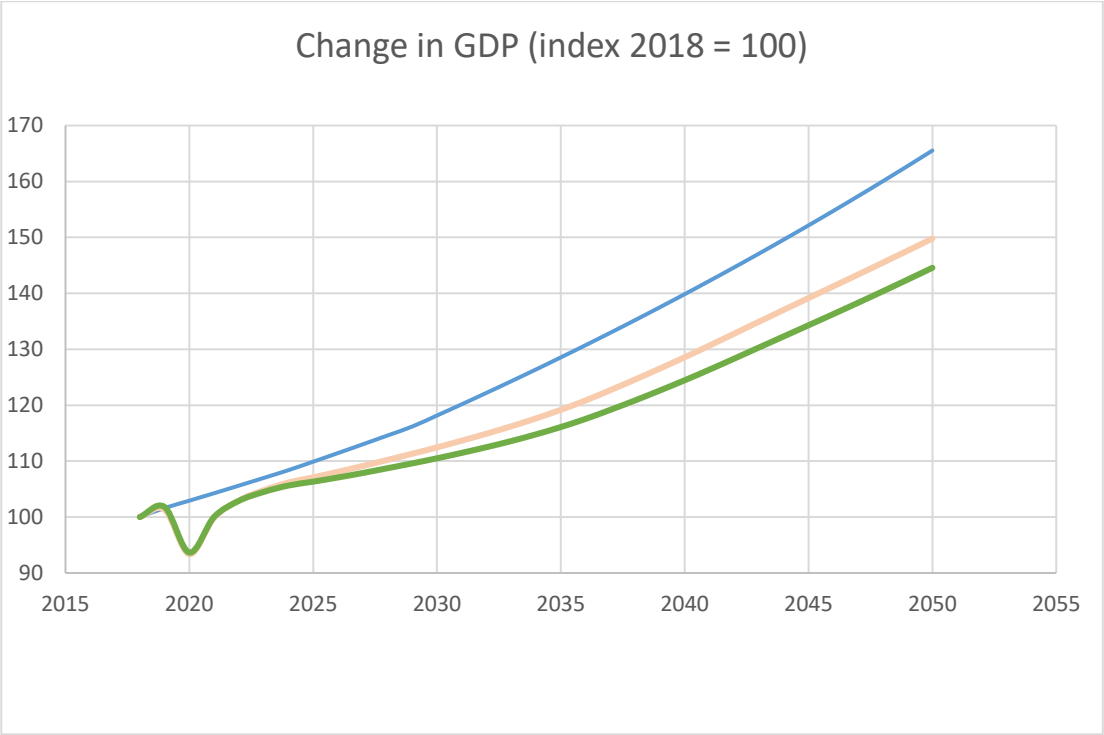


Figure7 . Change in GDP in the scenarios (hexagon + DROM perimeter). Blue: PPE 2; Orange: European Commission; Green: European Commission adjusted to INSEE population, used for PPE 3.

2.1. Reducing final energy consumption - overall approach

Reducing our energy consumption is essential if we are to achieve our climate objectives. It will not only reduce greenhouse gas emissions, but also secure our ability to meet our energy needs in the short, medium and long term with carbon-free energy. It also makes it possible to improve our energy independence.

The new Energy Efficiency Directive, revised on 20 September 2023 as part of the Fit for 55 legislative package, sets a new target for reducing consumption by 2030. France must therefore aim to achieve a final energy consumption of 1243 TWh in 2030, which corresponds to a reduction in final energy consumption of 28.6% over the period 2012-2030.

Between 2012 and 2022, France's final energy consumption will have fallen by around 10.7%, i.e. a dynamic of around -18.5 TWh/year. It is therefore necessary to double the overall rate of reduction in consumption over the period 2023-2030 to achieve the objective of the Fit for 55 European legislative package.

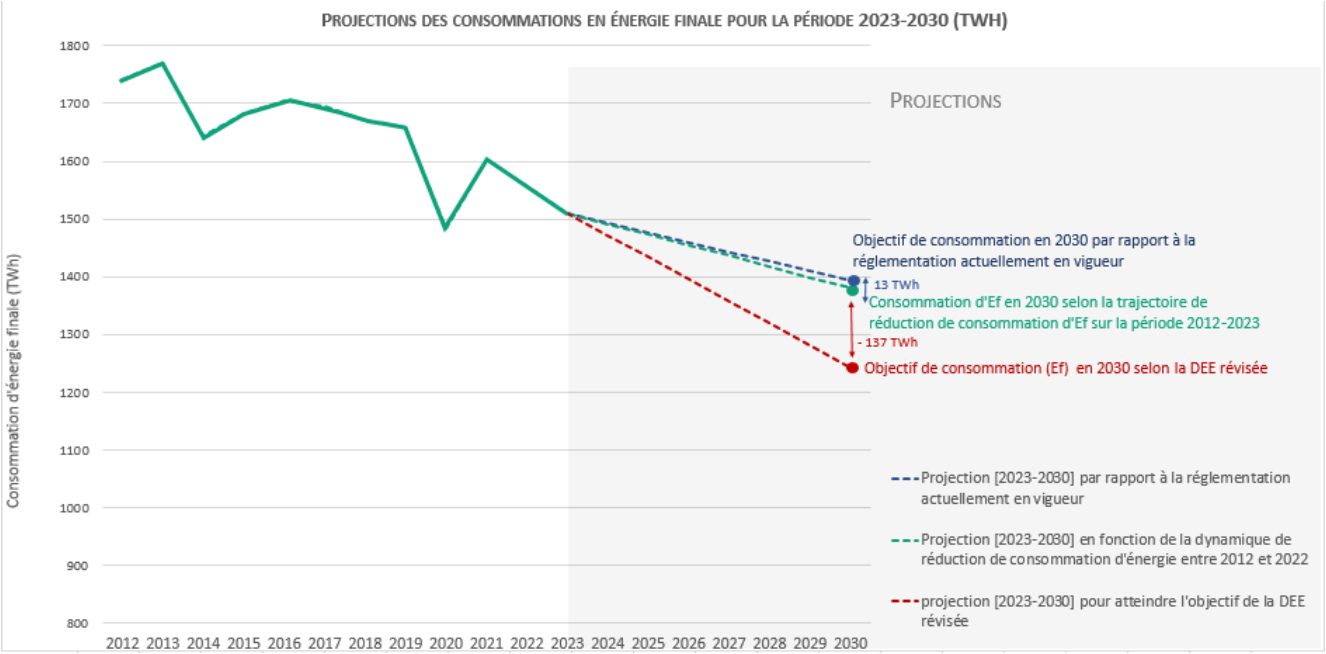


Figure8 . Projected final energy consumption to 2030 (DGEC modelling based on SDES data)

The trajectories modelled at this stage (see below) lead to final energy consumption in France in 2030 of 1,410 TWh, or 1,381 TWh according to the DEE perimeter ,[19][20] , representing a 20.7% reduction in final energy consumption compared with 2012 (1,741 TWh). These models include a reindustrialisation scenario, which would make it possible to reduce the French and European carbon footprint, but which would also automatically increase national energy consumption by around 50 TWh. However, the reindustrialisation of France has a positive impact on the climate, since the electricity mix in France is largely decarbonised, while at the same time creating jobs and wealth for the regions.

Additional levers will need to be identified and activated to ensure that the targets for reducing energy consumption are met.

ACTION CONS.1

GIVING PRIORITY TO ENERGY SOBRIETY AND EFFICIENCY

In application of the directive on energy efficiency, the French government requires that the principles of energy sobriety and efficiency be taken into account from the design stage of a plan or programme, a law, a project or a major investment decision. A bill containing various provisions for adapting to European Union law (DDADUE) will therefore propose a proportionate assessment of the extent to which energy efficiency and energy sobriety are taken into account in planning decisions or projects costing more than €100 million (€175 million for transport infrastructure).

In addition, a number of measures provided for in the Energy Efficiency Directive will be implemented to accelerate energy savings, in particular :

[19] Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955.

[20] Final energy consumption within the meaning of the Energy Efficiency Directive excludes energy extracted from ambient air by heat pumps and marine bunkers, but includes air bunkers.

Public bodies will have to set an example and plan to reduce their cumulative final energy consumption by 1.9% per year and renovate 3% of the surface area of their buildings over 250 m^2 to a high level of energy performance;

The most energy-intensive companies will be required to carry out energy audits or implement energy management systems (currently only large companies are required to do so, regardless of their consumption);

Data centres larger than 1 MW will have to recover the waste heat they produce.

At the same time, since energy saving is based on behaviour and, in particular, certain key actions, it is essential to maintain the new habits that were put in place during the energy crisis of winter 2022-2023.

To achieve this, we need to continue to mobilise all stakeholders and households by reminding them of their eco-gestures. For example, the Chaque Geste Compte (Every Step Counts) communication campaign, dedicated to energy savings, could be continued and broadcast systematically each year at the start of winter, using a multi-channel approach to reach as many people as possible. Although this campaign is aimed at households, it can also be used to support and encourage the implementation of energy-saving measures by professionals (particularly in the tertiary sector). Energy efficiency is also now a theme for action by the France Rénov' public service. France Rénov' advice centres can now advise and encourage households to take energy-saving measures in their homes.

For the record, these new low-energy behaviours helped to reduce gas and electricity consumption by 12% in the year 2022-2023 (from 1 August 2022 to 31 July 2023, compared with the reference year 2018-2019, climate-adjusted data) and by -12.46% for the year 2023-24 soon to end (from 1 August 2023 to 8 July 2024, compared with the reference year 2018-19, climate-adjusted data) .[21]

ACTION CONS.2

REDUCING ENERGY CONSUMPTION IN ALL SECTORS

Various levers will be used to ensure that these objectives are met:

→ Continuing the drive to reduce energy consumption (see above)

→ Reducing energy consumption in the residential and tertiary sectors, in particular by renovating buildings to make them more energy-efficient.

For the residential sector, a significant acceleration in the rate of major renovation is planned. The government has set a target of around 400,000 single-family homes and 200,000 apartment buildings benefiting from major renovation, in one or more stages, every year on average between now and 2030 for the private and social housing stock, while maintaining a strong base on the decarbonisation of heating systems.

In the case of private housing, this dynamic is made possible by the increased financial incentives for major renovations under the MaPrimeRénov' (MPR) scheme, the CEE system, local aid, tools for financing the remainder of the cost (Eco-PTZ, prêt avance rénovation, etc.) and by the action of the France Rénov' public service, which is being rolled out across the country. Some of these renovations will also be triggered by rental decency requirements, some of which came into force in 2023, as well as by the introduction of incentives or regulatory measures to renovate thermal flats on transfer. These additional measures are necessary to achieve the objectives of the French climate and energy strategy.

[21] Updated data available on the DGEC website: https://www.ecologie.gouv.fr/politiques-publiques/suivi-hebdomadaire-consommation-energetique-france

Decarbonising heating is also often accompanied by a reduction in energy consumption, since heat pumps, one of the main decarbonised alternatives to fossil fuels for heating, are highly energy-efficient. The plan is to phase out oil-fired boilers in the commercial sector by 2030, and to reduce the number of such boilers in homes by a factor of four (-75%), i.e. around 300,000 homes a year switching from oil-fired heating. Strong incentive mechanisms are also planned for the gradual replacement of gas boilers (with a target of 20% to 25% by 2030, i.e. around 350,000 homes per year switching from gas), in particular with the abolition of support for the installation of gas heating systems from [1]January 2025, as provided for in the revised directive on the energy performance of buildings (2024/1275/EU), and the maintenance of increased support for the decarbonisation of heating.

For the tertiary sector, the implementation of the 2019 tertiary eco-energy decree, which aims to reduce the final energy consumption of tertiary buildings by 40% by 2030 and by 60% by 2050 (or to achieve a maximum energy consumption threshold depending on the type of tertiary building in question), will speed up the reduction in consumption in the sector for buildings or groups of buildings over 1,000 m^2.

This will have to be supplemented by additional measures aimed at renovating the most energy-intensive tertiary buildings as a priority, regardless of their surface area, in application of the revised directive on the energy performance of buildings (2024/1275/EU).

→ Lower energy consumption in the transport sector

In the transport sector, the reduction in energy consumption will be achieved first and foremost by controlling the demand for transport, whether for passengers or for goods, and by switching to less energy-intensive modes of transport (cycling, walking, public transport, rail, waterways, etc.) wherever possible, in accordance with the attached strategy for the development of clean mobility.

Reducing fuel consumption will also require the development of lighter vehicles, which consume less material in their manufacture and are more fuel-efficient in use. This reduction in the weight of vehicles will be supported by the strengthening of vehicle taxation on the heaviest vehicles (mass penalty, introduced on 1 January 2022) and the strengthening of the conditions of eligibility for subsidies for the purchase of low-polluting vehicles (introduction of a maximum weight limit from 1 January 2023, introduction of a minimum environmental score from 15 December 2023).

Electrification will improve the energy efficiency of vehicles. The momentum that is already underway needs to be stepped up, in line with the European Union's target of phasing out the sale of new light internal combustion vehicles by 2035. This development of the electric vehicle will be supported by (i) a strengthening of vehicle taxation on the vehicles that emit the most greenhouse gases (CO2 malus and annual tax on CO2 emissions from vehicles used for economic purposes), (ii) the implementation and strengthening of the obligation to make vehicle fleets greener, (iii) a system of subsidies for the purchase of low-polluting vehicles, regularly revised to support this transition, with specific targeting of the most modest households (marked in particular in 2024 by the launch of the social leasing scheme) and (iv) an ambitious roll-out of charging stations throughout our territory.

Finally, as far as road freight transport is concerned, the levers that can be mobilised to encourage reductions in energy consumption are based in particular on controlling freight demand and optimising logistics flows, with the development of short circuits, the supervision of fast and/or free delivery (making shippers responsible, informing consumers, limiting free delivery and returns, etc.) or the development of just-in-time industrial processes. Logistical flows will also be pooled and consolidated to optimise loading rates and the distances covered by heavy goods vehicles.

→ Lower energy consumption in the industrial sector

In the industrial sector, the detailed identification of areas for improvement in energy consumption and greenhouse gas emissions by sector within the strategic sector committees, which has been underway since 2020, followed by in-depth work on the 50 industrial sites to be decarbonised as a priority, This will enable the government to focus its efforts on supporting French industry in an integrated approach that combines reducing emissions at source through energy efficiency and waste heat recovery, decarbonising processes and, as a last resort, managing emissions that cannot be avoided given the current state of knowledge. With regard to energy efficiency, the CEE scheme will continue to support energy-saving operations in the industrial sector. Carrying out energy audits or setting up energy management systems, generalised to all energy-intensive companies, will enable them to identify appropriate ways of reducing consumption.

ACTION CONS.3

PERPETUATING THE ENERGY SAVINGS CERTIFICATE SCHEME

The CEE scheme is based on an obligation for energy suppliers (known as obligated parties) to carry out or initiate energy-saving operations based on their volume of energy sold[22] . This obligation is set for a period of four years: currently, the fifth period, which began in 2022, runs until 2025. Energy-saving measures can be implemented in all sectors of the economy: residential buildings, tertiary buildings, industry, transport, agriculture and networks. The scheme involves individuals, businesses, local authorities, social landlords, ANAH, etc., who can either obtain financial incentives from obligated parties for the energy-saving operations they carry out, or, for those eligible (local authorities, ANAH, etc.), obtain CEEs directly, which they can then sell on the market. Each energy-saving action encouraged gives entitlement to energy-saving certificates, which are measured in cumulative kWh discounted over the lifetime of the operation (known as "cumulative" kWh) to take account of the lifespan of the equipment in particular. Energy suppliers ultimately finance these energy-saving operations by passing on the associated costs to consumers in their bills. The level of the obligation therefore has an impact on energy prices.

France introduced this system in 2006. Since 2014, it has been used to meet the annual energy savings obligations imposed on each Member State by the Energy Efficiency Directive, which recognises the Member States' option to implement this type of instrument. Article 8 of the revised Energy Efficiency Directive (EED - 2023/1791/EU) provides for a stepwise increase in the level of the energy saving obligation for the period 2021-2030 at the following rate (as a % of France's final energy consumption over the reference period 2016-2018):

→ 2021-2023: 0.8% or 13.5 TWh/year ;

→ 2024-2025: 1.3% or 22 TWh/year ;

→ 2026-2027: 1.5% or 25 TWh/year ;

→ 2028-2030: 1.9% or 32 TWh/year.

The EWC scheme also contributes to achieving the target of reducing energy consumption by 2030 set out in the EED, in conjunction with other regulations put in place to reduce energy consumption (such as the Eco-design regulations, which govern the energy performance of a large number of products placed on the European market). For France, this target, which has been raised as part of the European Fit for 55 legislative package, corresponds to a 28.6% reduction in final energy consumption in 2030 compared with 2012.

22 Further information: CEE 2023 annual report available on the Ministry of Energy website

There are plans to make the CEE scheme permanent by extending it into a 6th period. EWCs provide a framework for all sectors, including the residential, tertiary and industrial sectors, to make energy savings. The scheme will also be strengthened and made more effective through :

- a strengthening of the steering committee, in particular for monitoring operations that will benefit from CEE ;
- strengthening the fight against fraud. The staff of the National Fraud Prevention Unit (PNCEE) will be increased. Legislative changes will be proposed, in particular to facilitate the "naming and shaming" of players involved in fraudulent operations, and to enable the PNCEE to monitor and sanction operations before applications are submitted (beyond simply rejecting them);
- better evaluation of the scheme: it is planned to increase the resources dedicated to evaluation. In addition, studies on the energy savings generated by operations in real conditions, and their potential, should be developed. Axis 1 of the call for EWC programmes launched on 16 September 2024[23] also provides for the evaluation of the scheme.

An EWC steering committee will discuss the operational measures proposed following the consultation and working groups conducted in the first half of 2024.

The levels of obligations under the CEE scheme will fall within the following ranges:

(IN TWhc OF ANNUAL OBLIGATION)	5TH EEC PERIOD				6TH EEC PERIOD					
Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031 à 2035
1st scenario	625	825	825	825	To be defined between 825 and 1250	To be defined between 825 and 1250	To be defined between 825 and 1250	To be defined between 825 and 1250	To be defined between 825 and 1250	1250
2th scenario	625	825	825	925	2500	2500	2500	2500	2500	2500

[23] Specifications for the 2024 call for EWC programmes:
https://www.ecologie.gouv.fr/sites/default/files/documents/CahierCharges_AAP-CEE-2024.pdf

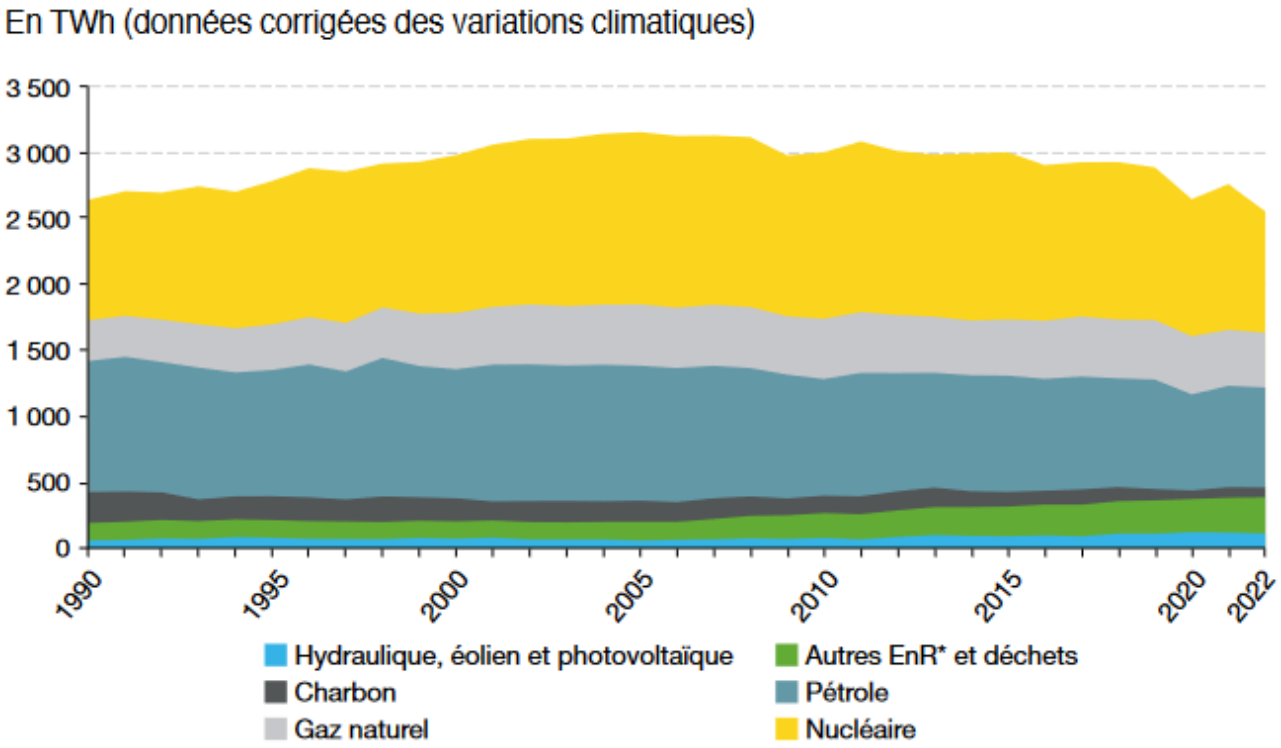
The 1st scenario corresponds to a relatively less central role for the EWC scheme in achieving the objectives of reducing energy consumption by 2030, requiring greater mobilisation of the lever to achieve the expected level of reduction in energy consumption. This low range does, however, make it possible to meet the annual energy savings requirements imposed by the Energy Efficiency Directive, with virtually no margin in the case of a low range of 825 TWhc/year.

2.2. Reducing fossil fuel consumption

2.2.1. Historical trend in primary energy consumption and reduction target

Current consumption :

Over the last decade, the energy mix has changed slightly, with renewable energies growing at the expense of fossil fuels, albeit at a slow pace compared with the overall energy mix. Natural gas consumption is relatively stable.



** EnR = énergies renouvelables.*
Champ : jusqu'à l'année 2010 incluse, le périmètre géographique est la France métropolitaine.
À partir de 2011, il inclut en outre les cinq DROM.
***Source :** SDES, Bilan énergétique de la France*

Figure9 . Primary consumption by form of energy - Source: SDES

Reduction targets :

The figure below shows primary fossil energy consumption in the past and projected in the provisional scenario of the French Energy-Climate Strategy ("AMS run 2").

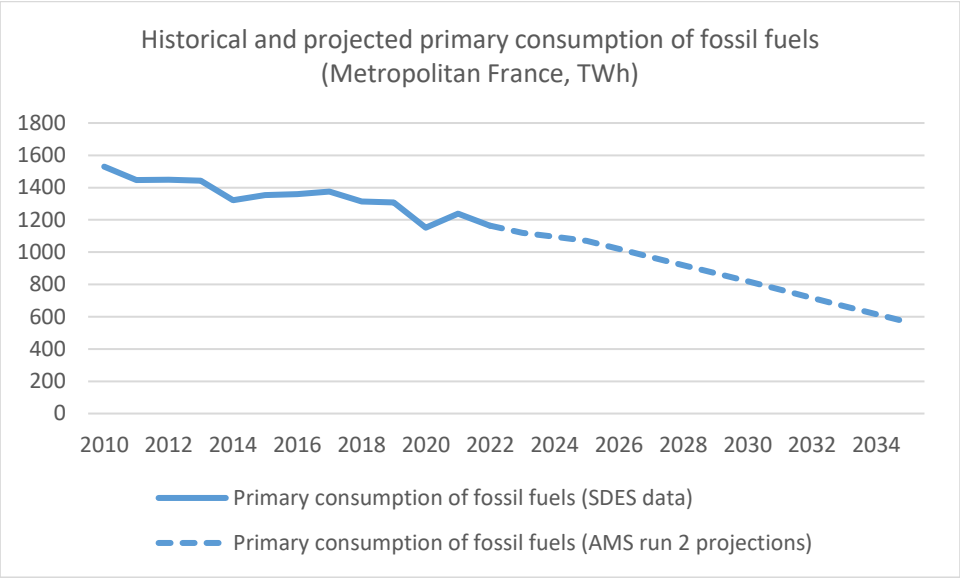


Figure10 . Primary consumption of fossil fuels for energy and non-energy uses - Past (2010-2022) and projected (2023-2035) trends

Primary consumption of fossil fuels for energy and non-energy uses (TWh), Metropolitan France perimeter	**2022**	**2030**	**2035**
Primary coal consumption (all products)	64.4	23.4	15.0
Primary consumption of natural gas	386.4	296.9	214.0
Primary oil consumption (Total crude and refined)	713.0	499.0	336.3
Primary consumption of fossil fuels (SDES data)	1163.8	819.4	565.4

As a result, primary consumption of fossil fuels will fall by around half between 2010 and 2035 in the provisional scenario of the French Energy-Climate Strategy.

The following figure shows this consumption, **excluding non-energy uses**:

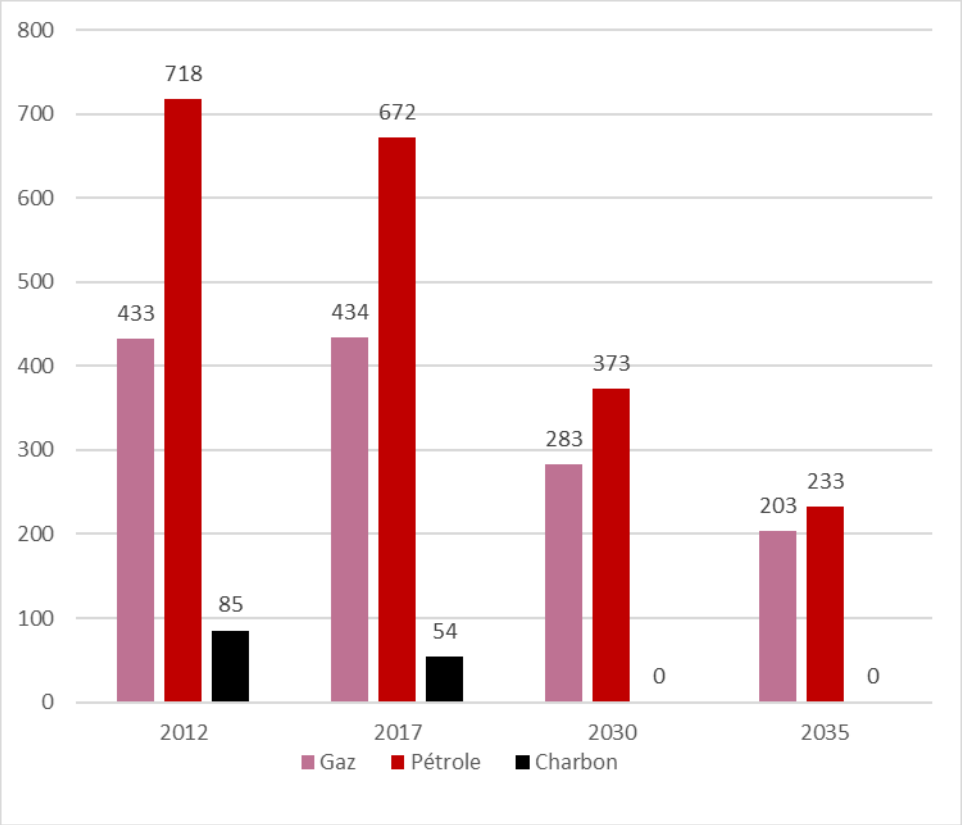


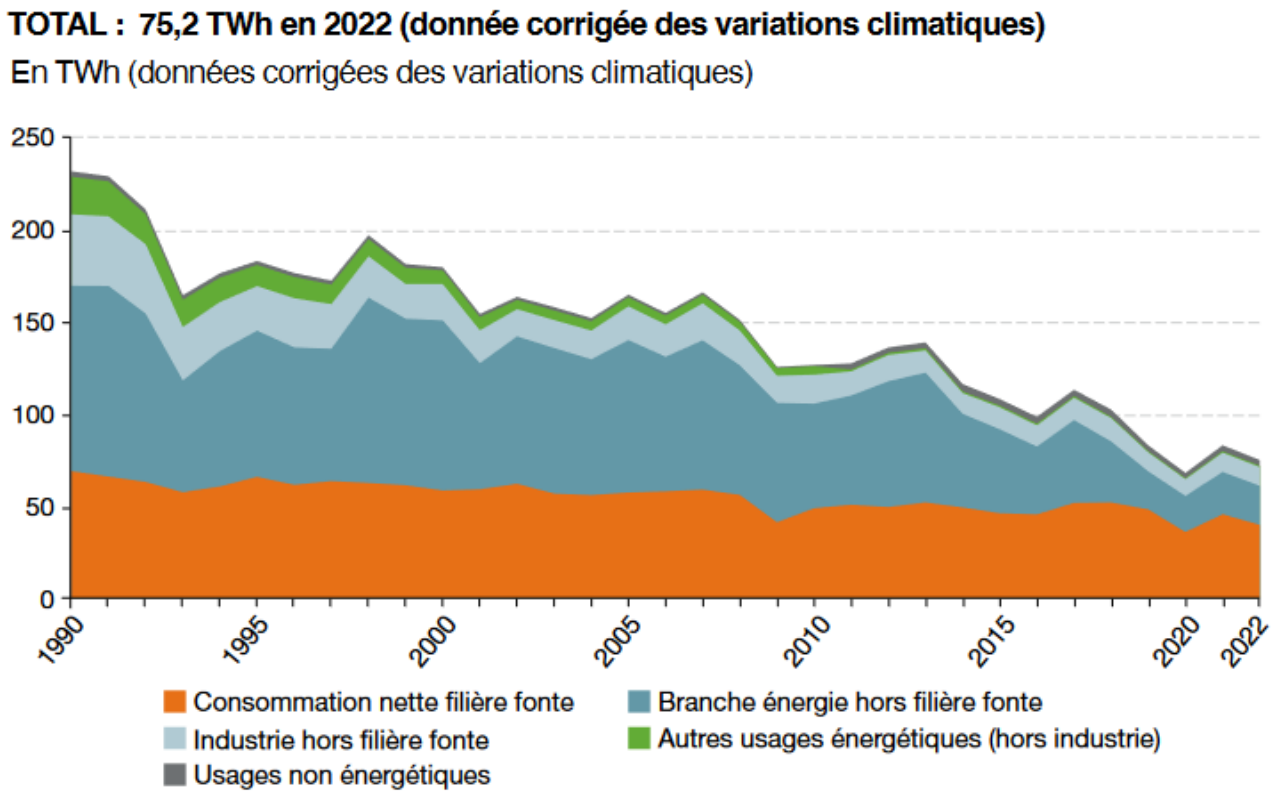
Figure11 . Change in primary fossil fuel consumption for energy uses compared with 2012 (DGEC modelling, excluding non-energy uses and the cast iron industry)

Achieving these targets will require a large number of measures and guidelines across all sectors of activity, which will be set out in detail in the **National Low Carbon Strategy**, France's roadmap for reducing its greenhouse gas emissions and achieving carbon neutrality by 2050.

2.2.2. Reducing primary coal consumption

Current consumption :

After a significant rebound in 2021 (+23%) linked to the economic recovery, primary coal consumption in France fell sharply again in 2022, to 75.2 TWh (-10%). The cast iron industry has been affected by supply and operating difficulties, including the shutdown of some blast furnaces. Primary coal consumption is on a downward trend, with other forms of energy gradually replacing it in most sectors. Consumption for electricity and heat production has fallen sharply with the closure of several facilities. The main consumer sectors in 2022 will continue to be the smelting industry (), electricity and heat production (28%) and manufacturing industry excluding blast furnaces (14%).



Notes : un opérateur a révisé fortement à la hausse ses productions de gaz dérivés, entraînant une rupture de série entre 2016 et 2017. Par ailleurs, à partir de 2017, les pertes, auparavant incluses dans l'écart statistique, sont intégrées à la consommation de la filière fonte.
La somme des consommations des différentes branches représentées sur le graphique peut différer légèrement de la consommation primaire totale, cette dernière intégrant un écart statistique.
Champ : jusqu'à l'année 2010 incluse, le périmètre géographique est la France métropolitaine.
À partir de 2011, il inclut en outre les cinq DROM.
***Source :** SDES, Bilan énergétique de la France*

Figure12 . Primary coal consumption by sector - Source: SDES

Reduction targets :

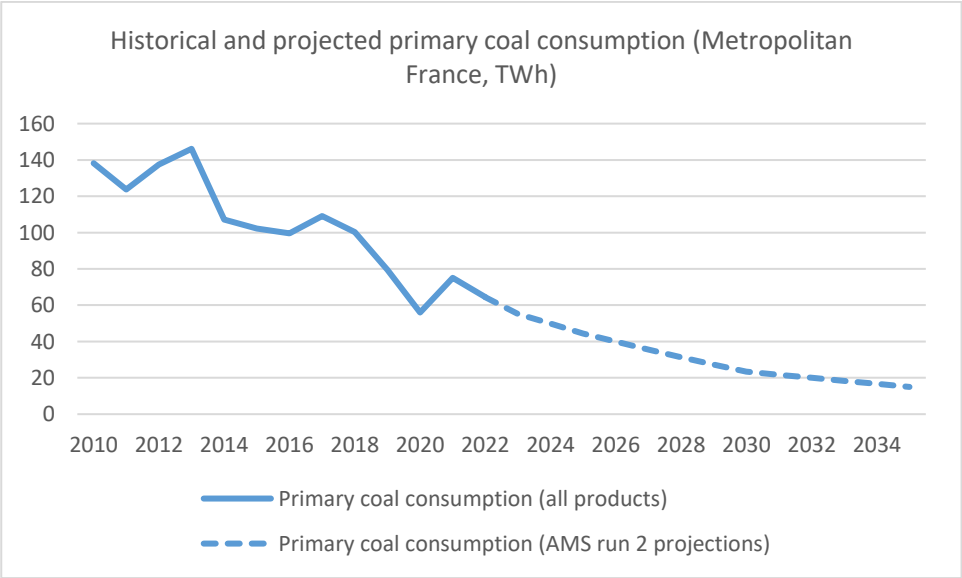


Figure13 . Historical and projected primary coal consumption

In the provisional scenario of the French Energy-Climate Strategy, primary coal consumption falls from 64 TWh in 2022 to 23 TWh in 2030 and 15 TWh in 2035, mainly as a result of decarbonisation measures in industry and the heating of buildings. In 2030 and 2035, residual coal consumption will be solely for non-energy purposes and in the smelting industry (mainly in the steel industry).

ACTION CONS.4

REDUCING COAL CONSUMPTION

In the energy sector :

- Stopping coal-fired electricity generation by 2027, while exploring opportunities for conversion to low-carbon fuels (e.g. biomass) where appropriate.

In the steel industry :

- Replace several blast furnaces with direct iron ore reduction plants using hydrogen or natural gas, coupled with electric arc furnaces, in order to reduce coal inputs into the smelting process.
- Supporting the use of hydrogen for direct reduction, through investment or operating aid, in particular as part of the Major Project of Common European Interest (PIIEC) for hydrogen and the call for tenders to support the production of carbon-free electrolytic hydrogen.

In industry excluding the steel industry :

- Continue to provide certain national support schemes, the Heat Fund, energy saving certificates and European funds, in particular the Innovation Fund, in order to supplement France 2030 funding, to provide the necessary complement to trigger investment, while preventing windfall effects, and to reduce greenhouse gas emissions and coal consumption.

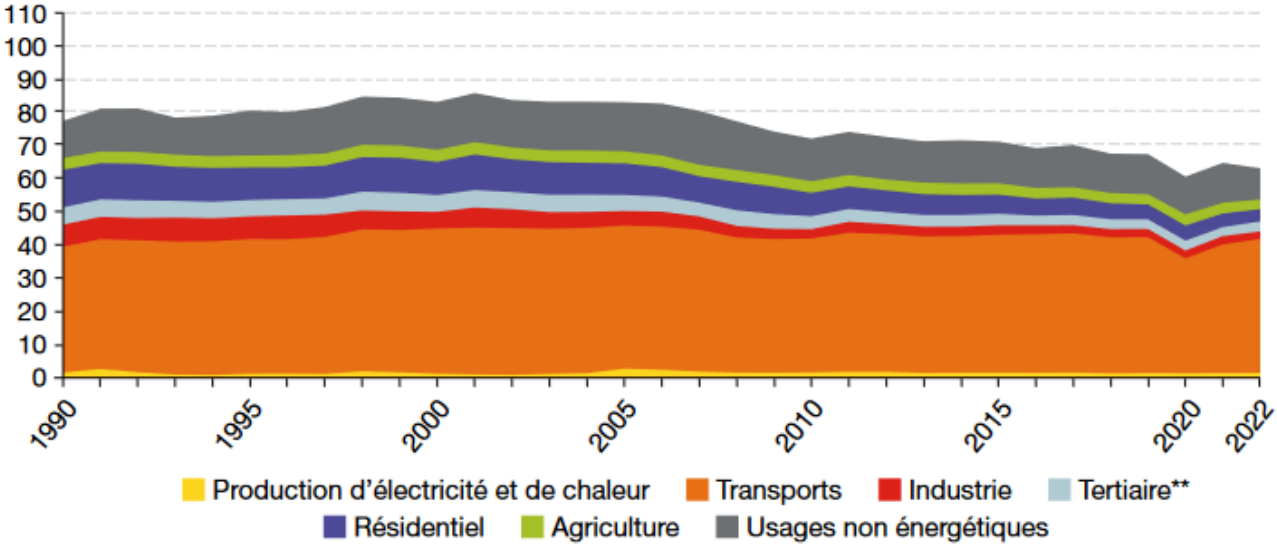
2.2.3. Reducing primary consumption of petroleum products

Current consumption :

In 2022, total consumption of refined petroleum products (excluding biofuels) will be 62.6 Mtoe. Over one year, consumption in non-energy uses, concentrated in petrochemicals, will fall by 21.2%, resulting in a 2.5% drop in total consumption. This follows a 6.8% rise in 2021, due to the economic recovery and the end of traffic restrictions linked to the health crisis. With an increase of 4.1% in 2022, following a 12. rise in 2021, the transport sector, which accounts for almost two-thirds of consumption in 2022, will catch up with its 2019 level. Total consumption has been on a downward trend since the mid-2000s (down by an average of 1.6% per year between 2005 and 2022), mainly attributable to industry, the residential sector and the tertiary sector.

TOTAL : 63,1 Mtep en 2022, soit 733,9 TWh

En Mtep (données corrigées des variations climatiques)



** Hors biocarburants et soutes maritimes et aériennes internationales.*
*** Les consommations des armées sont comptabilisées ici au sein du secteur tertiaire.*
Champ : jusqu'à l'année 2010 incluse, le périmètre géographique est la France métropolitaine.
À partir de 2011, il inclut en outre les cinq DROM.
***Source :** SDES, Bilan énergétique de la France*

Figure14 . Total consumption of refined petroleum products by sector*

Reduction targets :

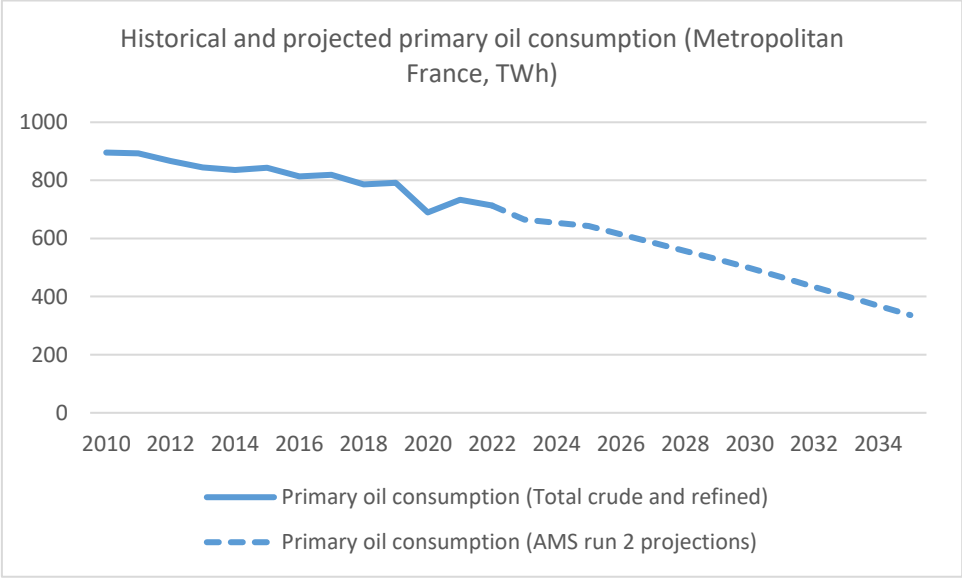


Figure15 . Historical and projected primary oil consumption

In the provisional scenario of the French Energy-Climate Strategy, primary oil consumption falls from 713 TWh in 2022 to 500 TWh in 2030 and 336 TWh in 2035, mainly as a result of measures to electrify vehicles and heating systems. The end of oil-fired electricity generation is scheduled for 2030. The long-term objective, announced by the French President, is to phase out oil-based energy consumption by 2045.

ACTION CONS.5

REDUCING OIL CONSUMPTION

All the sectoral measures to support this objective are set out in the national low-carbon strategy.

In the energy sector :

- Stop producing electricity from fuel oil by 2030.

In residential and commercial buildings:

- Accelerate the replacement of oil-fired boilers, which have been banned since July 2022, using MaPrimeRénov', CEE and local grants to subsidise the purchase of low-carbon heating systems (including heat pumps). The government has set a target of replacing 75% of oil-fired boilers in the residential sector by 2030 with a low-carbon heating system, i.e. around 300,000 homes a year. The development of the "go-to" approach, via the France Rénov' public service for private housing, for example, could help to support the replacement drive.
-
- Massively develop low-carbon heating systems, in particular through public support for the development of the French heat pump industry, with the aim of producing and installing one million heat pumps a year by the end of 2027.
- Eliminate the use of fuel oil in the commercial sector by 2030, except in situations where the transition to a low-carbon system is technically or economically very complex.
- Abolish the financial incentives for gas boilers that still exist today by 1 January 2025, in line with the Energy Performance of Buildings Directive.

In transport :

- Deploy sobriety measures (e.g. for passengers, by acting on regional planning and on habits and perceptions, and for goods, by mobilising the players in the sector to reduce demand) and modal shift (towards more energy-efficient modes) to reduce oil consumption in the transport sector. The attached Clean Mobility Development Strategy sets out these measures in detail.
- Accelerate the electrification of combustion-powered vehicles, in line with the end of sales of new light combustion-powered vehicles in 2035 set at European level. The development of electric vehicles will be supported in particular by a revised bonus-malus system in 2024 to support the transition for all French people, the €100 leasing scheme launched in 2024 for the most modest French people and an ambitious roll-out of charging points throughout France.
- Continue to support the deployment of electric heavy goods and passenger vehicles. In recent years, the public authorities have provided funding for the electrification of heavy goods vehicles (€130m in 2024). It will be appropriate to continue to support the electrification of heavy vehicles and to set an aid trajectory to give the players visibility. This objective of decarbonisation will also need to be accompanied by the deployment of electric charging points at depots, destinations and on the road, which are essential if heavy goods vehicles are to be put on the road. The attached Clean Mobility Development Strategy details these measures.

In agriculture and forestry :

- **Gradually phasing out the use of fossil fuels for farm machinery and introducing less energy-intensive cultivation methods.** The replacement and renewal of tractors, supported by public aid and the desire to eventually reduce the use of agricultural RNG, will gradually be replaced by biofuels and electric or even hydrogen engines, depending on use. Structures that enable farm machinery to be pooled will enable investment in low-carbon equipment. In addition, farming systems will evolve towards agro-ecology with less energy-intensive cultivation techniques.

- Continuing to provide financial support, such as that provided by the Heat Fund and the energy saving certificate scheme, to facilitate **the thermal renovation and construction of energy-efficient buildings using low-carbon energy sources, in particular geothermal energy and heat.**

In industry :

- Strengthen incentives to improve energy efficiency (CEE, other public support in line with existing support).
- Mobilising the circular economy as a lever for decarbonisation to reduce demand for primary production and improve its efficiency.
- Ensure that the price of low-carbon electricity is competitive with fossil fuel alternatives
- Continue to provide certain national support schemes, such as the heat fund, energy saving certificates and European funds, in particular the innovation fund, in order to supplement France 2030 funding, to provide the necessary complement to trigger investment, while preventing windfall effects, and to reduce greenhouse gas emissions and oil consumption.

In refining :

- Decarbonising refinery sites by optimising their energy efficiency and electrifying them initially, alongside the use of low-carbon hydrogen for their needs and carbon capture and storage technologies, which will be deployed in the medium term.
- Anticipate refinery closures with a view to continuity of supply for the strategic value chains that depend on them - organic chemistry in particular - as well as a just transition to facilitate the retraining of employees and offer alternatives to the regions concerned (e.g. conversion to bio-refineries, new industrial sites, etc.).

2.2.4. Reducing primary consumption of natural gas

Current consumption :

In 2022, a year marked by an energy crisis, natural gas consumption unadjusted for climatic variations will be 429 TWh HCV. Climate-adjusted consumption is 463 TWh, 2.7% lower than in 2021, but with significant differences between sectors (-20% for industry and +36% for power and heat generation, against a backdrop of difficulties in nuclear and hydroelectric power generation, at historically low levels in 2022). After strong growth in the 1990s, total climate-adjusted consumption has hovered around 500 TWh since the early 2000s. Between 1990 and 2022, the share of consumption for

electricity and heat production will rise sharply (from 2% to 24%). Conversely, the shares for industry (37% to 24%) and the residential sector (39% to 31%) will fall.

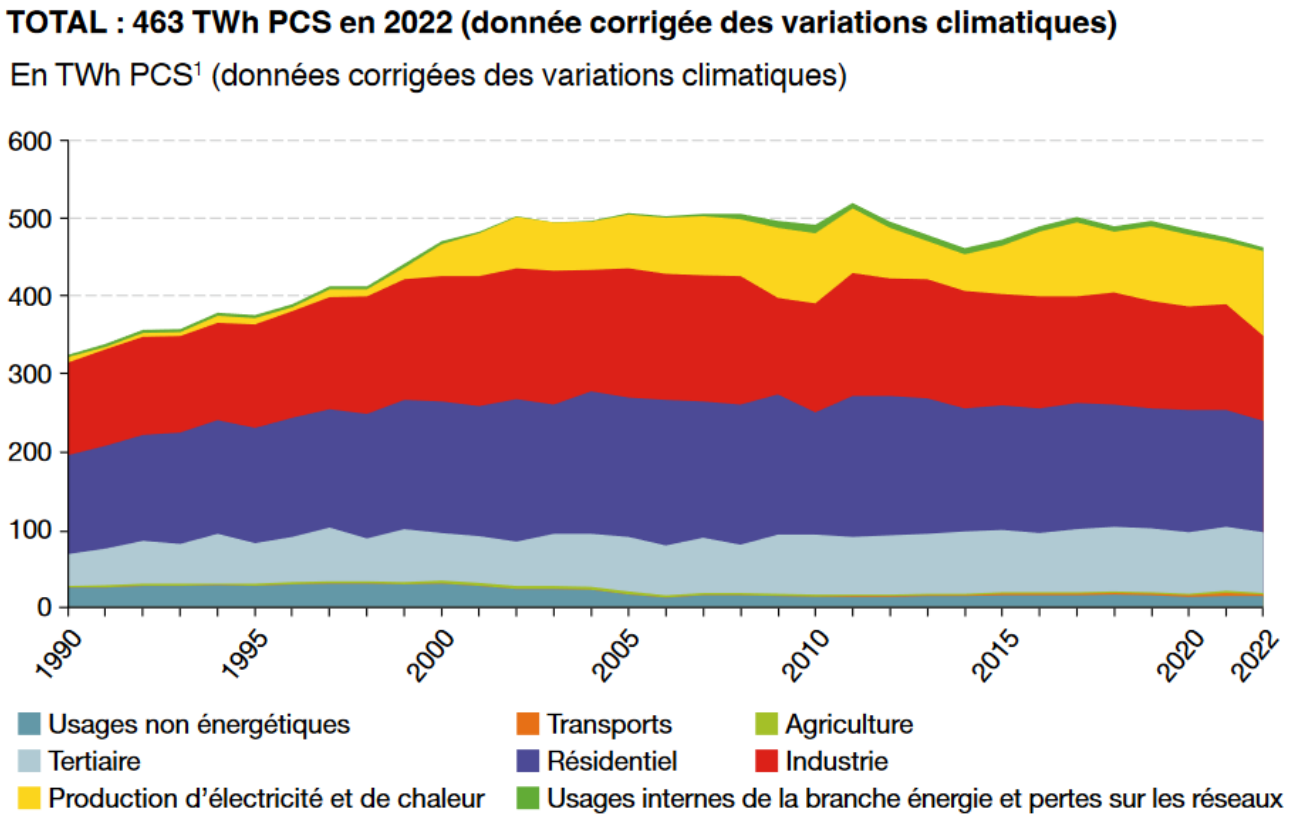


Figure16 . Total natural gas consumption (excluding losses) by sector

Reduction targets :

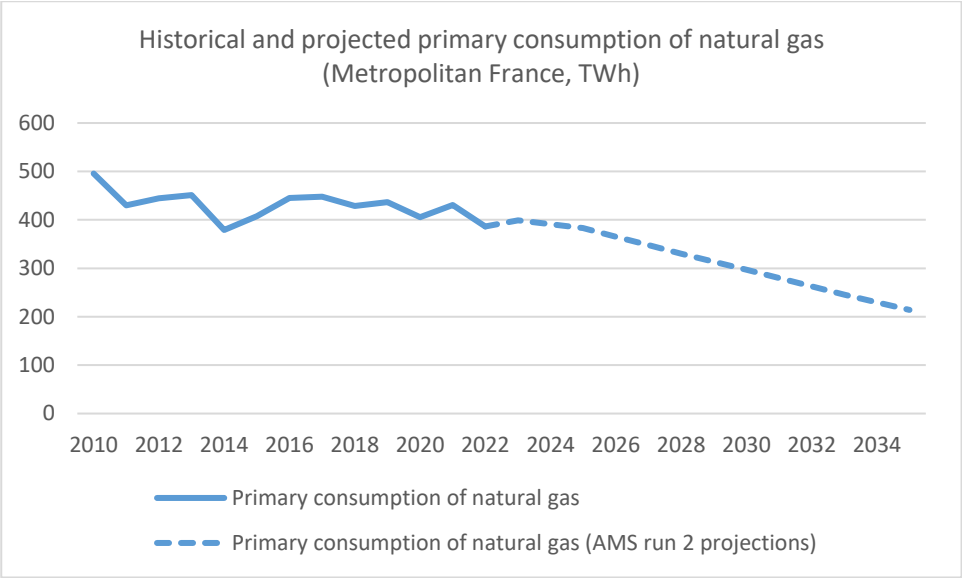


Figure17 . Historical and projected primary consumption of natural gas

In the provisional scenario of the French Energy-Climate Strategy, primary fossil gas consumption falls from 386 TWh in 2022 to 297 TWh in 2030 and 214 TWh in 2035, as a result of measures to decarbonise industry, renovate buildings and replace gas boilers with low-carbon equipment, as well as substitution by low-carbon gas.

ACTION CONS.6

REDUCING GAS CONSUMPTION

All the sectoral measures to support this objective are set out in the national low-carbon strategy.

In residential and commercial buildings:

- Renovate the stock of single-family homes and multi-family dwellings to improve their energy efficiency. The government has set itself the target of renovating an average of 400,000 single-family homes and 200,000 multi-family homes per year by 2030 in the private and social housing sectors.
- Abolish financial incentives for gas boilers from 1st January 2025, as provided for in the revised Energy Performance of Buildings Directive.
- Gradually replace gas-fired boilers (by around 20% to 25% in 2030 compared with 2021 in the residential sector, and by 15% to 20% in the commercial sector), both as part of major renovations and as part of step-by-step renovations. These renovations are supported by the MaPrimeRénov' and CEE schemes, which no longer subsidise the installation of gas-fired heating systems.
- Continuing to implement the 2019 tertiary sector eco-energy decree, which aims to reduce the final energy consumption of tertiary sector buildings by 40% by 2030 and 60% by 2050, will accelerate the reduction in gas consumption in the tertiary sector.

In industry :

- Strengthen incentives to improve energy efficiency (CEE, other public support in line with existing support).
- Mobilising the circular economy as a lever for decarbonisation to reduce demand for primary production and improve its efficiency.
- Ensuring that the price of carbon-free electricity is competitive with fossil fuels.
- Continue to provide certain national support schemes, the Heat Fund, energy saving certificates and European funds, in particular the Innovation Fund, in order to supplement France 2030 funding, to provide the necessary complement to trigger investment, while preventing windfall effects, and to reduce greenhouse gas emissions and gas consumption.

In heat production :

- Support the use of renewable and recovered thermal energy for heat production, in particular through the Fonds Chaleur, so as to completely decarbonise centralised heat production by 2050.

In energy production :

- Supporting the deployment of renewable gases (see section 3.4.2)

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

PEP 3 THEREFORE SETS MORE AMBITIOUS TARGETS FOR DECARBONISED ENERGY PRODUCTION THAN THE PREVIOUS PEP:

→ Accelerating the shift away from fossil fuels, in particular through the electrification of uses, leading to an upwardly revised level of decarbonised electricity production of at least 640 TWh in 2035, i.e. an increase of 22% compared with total production in 2021. This is a key element of the French strategy, as electrification is in many cases synonymous with intrinsic energy efficiency gains. A level of production in excess of 640 TWh will enable France either to export more electricity or to accelerate the decarbonisation of certain uses.

→ Upward revision of the development of photovoltaic electricity (54 to 60 GW in 2030, compared with a target of between 35 and 44 GW in 2028 in the previous EPP, which corresponds to a sharp increase in the current rate of deployment), while giving priority to competitive development on already developed land:

- On the ground: giving priority to land that has already been artificially developed or where there are fewer issues, particularly in terms of biodiversity (car parks, wasteland, derelict roads, motorways, railways, etc.).
- On buildings: obligations have been introduced into the law to increase the number of new and existing buildings required to install photovoltaic panels.
- On natural, agricultural and forestry land: installations may not compete with agricultural production or sustainable forestry management, and in all cases may not lead to the clearing of areas larger than 25 hectares. On the other hand, agrivoltaic projects will be able to provide a service to agricultural activity (adapting to climate change, protecting against meteorological hazards, improving agronomic potential or animal welfare).

→ Accelerating the rate of allocation of offshore wind capacity to aim for 18 GW of installed capacity by 2035, by developing planning by maritime facade, allocating up to 10 GW of additional capacity by the end of 2026 (in addition to the procedures already launched) and continuing to develop the floating wind sector.

→ Maintain the current rate at 1.5 GW/year for onshore wind power, ensuring a more balanced distribution across the country and investing in repowering.

→ Increased use of biofuels, to the tune of between 50 and 55 TWh in 2030, an increase of 39% compared with 2019.

→ Development of biomethane, with around 50 TWh of biogas, including 44 TWh injected by 2030, corresponding to a production capacity multiplied by 4 compared with today (compared with a target of between 24 and 32 TWh, including between 14 and 22 TWh injected, in 2028 in the previous EPP), taking into account the production and mobilisation limits of our biomass.

→ Development of renewable heat, with more than 280 TWh in 2030 (compared with a target of between 219 and 247 TWh in 2028 in the previous EPP), and recovery heat (20 TWh in 2030 compared with a target of between 7.6 and 9.9 TWh in the networks in 2028 in the previous EPP), corresponding to a more than twofold increase in the rate of deployment compared with today.

→ Deployment of network-delivered cooling, with 2 TWh in 2030 (compared with production of 0.99 TWh in 2022).

→ Relaunching the nuclear industry :

- Removal of the objective of closing nuclear reactors before their end of life and continued

operation of existing nuclear power reactors, taking into account international best practice, to enable them to operate after 50 or 60 years of operation, in compliance with all applicable nuclear safety requirements.

- Launch of a programme of work, led by EDF, to increase the available power (uprating) and annual output of existing reactors, for example by optimising or replacing certain parts, in compliance with all applicable nuclear safety requirements.
- Confirmation of EDF's programme to build 6 EPR2-type nuclear reactors, with a view to a final investment decision by EDF's Board of Directors so that the project can be launched by 2026 at the latest.
- Continued study of a possible second stage of at least 13 GWe, corresponding to the capacity of 8 EPR2s in their current design.
- Support for the Nuward project, led by EDF, to develop a small modular reactor model.
- Support for breakthrough innovation through the France 2030 plan, with the aim of launching at least one prototype of an innovative small nuclear reactor by 2030.
- Confirmation of France's strategy for the treatment and recovery of spent nuclear fuel and, with this in mind, continuation of work to renew the industrial facilities that enable it to be implemented, with a view to a decision being taken by the end of 2026, while ensuring that measures are taken to ensure that existing infrastructure meets requirements by 2035 and beyond.

3.1. Renewable and recovered heat and cooling

Heat currently accounts for just under half (43%) of final energy consumption[24] in France, of which only around a quarter is of renewable origin. France is counting on a sharp increase in the production of heat from renewable sources and the accelerated development of urban heating and cooling distribution networks to move rapidly away from fossil fuels.

Accordingly, the objectives of the EPP3 should enable consumption of renewable and recovered heat to rise from 172 TWh in 2022 to at least 330 TWh in 2035. The graph below shows the breakdown by sector. The targets set for the PPE3 mean that renewable and recovered heat consumption will more than double by 2035.

24 Final or available energy is the energy delivered to the consumer for final consumption (petrol at the pump, electricity in the home, etc.).

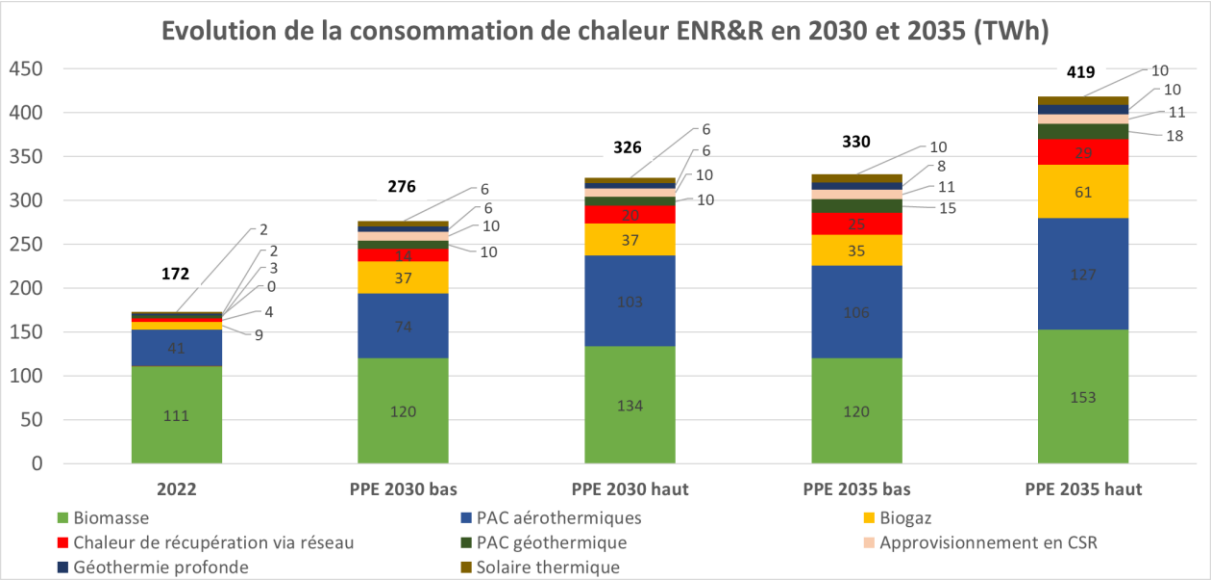


Figure18 . Evolution of ENR&R heat consumption up to 2030 and 2035

This increase in the consumption of renewable heat is based on the development of all renewable heat production methods, as well as increased use of waste heat recovery. The EPP3 therefore sets targets for each of the renewable heat production methods and for the recovery of waste heat used in heating networks. The biggest increase The biggest contribution is due to the deployment of heat pumps. However, the development of solar thermal energy, geothermal energy and biogas represent the biggest challenges.

To develop renewable heat, the government has four tried and tested schemes:

→ The MaPrimeRénov' aid scheme for private individuals;

→ The energy saving certificate scheme, in particular via standardised operation sheets supporting the installation of efficient renewable heat production systems in all sectors of activity;

→ The Heat Fund scheme to develop renewable and recovered heat in all sectors of activity, including through the development of heating networks;

→ France 2030 support for the decarbonisation of industry to develop low-carbon heating.

Created in 2009, the Heat Fund managed by ADEME has enabled the massive deployment of renewable heat production facilities across France. Over the past 15 years, the Heat Fund has supported more than 8,500 renewable and recovered energy (RE&R) installations, including 3,800 km of distribution networks, with €4.28 billion in aid, generating almost €14 billion in investment. This represents almost 45.4 TWh/year of additional renewable energy production, equivalent to the heat consumption of around 5 million homes. In addition, the France Relance and France 2030 programmes have supported the production of heat from biomass for the industrial target, to the tune of 6.4 TWh/year.

ACTION CHAL.1

FINANCIAL SUPPORT AND ASSISTANCE FOR THE DEVELOPMENT OF THERMAL RENEWABLE ENERGIES

Support schemes for renewable heat will be maintained and scaled to meet our objectives.

ADEME's Heat Fund was increased by 40% in March 2022, to €522 million for 2022 and €601 million for 2023. It was further increased to €820 million in 2024, to finance the creation of around 4 TWh/year of renewable energy capacity. Support will continue to grow, so that by 2030, around 12 TWh/year of capacity will have been financed.

MaPrimeRénov' will support the installation of heating equipment running on renewable energy sources for households that need it, in line with the decarbonisation trajectories of ecological planning. In addition, support for renewable heating projects will continue for private individuals as part of the FranceRénov' public service, and for manufacturers as part of the PACTE Industrie programme.

Support will be provided for structuring of networks of renewable heat coordinators throughout the country, local authorities and businesses design their projects and stimulate the development of new renewable thermal energy production capacity. Lastly, the human resources and skills needed to deploy renewable heat will receive special attention as part of the Jobs and Skills strategy of the General Secretariat for Ecological Planning.

In accordance with Directive 2024/1275 on the energy performance of buildings, the financial incentives for gas and oil-fired boilers that still exist today (such as reduced-rate VAT, the Eco-PTZ or certain CEE standardised operation sheets) will be abolished by 1 January 2025.

ACTION CHAL.2

SETTING UP A LONG-TERM FRAMEWORK FOR THE BUILDING HEATING MARKET

Following the consultation on the decarbonisation of buildings :

→ A long-term framework for the heating market will be put in place to steer the market towards low-carbon heating solutions and gradually reduce the proportion of gas boilers sold

→ Measures to support the end of the use of fuel oil for heating commercial buildings by 2030 must be identified and put in place, in particular to support small and medium-sized businesses and local authorities in replacing their oil-fired boilers with low-carbon heating systems.

3.1.1. Solid biomass

Solid biomass is France's leading renewable energy source, accounting for 32.9% of primary consumption of renewable energy and 61% of primary consumption of renewable energy for heating in 2022. This sector includes both wood used by households (in independent heating appliances such as inserts and stoves, as well as in boilers) and biomass heating plants in industry, collective housing and the tertiary sector, as well as renewable heat produced by biomass cogeneration plants and, finally, the renewable share of heat produced by municipal waste-to-energy plants.

Almost a quarter of French households use wood-burning equipment (logs or pellets)[25] . It may be used as the main source of heating in the home, or as a back-up to another form of heating using electricity, gas, fuel oil or a second renewable energy source (solar heating, heat pump, etc.).

In the collective, industrial and tertiary sectors, more than 7,000 heating plants, spread across the country, supply a district heating network or directly on the site of an industry, or collective or tertiary residential buildings.

The fundamental issue is the sustainability of the biomass resource, i.e. its rational use while preserving the natural environment in which it is harvested. Taking this issue into account has led to a reduction in energy consumption compared with the targets set in the previous EPP. In addition, a number of measures are being put in place to address this issue, in line with European legislation (the Renewable Energy Directive) and national measures (the hedgerow pact).

2022 CONSUMPTION AND GENERATION TARGETS IN TWh	2022	2030 LOW THRESHOLD	2030 HIGH THRESHOLD	2035 LOW THRESHOLD	2035 HIGH THRESHOLD
SOLID BIOMASS (NET CONSUMPTION)	110,7	120	134	120	153

ACTION CHAL.3

OPTIMISING THE USE OF BIOMASS TO DECARBONISE HEAT MORE EFFECTIVELY

Solid biomass is France's leading renewable energy source, making a major contribution to the decarbonisation of energy, particularly heat. It is a local, inexpensive energy source that complements the uses of wood-based products. It is also a resource that needs to be preserved and exploited in a sustainable manner (preservation of the carbon sink, biodiversity, etc.). The use of biomass must therefore be optimised through the use of high-efficiency appliances and the search for alternative solutions where appropriate. Support will continue to be provided for the replacement of old, inefficient combustion equipment, in order to improve energy efficiency and reduce emissions of atmospheric pollutants. In addition, in the support schemes, priority will be given to uses for which there are few substitutes, such as high-temperature heat requirements for industry or district heating networks. Priority will be given to short-circuit uses, through the on-site recovery of sawmill by-products to produce renewable heat. As part of the Heat Fund, project developers will be required to systematically study alternatives to biomass before considering the creation of a heating plant. They will therefore be encouraged to apply this approach when drawing up feasibility studies or, in the case of heating networks, master plans. Other effective and relevant uses of biomass to decarbonise heat production may continue to be supported, taking into account the prioritisation of biomass uses.

[25] SDES, https://www.statistiques.developpement-durable.gouv.fr/la-consommation-de-bois-energie-des-menages-en-2020

3.1.2. Heat pumps

Heat pumps produce heat by drawing calories from the ground or groundwater (geothermal) or from the air (aerothermal). The production of renewable heat from heat pumps (excluding geothermal) will be 41 TWh in 2022.

The number of heat pumps installed in France continues to grow rapidly. However, there are contrasts between air-source and ground-source heat pumps: on the one hand, there has been strong growth in the air/air and air/water heat pump markets in recent years, while ground-source heat pumps have seen a sharp slowdown (fewer than 3,000 sales a year since 2015, whereas the total market has topped one million units sold by 2021).

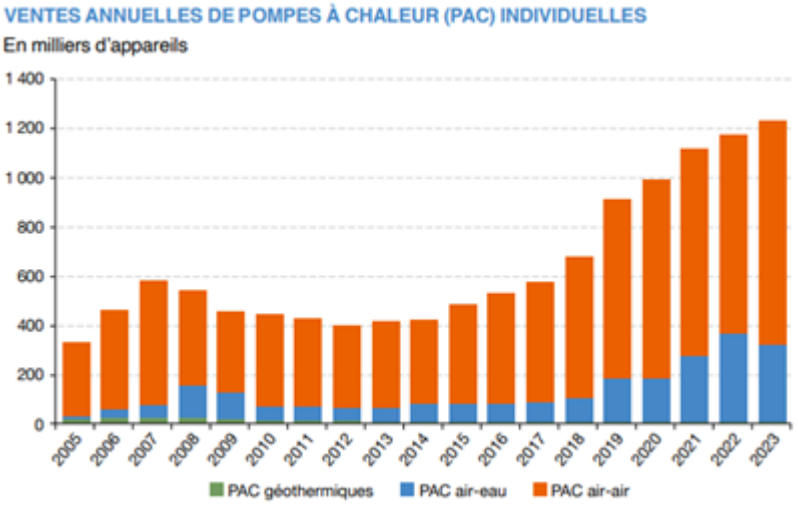


Figure19 . Annual sales of individual heat pumps - Source: Chiffres clés des énergies renouvelables - édition 2023, SDES

Sales of individual heat pumps continued to rise in 2023, reaching 1.2 million units, including 910,000 air-to-air heat pumps (+13% year-on-year), 307,000 air-to-water heat pumps (year-on-year) and 3,500 geothermal heat pumps (year-on-year). The ambitious targets set in the previous EPP exercise for 2028 [LBC1] [LBC2] [BQ3] (44 to 52 TWh produced from heat pumps) have already been achieved in 2023, with production of 50 TWh. In accordance with the "Heat Pump plan, public support for the development of the French heat pump industry will enable one million French heat pumps to be produced and installed each year by the end of 2027.

2022 CONSUMPTION AND PRODUCTION TARGETS IN TWh OF RENEWABLE ENERGY	2022	2030 LOW THRESHOLD	2030 HIGH THRESHOLD	2035 LOW THRESHOLD	2035 HIGH THRESHOLD
PAC (EXCLUDING GEOTHERMAL HEAT PUMPS)	41,1	74	103	106	127

ACTION CHAL.4

IMPLEMENT THE HEAT PUMP PLAN TO PRODUCE 1 MILLION HEAT PUMPS A YEAR BY 2027 AND STRENGTHEN THE INDUSTRY

In line with the objectives set by the French President, in April 2024 the government presented an action plan[26] to support the development of the French heat pump industry and **produce at least one million heat pumps every year by 2027**. Air-to-water heat pumps will mainly be installed to replace gas or oil-fired boilers, and will help to meet the target of phasing out fossil-fired boilers altogether by 2040 set by the directive on the energy performance of buildings.

New heat pump production plants will be set up, with part of the investment costs covered by the green industry investment tax credit (C3IV) and support for project developers in their search for land or permits. Innovation grants will be dedicated to the development of new heat pump products, to meet a range of challenges such as integration, refrigerants and noise. The heat pump industry will receive support to develop training in installation, maintenance and equipment production. To encourage the development of heat pump production in France (and Europe), the heat pump plan includes a measure aimed at making energy renovation aid (MaPrimeRénov' and CEE) conditional on compliance with environmental criteria, which would restrict aid to heat pumps produced in Europe.

A **specific plan will be put in place to develop heat pumps in collective housing**, which will include simplifying legislation to allow derogations from local town planning schemes. Work between government departments, the industry and local authorities will be launched and could lead to the adaptation of national regulations and/or the production of dedicated information for town planning departments, enabling local town planning plans to be adapted and practices to evolve. Subsidies will be reviewed to provide a better incentive for the installation of collective heat pumps, communication will be made with the building industry (project owners, project managers, construction and renovation professionals) and action will be taken with the heat pump industry and representatives of project owners and operators to develop a framework to ensure the quality of installation and operation of heat pumps.

In the absence of a hot water loop, air-to-air heat pumps will make it possible to replace inefficient joule-effect electric heating, thereby improving the energy efficiency of homes and reducing peak electricity consumption.

A **heat pump centre of expertise (CEPAC) will be set up by 2025, with financial support from the French government**, to provide information and tools for all building professionals. From the correct sizing of the system to the correct hydraulic installation, from setting the water law parameters to maximise the performance of the heat pump to ensuring that noise and electrical connection constraints are properly taken into account, information must be accessible and professionals must be able to receive support through guides, technical tools and participation in building industry events and trade fairs.

Finally, **a national communication campaign will be launched between now and 2025** to encourage the installation of heat pumps, a crucial solution for achieving CO_2 emission reduction targets in buildings. Knowledge about the operation and performance of heat pumps will also be developed, along the lines of the Vrai/Faux report published in April 2024 .[27]

[26] An action plan to produce one million heat pumps by 2027 https://www.economie.gouv.fr/actualites/plan-action-pompes-chaleur-2027

[27] For a clearer picture: True/false facts about heat pumps: https://www.economie.gouv.fr/files/files/2024/Guide_pompes_a_chaleur_vrai_faux.pdf?v=1713344875

3.1.3. Surface geothermal energy and deep geothermal energy

Geothermal energy harnesses the thermal energy of the subsoil and groundwater (aquifers). It can be used in a variety of sectors (residential, tertiary, agricultural, industrial) to produce heat and cold (heating, cooling, air conditioning, heat storage, steam production) or electricity (mainly in French overseas departments and territories). By 2022, geothermal installations in mainland France would account for 1% of final heat consumption and 5% of thermal production by heating networks.

Surface geothermal energy" refers to energy systems using a geothermal resource with a temperature of less than 30°C and a depth of less than 200 metres, consisting of an underground collection system (e.g. vertical heat exchangers through which a heat transfer fluid flows), a surface production system (geothermal heat pump) and a control system. Surface geothermal energy covers all or part of the heating and cooling needs of buildings in the residential and commercial sector (heating, domestic hot water, air conditioning, cooling); it can also be used on farms or industrial sites.

Deep geothermal energy" uses groundwater at a temperature of between 30°C and 200°C at depths of between 400 metres and 3,000 metres, via a producer well and an injector well. These deep aquifers are located in porous or fractured sedimentary rock (sand, sandstone, limestone, chalk), mainly in the Paris and Aquitaine basins. Mainly used to produce heat for urban heating networks, deep geothermal energy can also be used for industrial (processes using steam, hot air or hot water), agricultural (heating greenhouses, fish farming, drying) or aquatic (swimming pools, water sports centres, thermal baths) applications. Deep aquifers (geological formations that are sufficiently porous or fissured and waterlogged) suitable for deep geothermal energy are located in sedimentary basins (sand, sandstone, limestone, chalk) such as the Paris and Aquitaine basins, the Rhine Graben, the Rhone Corridor, Limagne and Hainaut. The characteristics of deep aquifers allow direct heat exchange without the need for a heat pump.

If the EPP3 targets are to be met, the pace of project development will have to increase significantly over the period 2024-2030, by strengthening the sector's material and human capacities. The current rate of development is below that forecast in the previous PPE exercise, even though BRGM estimates that surface geothermal energy alone could provide up to 100 TWh of geothermal heat in the next 15 to 20 years. In deep geothermal energy, one of the major challenges for the development of new projects is to improve knowledge of the subsoil, by analysing existing data at regional level and acquiring new data to characterise the target aquifers; several dozen deep geothermal energy projects are currently in the study phase.

2022 CONSUMPTION AND GENERATION TARGETS IN TWh	2022	2030	2035 LOW THRESHOLD	2035 HIGH THRESHOLD
SURFACE GEOTHERMAL ENERGY	3,2	10	15	18
DEEP GEOTHERMAL ENERGY	2,2	6	8	10

ACTION CHAL.5

IMPLEMENTING THE NATIONAL GEOTHERMAL ACTION PLAN

The national geothermal action plan, published in February 2023 and supplemented in December 2023[28] , was drawn up in conjunction with industry players and aims to accelerate the development of surface and deep geothermal energy in mainland France and the French overseas departments and territories through six key areas and around fifteen actions to :

- structuring the sector and strengthening its production and drilling capacity ;
- developing the range of initial and continuing training courses ;
- provide financial and other support to project sponsors and users;
- raise awareness among local players;
- simplify regulations ;
- improve our knowledge of the subsoil.

Each regional prefect is also responsible for drawing up and implementing three actions tailored to the regional context. At national level, the action plan is monitored by Ademe in coordination with a committee of public and private players that meets twice a year. For surface geothermal energy, the action plan aims to double the annual rate of installation of geothermal heat pumps, rapidly reaching 6,000 new installations per year in the individual sector and 1,000 new installations per year in the collective-tertiary sector. In deep geothermal energy, this national action plan should increase the number of operations by 40% to at least 110 operations in operation via projects launched before 2030.

3.1.4. Solar thermal

Solar thermal energy covers all the technologies used to convert solar radiation into usable heat. The type of solar collectors used (unglazed collectors, flat-plate glazed collectors, evacuated tube collectors, concentrating solar collectors, etc.) varies according to the temperature level targeted. Solar thermal energy covers low and medium temperature applications - producing hot water for buildings, heating networks or industry - and high temperature applications above 100°C - in the form of steam for industry in particular.

By 2022, the solar thermal sector will account for 0.2% of final heat consumption in mainland France, with 2.4 million m² of solar thermal collectors in service, producing 1.3 TWh/year of renewable heat. There are two main categories of solar thermal installations:

- individual or collective installations for space heating and domestic hot water production (solar water heaters, combined solar systems, solar heat pumps, etc.)
- Large-scale solar thermal installations (LSIs), typically with a capacity of more than 1 MWth, supplied by flat plate collectors (up to 100°C) or concentrating solar power plants (up to 300°C). These installations mainly meet the low- or medium-temperature heating needs of district heating networks or industrial sites.

The previous PPE foresaw a revival of the sector through the development of large-scale solar thermal installations in industry and on heating networks, and outlined growth prospects for individual and collective housing. In metropolitan France, the years 2021 and 2022 saw a recovery in the solar thermal market and the development of GISTs with glazed collectors, supported by a dedicated call for projects under the Ademe Heat Fund. This momentum is set to accelerate sharply over the next few years, with a view to achieving 6 TWh of solar thermal heat consumption by 2030 and 10 TWh

[28] https://www.ecologie.gouv.fr/sites/default/files/documents/20231222_DP_Plan-action-geothermie.pdf

by 2035. Meeting this challenge - by multiplying by 4 the number of collectors installed in the individual and collective sectors and reaching 1 million m^2 of collectors installed per year under GIST - will require a sustained effort in terms of industrial capacity, installation and operation, not forgetting the regulatory and financial aspects.

2022 CONSUMPTION AND GENERATION TARGETS IN TWh	2022	2030	2035 LOW THRESHOLD	2035 HIGH THRESHOLD
THERMAL SOLAR	1,5	6	10	10

ACTION CHAL.6

DRAW UP AND IMPLEMENT A NATIONAL SOLAR THERMAL ACTION PLAN

Based on the model of the geothermal action plan updated in December 2023, a national "solar thermal" action plan will be drawn up with all the players in the sector (professional organisations, associations, public bodies, etc.) to raise the profile of solar thermal technologies in the French energy landscape, develop the training on offer, facilitate the financial package for projects and strengthen the industrial production capacity for solar thermal equipment in particular.

3.1.5. District heating and cooling networks

The concomitant development of heating networks is essential to increase the use of this renewable heat. Heating networks enable needs to be pooled, making it possible to use sources of heat that are difficult to mobilise on an individual scale (industrial waste heat, deep geothermal energy) or to better control pollutant emissions linked to the use of biomass through the use of collective boiler rooms. Networks also make it possible to distribute renewable heat where it is difficult to produce (dense urban areas).

At the same time, the deployment of cooling networks can be an important element in adapting to climate change, while controlling the impact in terms of energy consumption and heat islands.

The government has therefore also decided to set targets for the quantities of heat delivered by the networks. These will have to increase from 26 TWh, of which will be from renewable energy sources, in 2022, to 68 TWh, 75% of which will be from renewable energy sources, in 2030, and then to 90 TWh, 80% of which will be from renewable energy sources, in 2035.

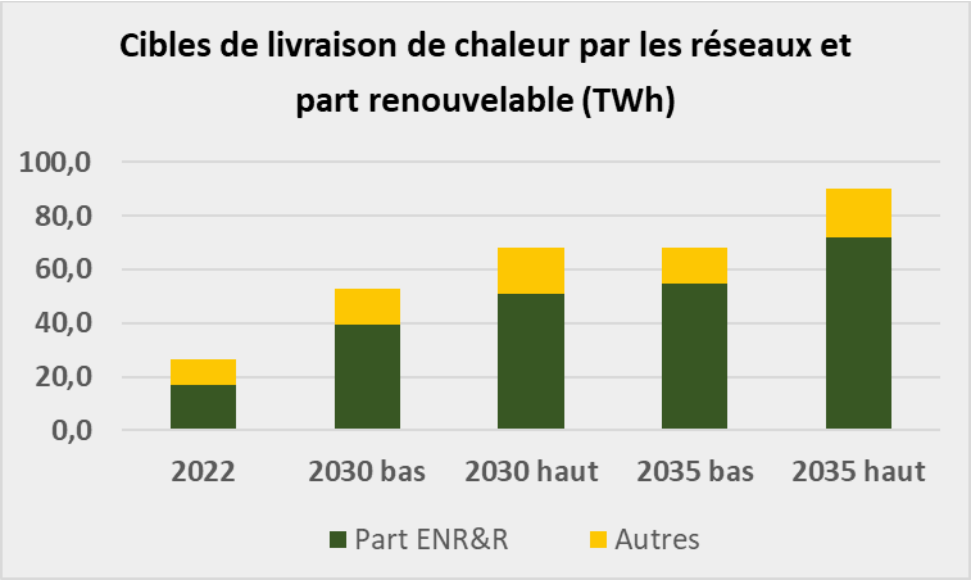


Figure20 . Delivery to ENR&R heating networks in 2030 and 2035

This level of delivery means that an average of 360,000 homes per year will need to be connected by 2035. This represents between 5.8 and 6.7 million homes connected in 2035, compared with less than 1.3 million in 2020. In the vast majority of cases, these connections will be for collective housing with collective heating, but a significant proportion may replace individual fossil heating by creating a secondary water loop in the home.

2022 DELIVERY AND HEAT DELIVERY TARGETS IN TWH	2022	2030 LOW THRESHOLD	2030 HIGH THRESHOLD	2035 LOW THRESHOLD	2035 HIGH THRESHOLD
QUANTITY OF ENR&R HEAT	17	39,5	51	54,5	72
TOTAL AMOUNT OF HEAT	26	52,7	68	68	90

Cooling networks were set up more recently. In 2022, the 40 cooling networks delivered 0.99 TWh (compared with 0.93 TWh in 2009). The French government has set the following targets for the supply of cooling to the networks:

2022 DELIVERY AND COOLING DELIVERY TARGETS IN TWH	2022	2030	2035 LOW THRESHOLD	2035 HIGH THRESHOLD
COLD DELIVERY TO NETWORKS	1	2	2,5	3

ACTION CHAL.7

SPEEDING UP THE DEPLOYMENT OF EFFICIENT HEATING AND COOLING NETWORKS

New digital tools, in particular the maps developed by the state-owned start-up France Chaleur Urbaine https://france-chaleur-urbaine.beta.gouv.fr/ and CEREMA's EnRezo tool https://reseaux-chaleur.cerema.fr/espace-documentaire/enrezo, which identify areas with network deployment potential, will be used to step up efforts to create heating and cooling networks, in addition to the awareness-raising initiatives already underway. Municipalities and intercommunal bodies with more than 5,000 inhabitants that do not have networks but have the potential to deploy them will be encouraged to carry out feasibility studies. In addition, EPCIs with more than 45,000 inhabitants will be required to draw up local heating and cooling supply plans, in accordance with the revised Energy Efficiency Directive. These action plans will make it possible to develop a local strategy for all forms of energy used for heating and the associated networks.

In addition, heating networks will continue to be supported by the Heat Fund, which will be strengthened to keep pace with the expected trajectory. Network operators will have to study the feasibility of using alternative solutions to biomass (geothermal, solar thermal, etc.) as part of the Heat Fund (ENR Choix method).

The classification of heating networks supplied with more than 50% renewable or recovered energy makes it compulsory for new or renovated buildings located within a priority development area to be connected to the network. This system can continue to be deployed by local authorities that own networks to speed up their development and ensure their long-term future.

Other acceleration measures will be studied or tested, in particular supporting work to create secondary hot water loops in collective buildings, or setting strong targets for connection to heating networks and developing the consumption of low-carbon heat in major urban development projects (e.g. OINs), ORCOD-IN (rehabilitation of run-down condominiums, concerted development zones above a certain size), by making State/public funding conditional on these commitments and by reinforcing them).

3.1.6. Recovered heat

Waste heat is heat generated by a process which is not its primary purpose and which is not necessarily recovered. When this waste heat is recovered and used, it is referred to as recovered heat. The sources of recovered heat are very diverse: it can be waste heat from industrial sites, tertiary buildings (data centres, waste water, etc.), existing household waste-to-energy units (known as UVEs) (only the non-renewable part of the heat they produce), or heat from sites treating other waste (thermal treatment of sludge, etc.).

A target has been set for the recovery of waste heat delivered by the networks.

On-site recovery of waste heat should also be developed, to help reduce our energy consumption.

HEAT RECOVERY 2022 AND RECOVERY TARGETS IN TWh	2022	2030 LOW THRESHOLD	2030 HIGH THRESHOLD	2035 LOW THRESHOLD	2035 HIGH THRESHOLD

RECOVERY OF WASTE HEAT DELIVERED TO THE RCU	3,9	13,6	20	25	29

ACTION CHAL.8

SPEEDING UP THE RECOVERY OF WASTE HEAT

The creation of a guarantee mechanism to cover the risk of default by the industrial supplier of waste heat or the customer will be studied. ADEME's Heat Fund can already be used to finance a replacement renewable facility in the event of industrial default.

In addition, cost-benefit studies on the recovery of waste heat will be required for (new or significantly modified) industrial installations of more than 8 MW, service installations of more than 7 MW and data centres of more than 1 MW. As far as existing installations are concerned, studies of the potential for recovering waste heat will be generalised for installations of more than 10 MW. Data centres over 1 MW will be required to recover the waste heat they produce, unless technically and economically incompatible, in accordance with the requirements of the revised Energy Efficiency Directive.

Finally, the recovery of nuclear waste heat to supply heating networks will be studied. The possibilities for recovering heat from wastewater (networks, treatment plants) will be explored in greater depth: support for the development of technologies, projects under the Heat Fund, etc.

3.2. Solid recovered fuels

Solid recovered fuels (SRF) are non-recyclable waste materials that have been specifically prepared for use as fuel in certain installations such as industrial boilers. The aim of SRF is to divert non-recyclable waste from storage (i.e. landfill), and the creation of SRF boilers to decarbonise the heat mix is a particularly suitable solution for industrial users. For example, the Economic Recovery Plan of 2020 introduced a specific scheme to support low-carbon industrial heating, helping industrial companies to use heat sources that emit less CO2, such as biomass or solid recovered fuel (SRF).

This use of RDF is part of the objective of supporting the waste treatment sector and local authorities in complying with the objectives of the Energy Transition for Green Growth Act, which aims to reduce the amount of non-hazardous waste sent to landfill by 50% by 2025, and those of the anti-waste law (AGEC), which require 70% of non-recyclable waste to be recovered from landfill by 2025. The recovery of RDF as industrial fuel provides an outlet for part of this 70% of waste that could not be recovered from materials.

2022 CONSUMPTION AND HEAT PRODUCTION TARGETS IN TWh	2022	2030	2035 LOW THRESHOLD	2035 HIGH THRESHOLD
CSR	0,2	10	11	11

ACTION CHAL.9

SUPPORTING THE DEVELOPMENT OF CSR HEATING SYSTEMS

→ Launch calls for projects backed by Ademe to support the development of RDF boiler plants

→ Continue to increase the TGAP on landfill.

3.3. Liquid fuels

3.3.1. Crude oil production in France

In 2023, national production of liquid hydrocarbons in France will be 584,114 tonnes. Since 2019, production has fallen by 20%. It is at a very low level, representing less than 1% of French consumption of liquid hydrocarbons.

With a view to combating climate change, Act no. 2017-1839 of 30 December 2017 putting an end to the exploration and exploitation of hydrocarbons and containing various provisions relating to energy and the environment aims to phase out the extraction of hydrocarbons in France by 1st January 2040.

The 2017 law therefore decided to stop issuing new exploration licences in order to gradually phase out the country's residual hydrocarbon production.

If new permits for hydrocarbon exploration throughout France can no longer be issued, holders of currently valid exploration permits may continue to obtain a concession, and holders of currently valid concessions may have their permits extended, subject to the conditions laid down by law. In all cases, the exploitation of these deposits may not exceed the deadline of 1st January 2040.

3.3.2. Refining

Despite a slight fall in fuel consumption, activity at France's 6 refineries remains buoyant, particularly with the halt in imports of refined products from Russia, especially diesel.

French refineries are committed to reducing their carbon footprint, sometimes by introducing co-processing. Some are transforming into biorefineries, such as La Mède in 2019 and Grandpuits by 2025. These transformations for the energy transition require significant technological adaptation and, consequently, major investment.

3.3.3. Biofuels and synthetic fuels

At present, most biofuel consumption comes from first-generation biofuels (known as "1G"), which are produced from agricultural resources that can also be used for food, and some of which are imported. In order to limit the impact of the production of these first-generation biofuels on food crops, their use is capped at in compliance with European legislation. The production of first-generation biofuels is integrated into the French agricultural and food industries. It enables the production of food co-products that are used in livestock farming (oilcake).

The current challenge is therefore to develop the production of so-called "advanced" biofuels, mainly derived from co-products, residues and waste that do not compete with food or are part of sustainable forest management. Biofuels will support the decarbonisation of mobility in segments where alternatives are difficult to implement, particularly where the decarbonised solution is not very mature or non-existent.

In the short term, the production of these advanced biofuels should complement the supply of 1G biofuels to start decarbonising heavy mobility (sea, river, air) in addition to land transport.

In the medium and long term, with the electrification of the vehicle fleet and the end of internal combustion engines in light vehicles, these fuels should enable greater decarbonisation of heavy mobility (air and sea transport, site machinery, agricultural and forestry machinery, rail and river transport, fishing, etc.). New synthetic fuel production facilities could also be developed to increase the decarbonisation of heavy mobility and limit the pressures and challenges of biomass supply/demand balancing.

Synthetic fuels will also play a role in decarbonising heavy mobility, particularly air and sea transport. European regulations already set targets for the incorporation of synthetic fuels, which should help to give visibility to project developers. The mechanism put in place to transpose the objectives of the REDIII directive should therefore contribute to the emergence of the first production projects in Europe, thereby contributing to our energy sovereignty.

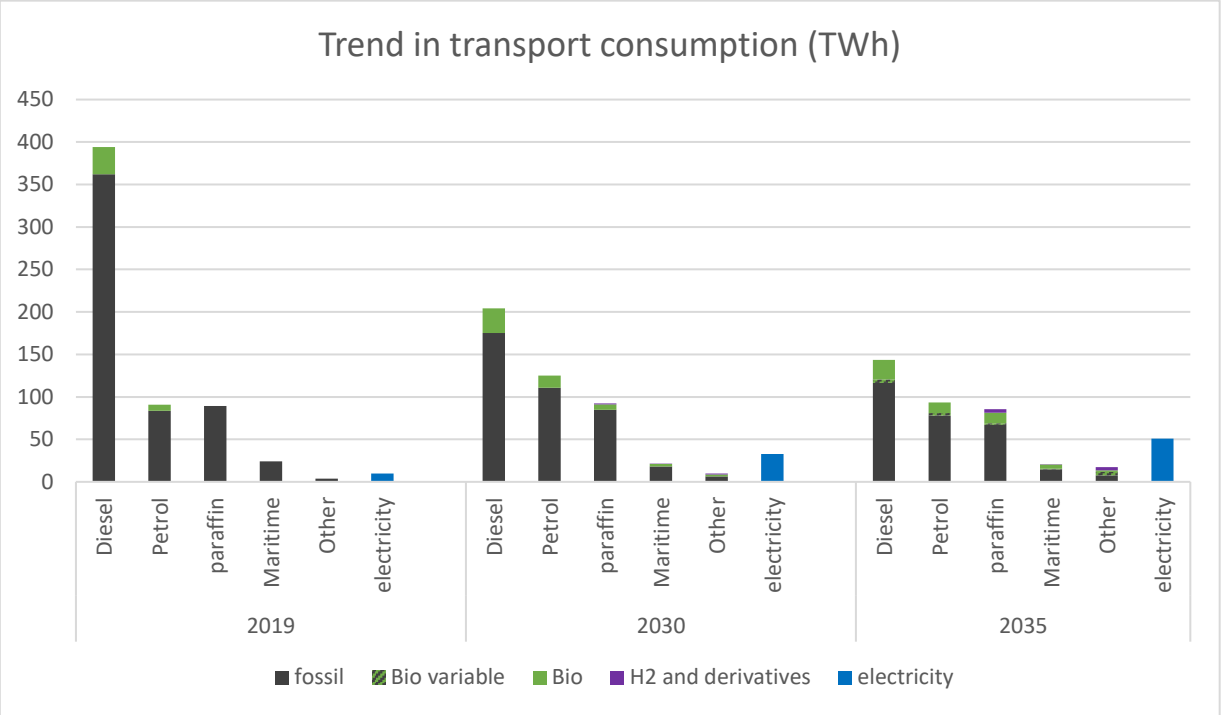


Figure21 . Trends in transport energy consumption (in TWh). As consumption data for 2020 and 2021 are affected by the COVID crisis, 2019 is used as the reference year.

In 2030, the need for biofuels for land, air and sea transport is estimated at 50-55 TWh in mainland France.

In 2035, the assumptions of the provisional energy-climate scenario could lead to consumption of around 70-90 TWh, for biofuels for transport, non-energy uses and overseas electricity production, and an increase for agriculture, maritime transport and the aviation sector.

National biofuel production in 2030 and 2035 is expected to be around 50 TWh. As is the case today, it will be based in part on imports of raw materials from sectors whose sustainability can be traced and secured (for used oils in particular).

It should be noted that the figures for biomass consumption and production are the subject of additional modelling, currently being finalised as part of the preparation of the SNBC, which may lead to a revision of the above trajectories.

The incentive tax on the use of renewable energy in transport (TIRUERT) sets a target for the incorporation of renewable energy into fuels. The principle of this system is that the incorporation of renewable energy means that the taxpayer does not have to pay this tax once the target has been reached.

In order to promote the biofuels with the highest greenhouse gas emission reduction rates, a new mechanism will replace the TIRUERT and will set greenhouse gas emission reduction targets, in the form of a reduction in carbon content per unit of energy used in the transport sector from well to wheel. An additional target for the use of renewable energy per fuel will also be imposed in order to ensure the contribution of these sectors to the reduction of GHG emissions, in line with the structure of the RED3 targets.

On the basis of the above trajectories (diesel and petrol consumption, volumes of biofuels to be incorporated, number of electric vehicles, quantity of electricity consumed in mobility, volume of hydrogen consumed in mobility), the proposed national trajectory for the new mechanism to reduce greenhouse gas emissions would be as follows.

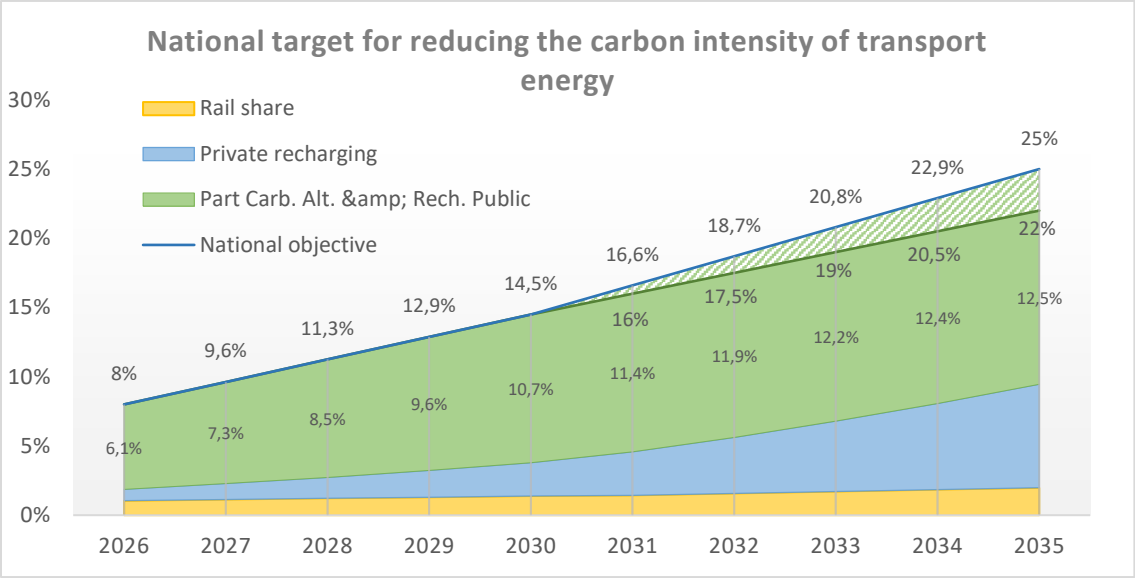


Figure22 . National trajectory and contribution of the mechanism to the objective of reducing GHG emissions from transport. By 2035, the target for reducing the carbon intensity of transport energy is between 22% and 25%.

The current TIRUERT Aviation will also be reviewed in order to take account of the provisions of the Refuel Aviation Regulation, which imposes specific incorporation targets for homogeneous aviation in the EU in volume terms for non-1G biofuels from 2025 and incorporation sub-targets for synthetic fuels from 2030, and to provide for their proper coordination with the RED III Directive.

For land transport, the basis for the mechanism could be changed to take account of CNG and LPG. Special measures could be taken to support the decarbonisation of vehicles that are more difficult to electrify, such as non-road vehicles (farm machinery, construction equipment, etc.).

ACTION CARB.1

SUPPORTING THE DEPLOYMENT OF BIOFUELS

→ Supporting the establishment of the first industrial facilities for the production of advanced biofuels, in particular for aviation and shipping;

→ Define a multi-year trajectory of fuel incorporation targets, to achieve a 14.5% reduction in the carbon intensity of transport energy by 2030[OBJ]. Consultation on this trajectory was launched in July 2023;

→ Supporting the adaptation of oil logistics to the development of biofuels, in particular by including biofuels in discussions on strategic storage..;

→ Direct consumption towards fuels with very high biofuel content (B100, etc.), and gradually direct it towards sectors that will have few alternatives in the long term (heavy construction machinery, agricultural machinery, air transport, maritime transport, fishing, etc.).

3.3.4. LPG

Liquefied petroleum gas (LPG) is used as a fuel. Although it accounts for only a small proportion of the primary energy consumed in France, when used as a fuel it is an important energy carrier in areas where there are no gas distribution networks. It is therefore key in certain rural areas, and the avenues proposed by the industry will be studied. For its use as a fuel, **the** use of low-carbon **LPG** could be encouraged through the mechanism encouraging the reduction of the carbon intensity of fuels. (see section 3.3.3 Biofuels and synthetic fuels).

3.4. Gases

3.4.1. Natural gas

Current situation and outlook for national natural gas production

France has few conventional natural gas resources. Commercial exploitation of the Lacq field, France's main natural gas field, is now limited and, since 2013, its production has no longer been injected into the grid but consumed directly on site. Law no. 2017-1839 of 30 December 2017 also provides for the phasing out of research and exploitation of new resources.

Natural gas supply

In the absence of significant domestic production, natural gas supply relies on imports. Two types of natural gas are distributed in France via separate networks: high-calorific gas or H-gas, which accounts for 94% of consumption, and low-calorific gas or L-gas. To ensure a high level of security of supply for H gas, France has built up an infrastructure comprising five interconnections for imports and five LNG terminals. This infrastructure provides access to diversified sources of natural gas.

The reduction in Russian gas exports to the European Union, starting in 2021, has significantly changed the origin of natural gas imported into France. Norway remains France's main supplier of natural gas, providing around a third of French H-gas imports (33% in 2023). Imports of liquefied natural gas (LNG) have risen sharply, with the United States now the second-largest source of H gas imported into France (25% of H gas imports in 2023), ahead of Russia (13%), Algeria (12%) and Qatar (6%). Generally speaking, the diversification of supply sources has tended to increase in recent years, with a reduction in imports from Russia and an increase in LNG imports.

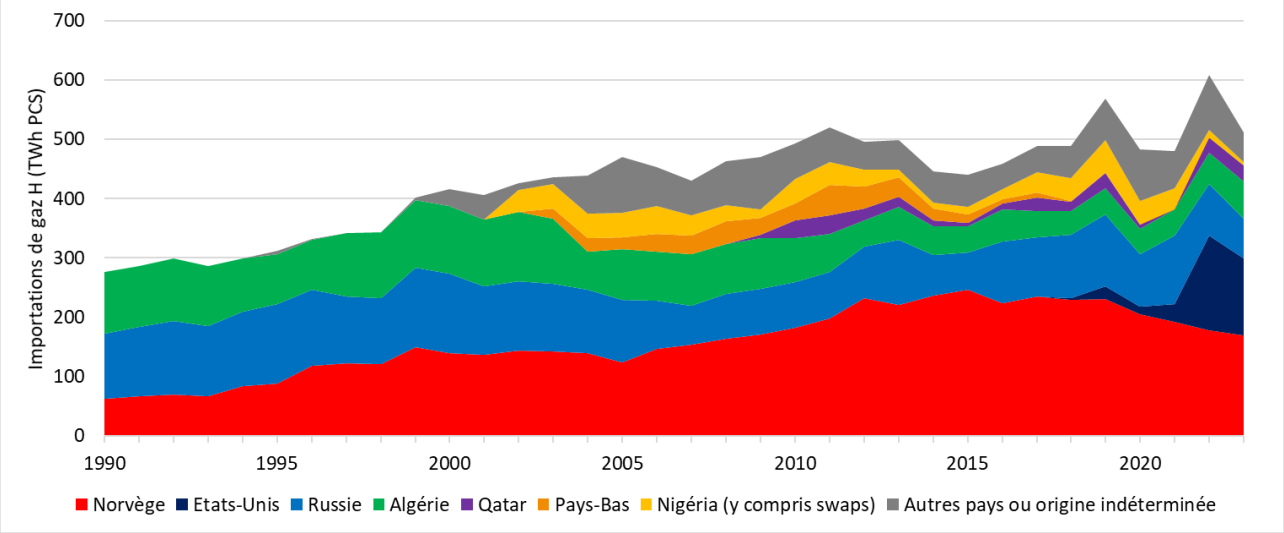


Figure23 . Origin of French imports of high-calorific natural gas since 1990 (source: SDES and GRTgaz)

The special case of low calorific value natural gas

Natural gas consumers in a large part of the Hauts-de-France region are supplied by a separate network with low calorific value natural gas, known as B gas. All B gas is imported from the Netherlands, and historically most of it was extracted from the Groningen field.

Following the observation of an increase in the frequency and intensity of seismic activity around the Groningen field, in an area hitherto classified as asismic, the Dutch government announced a reduction in the field's production ceiling, followed by a cessation of production in 2024. Exports continue from other sources, but are scheduled to cease in 2029.

In order to ensure continuity of supply for B gas consumers, a gradual conversion of the network to H gas has been launched. This is a large-scale operation, requiring changes to the natural gas transmission and distribution networks, as well as work at each consumer site to check that the various gas appliances (boilers, water heaters, gas cookers, furnaces and industrial equipment, etc.) can be supplied with H gas. Some appliances will have to be adjusted, adapted or even replaced in some cases, to guarantee the safety of people and property.

The operation to convert the network to low-calorific gas began in 2018 and will be completed by 2029 at the latest. It is being carried out in successive sections of the B gas network.

3.4.2. Renewable gas

At 30 June 2024, 694 facilities were injecting biomethane into natural gas networks. Their capacity amounted to 12.5 TWh/year, an increase of 5.9% compared with the end of 2023.

In 2030, the PPE 3 sets a target of 50 TWh of biogas production, of which 44 TWh will be injected into the gas network distributed in France, which would represent around 15% of network gas consumption. Achieving this target will require significant development of intermediate crops for energy purposes and greater use of livestock effluents and crop residues to produce injected biomethane. The value of developing intermediate crops between main crops for agro-ecological purposes should be emphasised, particularly in terms of carbon storage and reducing nitrogen losses. However, their development will have to take account of agronomic conditions and the place of energy crops in crop cycles. The use of intermediate crops and the mobilisation of livestock effluent for biogas production can reduce greenhouse gas emissions (methane), improve nitrogen management in agriculture and reduce the use of synthetic mineral fertilisers

By 2035, biogas production from methanisation could be between 50 and 85 TWh, in line with current assumptions for biomass production in this timeframe. Depending on their level of maturity and cost of deployment, other technologies (pyrogasification, hydrothermal gasification, etc.) exploiting non-competing resources, in particular those that cannot be used for methanisation, could enable this production to be increased still further.

It should be noted that the estimates biomass consumption and production are the subject of additional modelling, currently being finalised as part of the preparation of the SNBC, which may lead to a revision of the above trajectories.

In accordance with the provisions of the French Climate and Resilience Act, the policy of support for injected biomethane, which until now has been essentially based on a budgetary system of compulsory purchase, is to be supplemented from 2026 by an extra-budgetary system consisting of a compulsory incorporation obligation imposed on natural gas suppliers, who will have to obtain and return biomethane production certificates (CPB) to the State. The final texts required for this system to come into force were published in July 2024.

Although the cost of producing biomethane is still three to four times higher than the cost of natural gas, as a renewable gas it meets the major climate challenge of decarbonising natural gas consumption, but also the challenge of energy sovereignty by replacing our fossil gas imports with domestic biogas production, as well as the economic challenges of providing stable, secure additional income for many farms and, more broadly, development opportunities for French companies that are well positioned in the sector.

ACTION GAZ.1

SUPPORTING THE DEPLOYMENT OF RENEWABLE GASES

→ Define a trajectory for the obligation to surrender Biogas Production Certificates (CPBs) for the period 2028-2035, in line with the biomethane production targets of EPP3, taking into account both the necessary decarbonisation of gas consumption and the impact on the cost to consumers in a context of generally rising gas prices.

→ Adjust the level of public support from the open feed-in tariff (granted by tariff order) for small facilities with a forecast annual production of less than 25 GWh HCV per year, the aim of ensuring an overall balance between budgetary and extra-budgetary support for the development of injected biomethane.

Tighten controls on the proportion of main crops authorised for methanisation (currently set at);

3.4.3. Hydrogen

Every year in France, around 900,000 tonnes of hydrogen are produced from fossil sources, around half of which is co-produced, mainly for refining, fertiliser production and the chemical industry.

To achieve carbon neutrality, we need to :

→ Decarbonising existing uses of hydrogen (excluding co-products), in particular by producing hydrogen through water electrolysis

→ meet new needs for carbon-free hydrogen by prioritising both industrial and mobility uses, given the large volume of electricity required to produce hydrogen by electrolysis.

In 2020, France adopted an ambitious strategy to accelerate the deployment of hydrogen production by electrolysis and its use. This national strategy for the development of low-carbon hydrogen aims to master the entire value chain, its products and its key technologies. By supporting research and development projects through to industrialisation, as with the France 2030 programmes and the Major Project of Common European Interest (PIIEC) Hydrogen, the strategy aims to bring about the emergence of 5 gigafactories of electrolysers, as well as an industry of equipment manufacturers for hydrogen mobility.

Through the 2020-2021 recovery plan and the France 2030 investment plan, as well as the general budget, the French government has announced a commitment of almost €9 billion between now and 2030, with a dual objective of technological development and ecological transition.

The hydrogen strategy deployed since September 2020 has already supported around 300 MW of electrolysis capacity, both locally and on an industrial scale, in addition to the various investments already made across the value chain. However, this large-scale public effort at national level could prove insufficient to achieve the European objectives in this area, and efforts will be needed both from the private sector and via the European Union's financial instruments to support low-carbon hydrogen.

Several stakeholder consultations were held in 2023 and 2024, leading to the updating of the French hydrogen strategy in 2024.

The development of hydrogen produced by electrolysis will lead to an increase in the volumes of electricity passing through the electricity networks. To manage consumption peaks, the possibilities of reducing electrolysis consumption during these periods will be studied and encouraged. This reduction through occasional load shedding will contribute to the security of electricity supply. Flexible operating modes would also make it possible to concentrate hydrogen production during periods when cheap, low-carbon electricity is abundant, thereby optimising system operation. However, these possibilities presuppose the installation of hydrogen storage facilities to maintain a continuous supply of hydrogen to industrial customers

The updated target is to install up to 6.5 GW of electrolysers by 2030. This capacity will be supplied by France's carbon-free electricity mix, or by dedicated renewable electricity production facilities, depending on the economic optimum that is found for each installation

ACTION GAZ.2

PROMOTE THE USE OF LOW-CARBON HYDROGEN IN INDUSTRY, IN LINE WITH EUROPEAN AMBITIONS.

The Renewable Energy Directive (RED III) sets ambitious targets for the share of carbon-free hydrogen consumption in industry and transport. France will promote the need for EU support for all low-carbon energies

In addition to the various investments already made in hydrogen equipment, the government plans to launch a support mechanism for the production of renewable, low-carbon hydrogen for industry.

ACTION GAZ.3

CONTINUE TO DEPLOY HYDROGEN PRODUCTION, AS A PRIORITY NEAR MAJOR CENTRES

Hydrogen production will be supported in three ways: (i) "centralised" consumption centres in the largest industrial platforms (Fos-sur-Mer, Dunkirk, the Chemical Valley and the Seine Valley), (ii) "semi-centralised" centres around smaller industrial platforms and, (iii) if the economic results are positive, a more diffuse activity, limited to specific uses or to the need for a network for heavy or intensive mobility.

A special effort must be made to ensure that, by 2030, France's main industrial basins have the first production capacity for carbon-free hydrogen.

ACTION GAZ.4

ANTICIPATE THE DEVELOPMENT OF HYDROGEN :

Over the coming years, France will support the deployment of national hydrogen production. Priority infrastructure development will focus on intra-hub networks and their connection to storage infrastructures, in order to optimise the production, storage and use of hydrogen within these industrial hubs. The hydrogen network will have to be developed alongside the existing methane networks, given the distinct characteristics of the two gases, and the need to continue to dedicate the majority of current transmission networks to the transport of methane at least until 2035.

France will also continue the initial studies into the prospects and needs for imports, which the French government currently considers to be limited, and their implications in terms of developing and financing a major transport network. These prospects could involve ammonia and hydrogen derivatives in the future.

3.4.4. Recovered gas produced by gasification

The multi-annual energy programme may not define targets on this subject for 2035. At this stage, the SNBC scenario does not take into account significant volumes of gasification.

3.5. Electricity

Electricity currently accounts for just over a quarter of final energy consumption in France. Most of it is carbon-free, thanks to nuclear generation (around by 2022) and renewable generation (around 25% by 2022).

Despite an overall fall in energy consumption, electricity consumption is set to rise sharply as a result of the electrification (direct or via hydrogen or e-fuel) of many uses (transport, heating, industry, etc.), accounting for more than 50% of our energy consumption by 2050. This means that **there will be a clear shift in the need to develop decarbonised electrical energies from 2025 onwards, and that nuclear power generation will need to be brought back up to its 2022 level.**

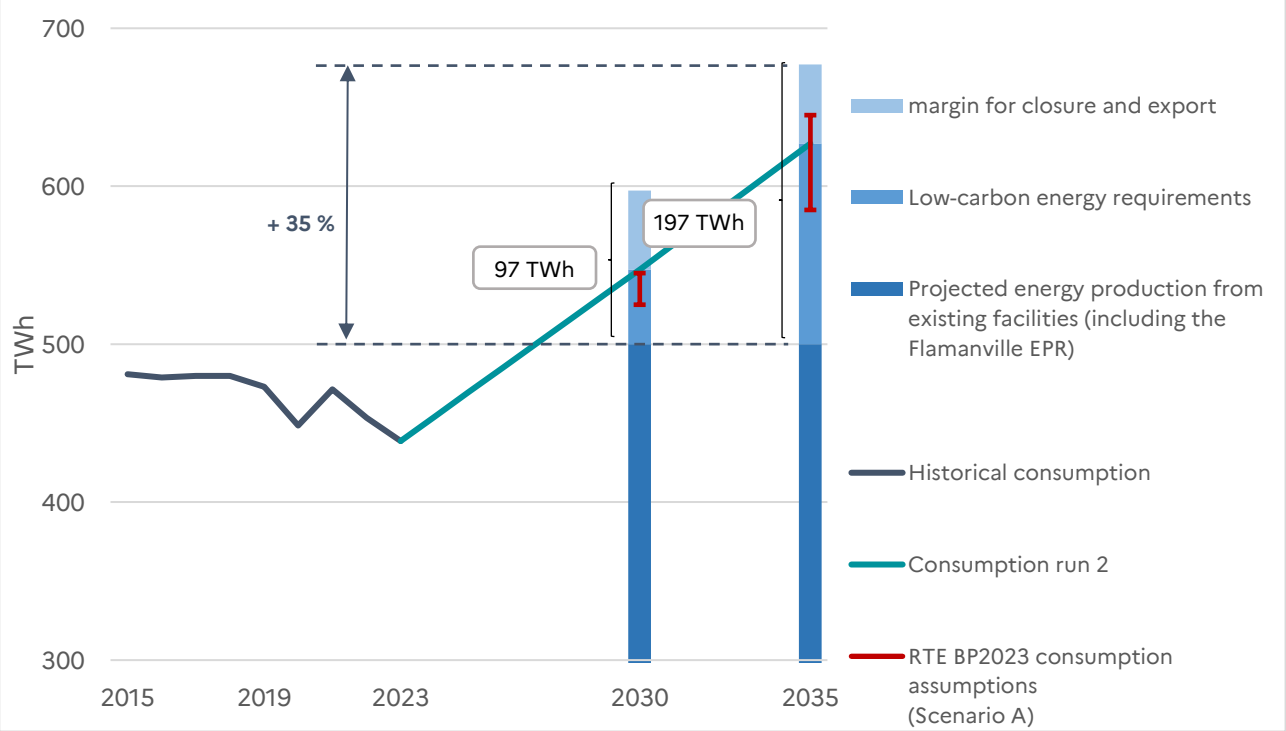


Figure24 . Projected electricity consumption in 2030 and 2035 (Source: SGPE/DGEC modelling)

In order to cope with these increases in consumption, it is necessary to rely on an electricity mix based on the two pillars of low-carbon production available - nuclear power, with increased production from the existing fleet and the construction of new reactors, and electric renewable energies, which will have to be developed significantly, taking into account the development times specific to each type of energy. Analyses, including those by RTE initially presented in its "Energy Futures 2050" report published at the end of 2021 and then confirmed by its 2023 forecast, have shown that the logic of adding low-carbon electricity production, through the development of renewable energies and the continued operation of existing nuclear reactors, increases the chances of achieving our climate targets and is economically efficient.

In addition to the projects already underway (Flamanville 3 reactor, onshore and offshore wind farms, photovoltaic projects) and the objective of improving the availability of existing nuclear reactors :

- **Between now and 2030**, 4 additional new offshore wind farms resulting from tenders 1 to 3 will be commissioned (the Saint-Nazaire, Fécamp and Saint-Brieuc wind farms have already been commissioned), **bringing the total number of offshore wind farms in service to 7**. The development of additional onshore wind and photovoltaic projects, which are the only ones capable of making a significant contribution to the increase in low-carbon electricity production capacity by this date, will continue

- **Between 2030 and 2035,** the commissioning of offshore wind farms currently being developed, awarded or planned, particularly following the planning exercise currently being finalised, will make a significant additional contribution, with **around fifteen more wind farms coming on stream**;
- **After 2035, the gradual deployment of the new EPR 2 and small modular or innovative nuclear reactors, as well as the continued operation of the existing fleet of nuclear reactors, will make** it possible to significantly bolster the electricity generation fleet, while continuing to develop renewable energies.

While the central scenario used in this document is a conservative one of nuclear generation of 360 TWh over the entire period, the objective given to EDF, and endorsed by the company's management as a managerial ambition, is to achieve annual nuclear generation in excess of 400 TWh. Like RTE in its Generation Adequacy Report, it has been decided to include in the modelling a conservative assumption of average annual generation of 360 TWh between now and 2035 in the event of unforeseen events. Compared with 2022, when nuclear generation was 280 TWh, this represents an increase in nuclear generation of 80 TWh in the median scenario and 120 TWh in the target scenario.

Priority will be given to all investments that will restore peak management capacity. Even if the total energy produced will not necessarily increase significantly because of the likely impact of climate change on water resources (reduced flow, multiple use of water), the development of total installed capacity will be a valuable lever for balancing the electricity system, both for peak consumption and for the total volume of production.

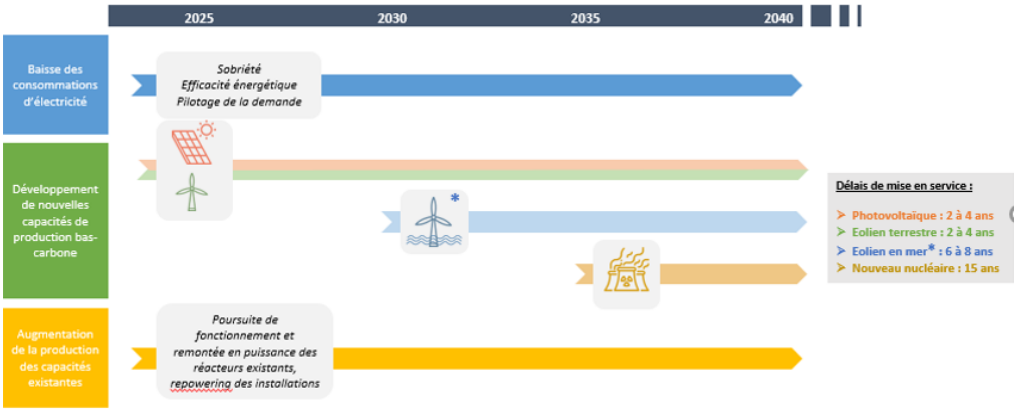


Figure25 . Temporality of the levers available to ensure the electricity energy loop[29]

The graphs below show the means of electricity production at the horizons of the EPP when the measures provided for in this EPP are adopted. Compliance with the low trajectories of EPP 3 implies additional production of electricity from renewable sources of just under 200 TWh in 2035 compared

[29] Offshore wind projects launched since 2010 will gradually join the production fleet, representing 3.6 GW in 2030, with 1.5 GW already in service by mid-2024. This graph therefore only shows the timeframe for the commissioning of new projects. This graph does not show the challenge of increasing nuclear output from the existing fleet, as it does not involve new capacity.

with 2022. In 2030, the EPP should lead to the production of around 206 TWh of electricity from renewable sources, 31.5 TWh from thermal sources and 360 TWh from nuclear sources, i.e. 35% of electricity production from renewable sources and 60% of electricity production from nuclear sources. In 2035, the EPP should lead to the production of at least 306 TWh of electricity from renewable sources, 25.5 TWh from thermal sources and 360 TWh from nuclear sources, i.e. 44% of electricity production from renewable sources and 52% of electricity production from nuclear sources

Electrical mix

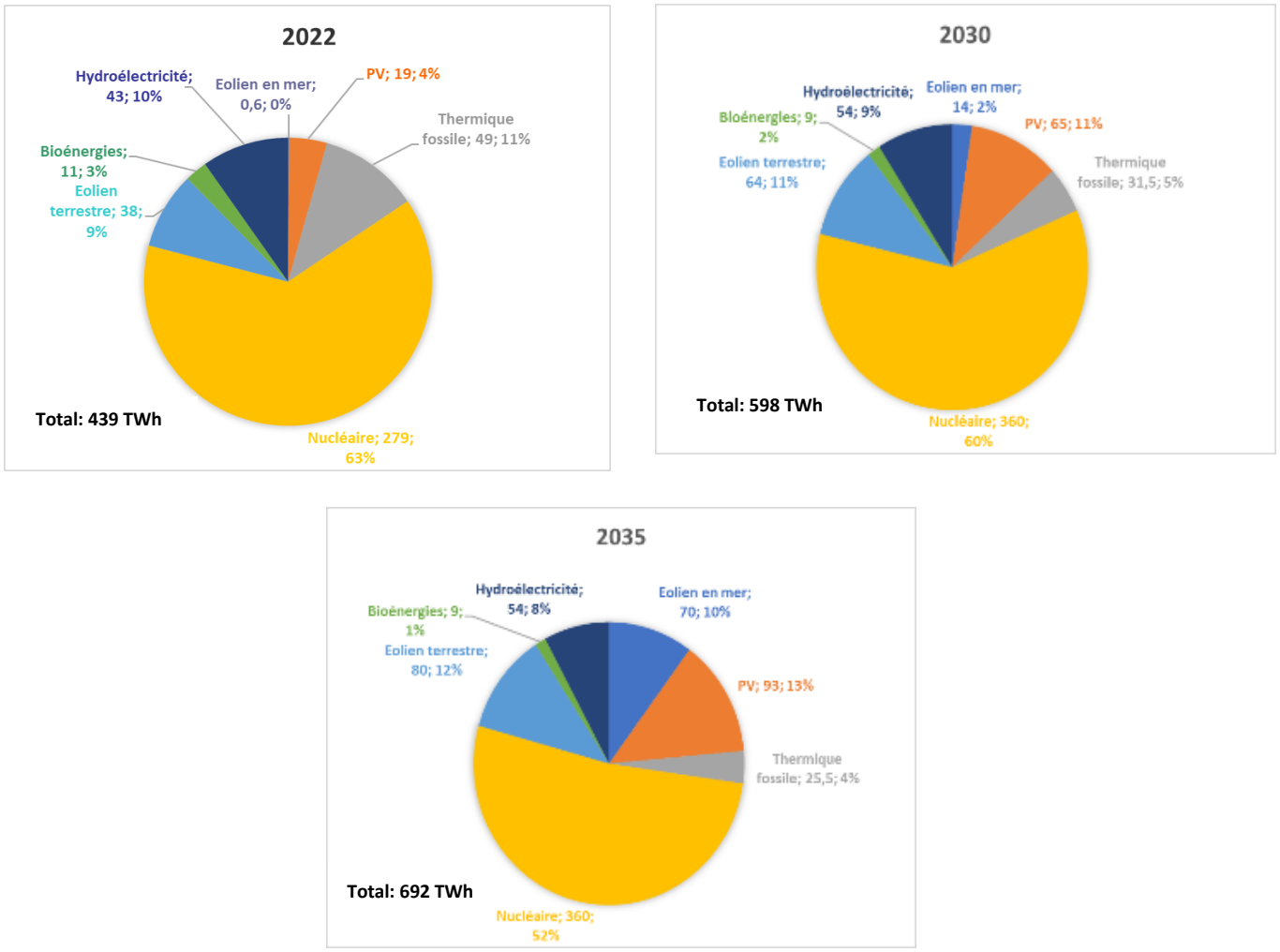


Figure26 . Electricity generation mix in 2022 and forecasts for 2030 and 2035 as set out in the PPE[30] (production volume of each type of electricity in TWh and share in the mix as a percentage)

Work currently underway on the third national plan for adapting to climate change **envisages incorporating the consequences of changes in consumption and production into** energy **planning**

[30] In accordance with article L. 141-4 of the Energy Code, the multi-annual energy plan will be updated at least every five years, to ensure that production and consumption targets are consistent up to 2035.

exercises: stress tests modelling extreme situations (heatwave or cold spell combined with periods without wind) will make it possible to estimate the resilience of the electricity system. Modelling is carried out by RTE as part of the preparation of the Generation Adequacy Reports

3.5.1. Renewable electrical energy

In 2035**, at least 197 TWh more electricity will need to be generated from renewable energies** than in 2022 in order to meet the growth in demand and ensure our security of supply (Figure 24). This will be made possible by the deliberate deployment of all types of renewable energy (photovoltaic, wind and hydroelectric), **reaching around 120 GW in 2030 and between 160 and 190 GW in 2035**

- For photovoltaics: **double the annual rate of development of new capacity compared** with recent yearsworking towards a balanced distribution between ground-mounted plants, large roofs and residential buildings;
    - For onshore wind power: **maintain the current rate of** deployment at 1.5 GW/year, ensuring a more balanced distribution of installations across the country and investing in the repowering of existing facilities.

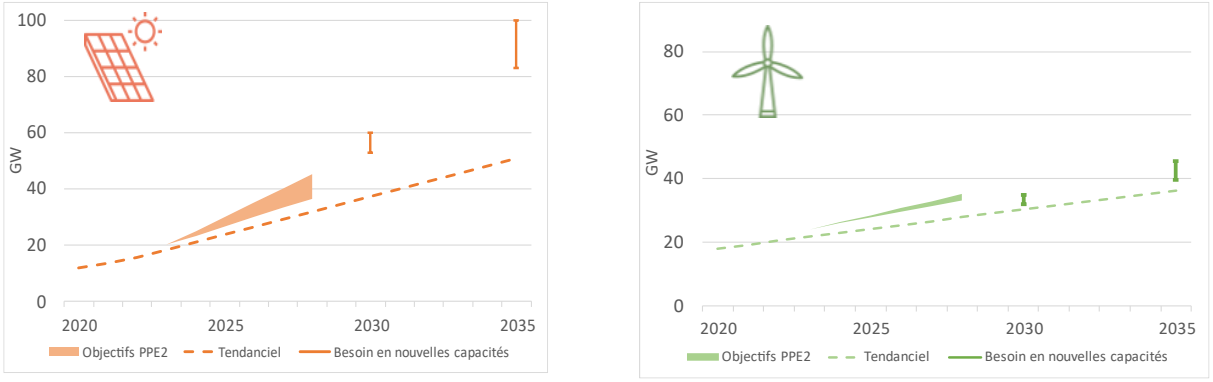


Figure27 . Onshore renewable energy development trajectory in GW (Source: DGEC modelling)

For offshore wind energy: **accelerate the rate at which offshore wind energy capacity is allocated, with the aim of achieving 18 GW of installed capacity by 2035**, (i) by drawing up a plan for each coastline, (ii) by launching one (or more) additional calls for tenders representing up to 10 GW (in addition to the procedures already launched), with the aim of awarding the contract by the end of 2026, and (iii) by continuing to develop the floating wind energy sector.

For hydroelectricity**: increase installed capacity by 2.8 GW by 2035,** largely on existing installations.

The EPP3 therefore reinforces the development of electric renewable energies and sets the following targets:

INSTALLED CAPACITY IN GW	2022	2030	2035
PHOTOVOLTAIC	15,9	54 à 60	75 à 100
ONSHORE WIND	20,6	33 à 35	40 à 45

OFFSHORE WIND ENERGY	0,5	3,6	18
HYDRO-ELECTRICITY (INCLUDING STEP)	25,7	26,3	28,5

Compliance with the low trajectories set out above will enable additional renewable electricity generation of just under 200 TWh in 2035 compared with 2022.

ENERGY GENERATED IN TWh	2022	2030	2035
PHOTOVOLTAIC	19	~65	~93
ONSHORE WIND	39	~64	~80
OFFSHORE WIND ENERGY	1	~14	~70
HYDRO-ELECTRICITY (EXCLUDING STEP)	43[31]	~54	~54
TOTAL	101	~197	~298
			i.e. +197 TWh compared with 2022

[31] This value is not representative given the exceptionally hot and dry conditions in 2022, which was the lowest year for hydroelectric generation since 1976. By way of illustration, the values for 2021 and 2023 were between 54 and 59 TWh

ACTION ENER ELEC.1

CONTINUING TO SUPPORT RENEWABLE ENERGY INDUSTRIES

→ Support projects to relocate key industrial sectors for the energy transition (solar, onshore and offshore wind, geothermal, heat pump, network industry), following on from the working group for the reindustrialisation of renewable sectors launched in January 2023 in :

- formalising an industry pact for key sectors, along the lines of the solar and offshore wind pacts
- mobilising all the facilities available under the Net Zero Industry Act, particularly in terms of organising calls for tender, to strengthen their strategic autonomy and resilience, making greater use of non-price criteria
- supporting innovation and the structuring of industrial sectors contributing to the energy transition and the large-scale development of renewable energies, in particular with the tools of the France 2030 Plan, the measures of the Green Industry Act of 23 October 2023, and the Green Industries Tax Credit (C3IV).

→ Pursue our strategy of securing supplies of critical metals for the energy transition (lithium, nickel, cobalt, copper, aluminium, rare earths, etc.) to control their value chains, from extraction to recycling. In addition to support for projects via the France 2030 "critical metals" call for projects, the green industries tax credit (C3IV) and the investment fund set up by the State in 2023, an update of the national mining inventory, through the launch of a campaign to identify our subsoil resources, will be launched in 2024.

→ Identify skills requirements and implement forward-looking skills management plans as part of a joint project between the State, the Regions and the sectors in order to attract, train and recruit the people needed to meet the objectives.

ACTION ENER ELEC.2

OPTIMISING PUBLIC SUPPORT SCHEMES WITH A VIEW TO CONTROLLING PUBLIC SPENDING

→ Optimise support systems to enable the optimum development of renewable energy projects at a controlled cost, particularly in the case of self-consumption by private individuals.

→ Evaluate the benefits of using mixed tenders, in which the remuneration supplement contract covers only part of the energy produced by the installation, particularly for offshore wind, with regard to the objective of securing projects and optimising public spending.

ACTION ENER ELEC.3

ACCELERATE LOCAL RENEWABLE ENERGY PLANNING UNDER THE 2023 LAW TO ACCELERATE RENEWABLE ENERGY PRODUCTION (APER)

→ Support local authorities in defining the renewable energy acceleration zones provided for by law, and the Regions in the work of the regional energy committees, and in updating their regional development, sustainable development and territorial equality plans (SRADDET) (see section 7.2 on mobilising the territories).

→ Encourage the consideration of biodiversity and landscape issues at the planning stage of renewable energy projects, in line with the guidelines of the National Biodiversity Strategy.

To achieve the ambitious development targets, the EPP sets out measures for each sector:

3.5.1.1. Photovoltaics

The aim is to increase the rate of development of solar energy to at least 5.5 GW/year, compared with 3 GW/year in the previous EPP, with a target of 7 GW/year

Photovoltaic projects on buildings and shading systems on car parks make it possible to minimise conflicts of use by creating synergies (provision of shade, self-consumption, etc.). It will be important to encourage the development of these projects through the obligations introduced by the Climate and Resilience Act and the Acceleration of Renewable Energy Production Act (APER), as well as by introducing appropriate financial incentives.

As the potential for low-cost projects on buildings is limited, we also need to develop ground-mounted photovoltaic systems, while limiting the impact of installations on natural, agricultural and forestry (NAF) areas, which are severely restricted by the Climate & Resilience Act (limitations on the consumption of NAF space, even though exemptions from space consumption have been introduced for photovoltaic systems on natural and agricultural areas) and the APER Act (severe restrictions on land eligible for ground-mounted photovoltaic development). Agri-voltaics, an emerging but promising sector, will be an important lever for achieving our photovoltaic development objectives, while providing direct services to agriculture, and thus promoting the resilience of the farming world, provided that the costs are kept under control

ACTION PV.1

PROMOTE A BALANCED DISTRIBUTION OF PHOTOVOLTAICS BETWEEN LARGE AND SMALL PHOTOVOLTAIC ROOFS, LARGE AND SMALL GROUND-MOUNTED POWER PLANTS, AND AGRIVOLTAICS

→ Work towards a **balanced distribution, taking into account the potentially higher costs of certain technologies and the need to minimise conflicts of use and impacts** (maximum use of derelict and degraded land, use of agrivoltaics).

The renewable energy planning work resulting from the APER law will provide an opportunity to specify the distribution of ground-based power plants between the different types of land that can be mobilised. As an indication, the following distribution could be envisaged:

- 55% on small and medium-sized roofs
- 10% on small ground-mounted installations
  35% on large-scale installations, of which 70% on the ground (including agrivoltaics) and 30% on roofs. The exact proportion of this target accounted for by solar farming remains to be determined, depending on the deployment possibilities for these installations, other photovoltaic installations and the needs of the farming community (see below

→ Support the emergence of agrivoltaic projects following the recent introduction of the regulatory framework for agrivoltaics under Article 54 of the Renewable Energy Acceleration Act, and continue to encourage its development.

→ Adapt public support schemes in line with the target distribution, taking into account the size of projects. Introduce support by tariff order for ground-mounted photovoltaic projects with a capacity of less than 1 MWp.

Focus on agrivoltaics :

Article 54 of the law on the acceleration of renewable energy production published on 10 March 2023 distinguishes :

- agri-voltaic projects that must provide a direct service to farming (one of the following 4: improving agronomic potential and impact, adapting to climate change, protecting against hazards, improving animal welfare) and guarantee, on the one hand, the maintenance of a significant main agricultural activity and, on the other, a sustainable income from it. Agrivoltaic installations must be reversible. (L. 314-36 of the French Energy Code).
- photovoltaic projects that are compatible with agricultural, pastoral or forestry activity (known as "compatible PV"), which may only be authorised on land identified in a departmental framework document drawn up on the recommendation of the departmental chamber of agriculture and identifying, in particular, uncultivated land or land that has not been farmed for at least ten years (R. 111-57 of the town planning code). These facilities must also be reversible (L. 111-29 and L. 111-32 of the Town Planning Code).
- the installation of greenhouses, sheds and shadehouses for agricultural use supporting photovoltaic panels. Their installation must be "necessary for the exercise of a significant agricultural, pastoral or forestry activity". Article L. 111-28 of the French Town Planning Code is designed to regulate the simultaneous installation of a greenhouse, hangar or shade house with a photovoltaic installation above it. The installation of photovoltaic panels on an existing greenhouse, hangar or shade structure does not fall within its scope.

The various provisions of the law were transcribed into a decree by the Conseil d'Etat, signed on 8 April 2024, accompanied by a decree on the development of agrivoltaics and the conditions for installing photovoltaic installations on agricultural, natural or forest land, published on 7 July 2024.

Because of the size of France's agricultural area (26.7 million hectares), agricultural land is a powerful lever for the development of photovoltaics (ground-mounted or agrivoltaics). As

an order of magnitude, less than 1% of France's utilised agricultural area would be required to meet photovoltaic development targets if these targets were to be met solely from agrivoltaics (assuming a ratio of 0.5MW/ha). Given that other photovoltaic development vectors need to be activated as a priority (car parks and buildings, wasteland and derelict land), only a small proportion of the usable agricultural area will need to be mobilised to achieve the photovoltaic development targets. As agrivoltaics is first and foremost a tool for serving agricultural activity, development targets will also depend on the needs of the farming community. Ground-mounted photovoltaic systems, excluding agrivoltaics, will be severely restricted by the provisions of article 54 of the APER law.

ACTION PV.2

SETTING UP GIGAFACTORIES IN FRANCE

France has several gigafactories on its territory, which should make it possible to produce up to 10 GW of components in various strategic links in the value chain by 2030 (3 to 5 GW in the silicon value chain, 5 to 10 GW of ingots & wafers, 5 to 10 GW of battery cells, 3 to 5 GW of solar glass, 3 GW of inverters).

3.5.1.2. Onshore wind power

To achieve the objective of maintaining the rate of development of onshore wind power at+ 1.5 GW/year, with a more balanced distribution between regions, the measures in this EPP are as follows:

ACTION EOL TERR.1

MAINTAINING THE PACE OF DEVELOPMENT OF ONSHORE WIND POWER WHILE MAINTAINING HIGH ENVIRONMENTAL QUALITY

→ Continue with calls for tenders in order to ensure sufficient profitability for projects and thus support the development of onshore wind power, taking repowering projects into account.

→ Invest in research and innovation programmes to reduce the impact of wind turbines on avifauna, in particular by studying and improving the effectiveness of detection-reaction systems.

→ Put in place a system to reduce light pollution, for example by means of detailed beaconing depending on the presence of aircraft in the vicinity of the wind turbines.

→ In addition to the mechanism introduced in the APER law, set up a planning system for the development of compensation radars to free up areas for onshore wind power in zones subject to servitudes by military and weather radars, in particular by allowing costs to be shared.

→ Develop the work of the Renewable Energy and Biodiversity Observatory set up by the OFB and Ademe, to capitalise on knowledge of the impacts of renewable energy projects and good practice in minimising them.

3.5.1.3. Offshore wind and other marine renewable energies

ONE OBJECTIVE: TO AIM FOR 18 GW OF INSTALLED CAPACITY BY 2035, BY DRAWING UP A PLAN FOR EACH COASTLINE, LAUNCHING PROCEDURES LEADING TO THE ALLOCATION OF UP TO 10 GW OF ADDITIONAL CAPACITY BY THE END OF 2026, AND CONTINUING TO DEVELOP THE FLOATING WIND ENERGY SECTOR.

Installed offshore wind capacity in 2030 is expected to be 3.6 GW, and the procedures for tenders 4 to 9, currently underway or awarded, will make it possible to reach a total capacity of around 10.5 in the following years. **The challenge will then be to achieve the target set out in the Offshore Wind Pact of 18 GW commissioned by 2035, via one or more multi-GW tenders, while creating the conditions for further ambitious development in the years that follow.**

While the development of offshore wind power has accelerated significantly since 2019, with extensions already identified for some wind farms, long-term planning is needed to achieve a target of more than 45 GW by 2050. **To this end, a public debate was held on the four coastlines of mainland France, from 20 November 2023 to 26 April 2024, under the aegis of the National Commission for Public Debate (CNDP)**, to discuss issues relating to the future of the sea, the coastline, marine biodiversity and offshore wind power. In particular, it aimed to **plan the priority project areas to be allocated under the current EPP, as well as to pre-identify** potentially larger **areas for longer-term projects (between 2040 and 2050).**

In order to secure the trajectory to 2035, the EPP 3 provides for the allocation of an additional 8 to 10 GW[32] by the end of 2026 (AO10), in locations identified at the end of the public debate. In line with the objectives of the Offshore Wind Pact, one or more new calls for tenders of equivalent size may be launched between now and 2030, so as to reach at least 26 GW in service by 2040.

[32] Subject to grid connection capacity.

Call for tenders	Provisional award date	Power	Location	Cumulative offshore wind power capacity
AO7	Early 2025	1.2 GW	South Atlantic	6.6 GW
AO8	Early 2025	1.5 GW	Centre-Manche	8.1 GW
AO9	End of 2025	2.7 GW	Southern Brittany (0.5 GW) Mediterranean (2x0.5 GW) South Atlantic (1.2 GW)	10.8 GW
AO10	End of 2026	At least 8 GW	Multi-façade	At least 18 GW in service by 2035
AO11 and above	2030-2031	According to AO10*.	Multi-façade	At least 26 GW in service by 2040 45 GW in service by 2050

* to reach at least 26 GW

The geographical distribution and the split between land-based and floating technologies of the wind farms in tenders 10 and subsequent tenders will be refined according to the map published in autumn 2024 following the public debates by facade.

In addition to the **objective of a cumulative capacity of 26 GW allocated by 2030-2031, it will be necessary to continue the rate of allocation, in line with the objective of at least 45 GW in service by 2050**. The location of the wind farms needed to meet the 2050 target will be the subject of new phases of public participation, in particular during the revision of the strategic documents for the French coastline.

With regard to other marine renewable energies**, a 250 MW hydrolic tender could be launched at the Raz Blanchard, with the aim of being awarded by 2030, with a target value of €120/MWh.** The timing will depend on the network studies launched by RTE for the connection of these projects.

Depending on the results of the first call for tenders and the evolution of technology costs, **one or more additional calls for tenders of 250 MW or 500 MW could be launched between now and 2035 in the Raz Blanchard and/or the Fromveur.**

ACTION ENER MAR.1

MOVING FROM A PROJECT-BY-PROJECT DEVELOPMENT APPROACH TO OVERALL PLANNING FOR EACH SEAFRONT

→ Include offshore wind power fully in the new maritime façade strategies to be adopted in 2025, by defining maps relating to the development of offshore wind power (following the public debate "la mer en débat" in 2024) taking into account the various issues (technical constraints, environment, landscape, fisheries, etc.).

→ Anticipate technical studies to characterise sites and initial environmental conditions in project areas and the work required for connection upstream of tendering procedures for offshore wind farms.

→ Launch and award by the end of 2026 a tender for around 8 to 10 GW of offshore wind[33] (including floating and land-based projects), in the areas resulting from the offshore wind planning exercise conducted in 2024, so as to ensure that 18 GW commissioned by 2035 is achieved.

→ Launch and award one or more invitations to tender by the end of 2030, in the areas resulting from the offshore wind planning exercise carried out in 2024, so as to reach 26 GW commissioned in 2040.

→ To support the development of port infrastructures required for the development of offshore wind energy, particularly floating wind energy.

→ Disseminate the results of the studies launched by the Offshore Wind Observatory since 2022 to avoid, reduce and compensate for the impacts of future projects.

→ **A 250 MW hydrolic tender could be launched at the Raz Blanchard, with a target award date of 2030 and a target value of €120/MWh,** depending on the connection capacities analysed by RTE**.**

→ Subject to the costs of the first commercial bids, award additional projects of 250 or 500 MW by 2035 in the Raz Blanchard and/or Fromveur areas

→ Continue to monitor the potential, cost and feasibility of other marine energies.

ACTION ENER MAR.2

CREATING MANUFACTURING AND ASSEMBLY CENTRES IN FRANCE

France is supporting the modernisation of existing industrial sites (manufacture of blades and nacelles) and the development of industrial facilities for the manufacture of foundations and turbines, and their key sub-components (permanent magnets, etc.), as well as the equipment needed for connection to the grid (offshore substations, high-voltage connection cables) and the port facilities needed for the development and maintenance of wind farms. In particular, the strategy aims to create centres for the manufacture and assembly of floats and their sub-components, and for turbine-float integration, in order to achieve a production capacity of around 1 GW/year on each coastline by 2030, with a view to commissioning 18 GW in 2035 and 45 GW in 2050.

3.5.1.4. Hydropower

With regard to hydroelectricity, which is currently the leading source of renewable electricity (42% of renewable electricity production and a total capacity of 25.9 GW in 2022), **the aim will be to increase installed capacity by 2.8 GW by 2035, largely on existing installations. This 2.8 GW will include around 1,700 MW of pumped storage stations - essential for increasing our electricity storage capacity - and, way of indication, around 610 MW on installations of more than 4.5 MW and 485 MW on installations of less than 4.5 MW.**

As part of the work underway on the third national plan for adapting to climate change, a number of measures are being considered to ensure the resilience of hydroelectric production facilities while

33 Subject to grid connection capacity.

maintaining a high level of production, part of the management of a portfolio of facilities of varying ages:

i. Continue the studies currently underway to estimate the impact of climate change on hydrology (Explore2) and ensure that operators take this into account.
ii. Continue to take account of the effects of climate change, in terms of the safety of structures, in particular through regular updates of hazard studies and bringing hydraulic structures into compliance.
iii. Integrate other water resource issues within hydroelectric reservoirs, with studies on the subject of multi-purpose WWTPs.

ACTION HYDRO.1

INCREASING THE HYDROELECTRIC CAPACITY AND FLEXIBILITY OF THE ELECTRICITY FLEET (INCLUDING STEPS)

→ Increase large-scale hydropower capacity (above 4.5 MW - and including the development of STEPs) by **almost 2,300 MW by 2035**, in particular by optimising and over-equipping existing facilities through, for example, adapting the existing regulatory and economic framework and resolving pre-contentious issues surrounding the renewal of hydropower concessions.

→ **Continue with calls for tenders or tariff decrees to support the development of small-scale hydroelectricity and introduce a scheme to support the renovation of authorised hydroelectric facilities** in operation**, for almost 485 MW by 2035**, while maintaining a high level of protection for biodiversity and the natural functions of watercourses, giving priority to projects with the least impact on aquatic environments and water quality, in line with France's European commitments.

3.5.1.5. Electricity generation from bioenergy

Biogas was first developed in the form of combined heat and power (CHP), but is now mainly injected into networks for direct, more efficient use. In order to encourage the methanisation of livestock effluent as close as possible to the farm, and with the aim of reducing greenhouse gas emissions from the agricultural sector, **cogeneration will still be possible in very specific situations, as** will the production of bioNGV on the farm, particularly when the biomass available is too far from the sites to be connected to the network, and provided that the heat produced is used efficiently.

3.5.2. Self-consumption and local energy production

Self-consumption means that an electricity producer consumes all or part of the electricity produced by its installation itself. There are two main categories of self-consumption:

- **Individual self-consumption** is defined in article L. 315-1 of the Energy Code as "*the fact that a producer, known as a self-producer, consumes all or part of the electricity produced by his installation himself on the same site*".
- **Collective self-consumption**, as set out in article L.315-2 of the Energy Code, occurs when *"electricity is supplied between one or more producers and one or more final consumers linked together within a legal entity*". Collective self-consumption can be described as extended when the participants are not on the same site, but meet criteria including geographical proximity

defined by order. The Order of 21 November 2019 sets a maximum power output of 3MW (0.5MW in ZNIs) and a maximum distance of 2km between the most distant participants for a single operation. This maximum distance can be extended to 10 and 20 km in rural and peri-urban areas.

Self-consumption of electricity is a fast-growing model, based mainly on photovoltaic operations. Most of these are small-scale projects run by private individuals, SMEs or local authorities. At 30 June 2024, there were almost 500,000 individual self-consumption installations, an increase of 79% in one year**, with a total installed capacity of 2.6 GW**. In terms of collective self-consumption, there were more than 400 active operations with a total installed capacity of almost 30 MW. The rate of deployment of these operations is also high, and their number is doubling every year .[34]

Self-consumption contributes to the development of new low-carbon renewable energy production capacity. By bringing production and consumption closer together, it puts consumers back at the centre of energy issues and gives them a stake in the development of renewable energies. It also brings other benefits:

- **Controlling electricity bills and strengthening energy independence:** For consumers, the impact on costs is direct, with electricity bills stabilised and reduced on the basis of the production costs of their facilities. As a result, they have better visibility of electricity costs and are less dependent on fluctuating market prices, at least for part of their consumption. Finally, they are encouraged to organise their consumption in line with production times.
- **Creating social links and local roots:** Self-consumption, whether collective or individual, makes it possible to offer local energy, by bringing production and consumption locations closer together. It can be a tool for local authorities to strengthen local synergies between different players in a given area. In this way, local authorities, private individuals and SMEs can work together on an energy project that provides them with shared benefits, particularly in economic terms.

While it does not seem appropriate to set a target for the development of self-consumption as such, it is important to make self-consumption part of the energy transition for the development of all types of renewable energy (photovoltaic in particular, but also onshore wind power, etc.).

ACTION AUTOCONSO.1

MAKING SELF-CONSUMPTION PART OF THE ENERGY TRANSITION LANDSCAPE FOR THE DEVELOPMENT OF ALL TYPES OF RENEWABLE ENERGIES

→ Strengthen incentives for self-consumption by homes and businesses, in particular through investment grants.

→ Plan to re-examine the economic model for self-consumption in order to adjust support schemes.

The government **is committed to developing this sector, in particular by making it easier for local authorities to use collective self-consumption** (exemption from the obligation to set up an annexed budget, easier possibilities for increasing the geographical scope of collective self-

[34] According to figures from the French ecological transition observatory run by Enedis (which covers around 95% of the distribution network)

consumption operations, etc.)**, but also by supporting self-consumption in calls for tenders,** with specific provisions and in tariff decrees.

3.5.3. The nuclear

France's nuclear fleet comprises 57 electricity-generating reactors at 18 different sites, with an installed capacity of 62.9 GWe. These reactors, operated by EDF, are all based on the same technology known as "pressurised water" and are divided into different standardised levels depending on the power of the reactors:

- 32 900 MWe reactors ;
- 20 1300 MWe reactors;
- 4 reactors of 1450 MWe ;
- 1 1650 MWe reactor, the Flamanville 3 EPR technology reactor, commissioned in May 2024.

By 2023, the nuclear fleet was generating 320 TWh, or around 65% of France's total electricity output.

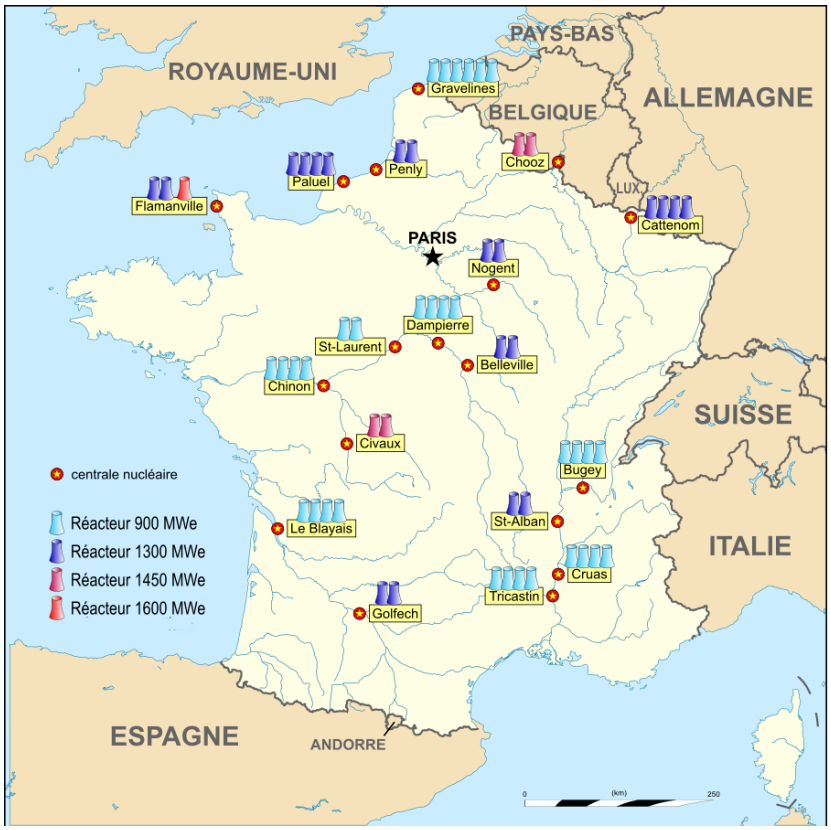


Figure28 . French nuclear power reactors in operation in 2024

The operating licence issued for each nuclear reactor is not limited in time. In addition to regular shutdowns for maintenance and refuelling, every ten years EDF must carry out a full safety review of each reactor, during which compliance with the initial authorisation is checked. In this context too, safety improvements are implemented to achieve a higher level of requirement. This level is continually reviewed by the French Nuclear Safety Authority (ASN) in the light of experience feedback, best available techniques and the work of the International Atomic Energy Agency (IAEA).

At the end of each review, the ASN decides whether the reactor in question should continue to operate.

Of the reactors in operation in 2024, 52 were commissioned during a period of around 15 years between 1979 and 1994. At the end of 2023, the operating life of reactors in service in France was between 21 years (Civaux 2) and 44 years (Bugey 2), with an average of 37 years.

The choice of a strategy for managing the timetable for the final shutdown of the oldest reactors is an important issue. In its "Energy Futures 2050" report, RTE points out that a marked reduction in nuclear generation capacity by 2050 would make security of supply dependent on risky technological and industrial bets (risk of a "cliff effect"). Maintaining the option of retaining a significant proportion of nuclear-generated electricity in the French mix by 2050 means planning a shutdown schedule for existing reactors that is compatible with the commissioning of new generation capacity, in order to ensure that needs are covered.

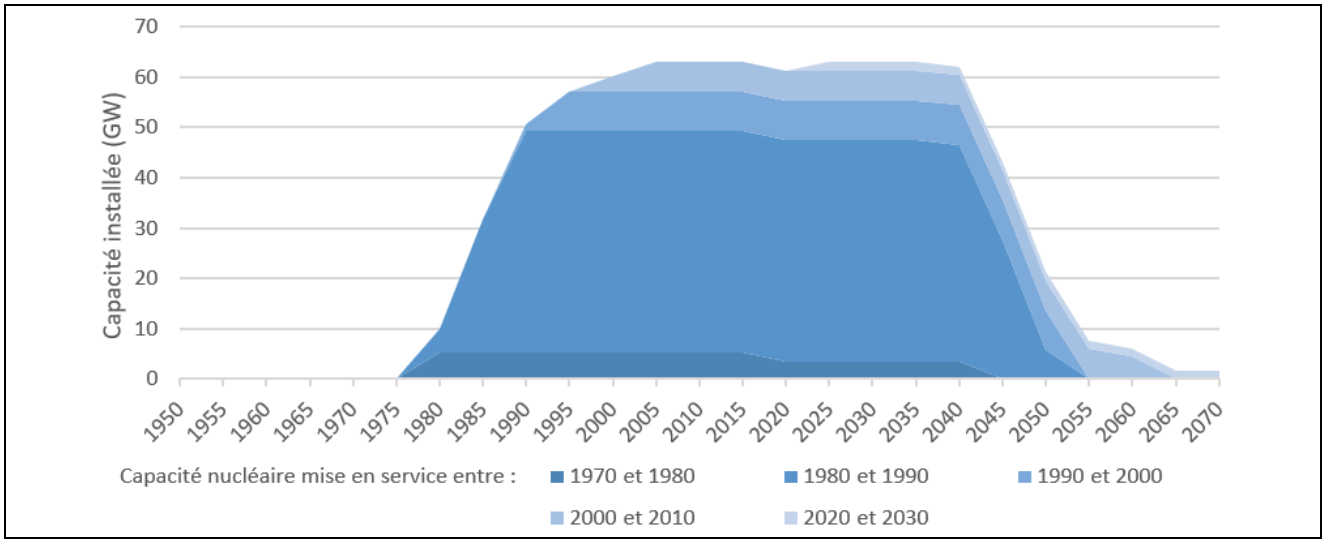


Figure29 . Illustration of the risk of a "cliff effect" in the event of a large number of reactors being shut down over a relatively short period.

In addition, with a view to shutting down most of the reactors currently in operation over a relatively short period, the 2019-2028 multiannual energy plan (PPE2) has asked the nuclear industry to study ways of building new capacity:

- The EPR2 reactor, developed by EDF, is the technology available in the short term in the high-power segment (around 1,650 MWe). It is adapted to the characteristics of the French electricity grid.

- The development of Small Modular Reactors (SMRs), with outputs ranging from a few tens of MWe to around 300 MWe, has also been launched at less advanced stages of maturity, in particular with the support of the France Relance and France 2030 plans. This low-power offer could complement the high-power reactors and would also be intended for export.

Lastly, Act no. 2023-491 of 22 June 2023 on the acceleration of procedures relating to the construction of new nuclear facilities near existing nuclear sites and the operation of existing facilities repealed the target of achieving a 50% nuclear share of the electricity mix by 2035.

France also has an industry that covers the manufacture and supply of fuel to reactors and the management of spent fuel, from ore extraction to waste management, including the reprocessing and recovery of spent nuclear fuel.

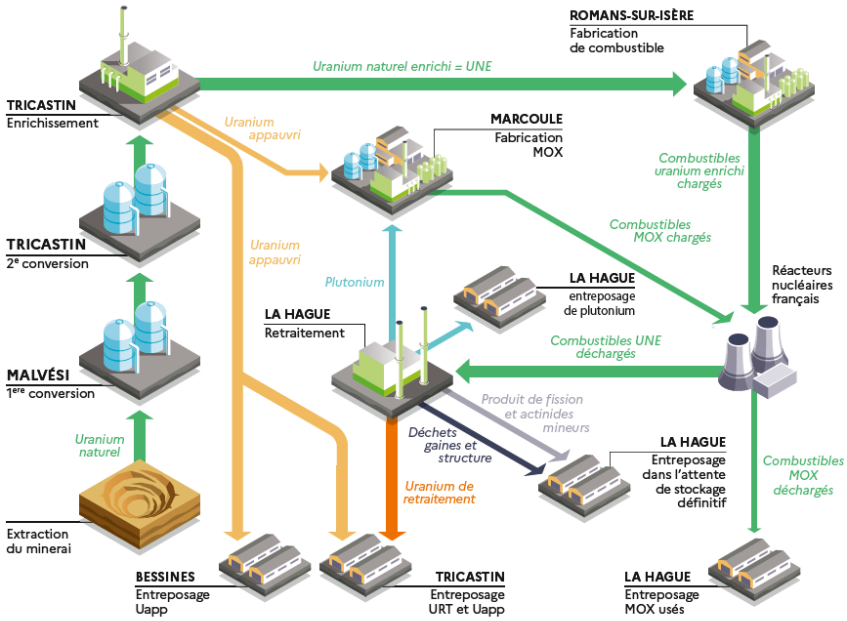


Figure30 . French nuclear fuel cycle facilities in 2024

The fuels used in nuclear reactors are most often composed of enriched natural uranium oxide (UNE). Spent UNE fuel can be reprocessed on an industrial scale at the La Hague plant (Manche). Plutonium from reprocessing is used at the Mélox plant in Marcoule (Gard) to manufacture MOx fuel[35] , while uranium from reprocessing (URT) is used to manufacture enriched reprocessing uranium (URE) fuel. Residual radioactive waste (high-level waste (HLW) in the form of standard compacted (CSD-C) or vitrified (CSD-V) packages) is destined for deep geological disposal in the planned Cigéo facility (Meuse). Spent MOx and ERU fuels are stored pending their subsequent reprocessing.

This strategy, known as mono-recycling of spent fuel, was put in place in France as the first step towards closing the fuel cycle, which is based on the use in fast neutron reactors (RNR) of substances resulting from nuclear reactions that are not currently recovered industrially. The current strategy is already likely to meet the objectives of energy independence and sovereignty, since it offers the potential to reduce France's need for natural uranium by 10% through the MOx option and by a further 15% through the ERU option, giving a total reduction of 25%. These savings reduce France's exposure to geopolitical uncertainties and could prove invaluable in the event of global growth in fuel demand. This strategy also contributes to reducing the environmental impact of the nuclear sector, to the economic development of the regions where the plants are located and to France's trade balance.

In addition, Orano, EDF, CEA and Framatome are taking part in a programme of R&D and associated industrial feasibility studies supported by France 2030 to study the benefits of multi-recycling uranium and plutonium in PWRs (MRREP) in terms of economic competitiveness and materials and waste management, in line with the requirements of the previous PPE. In the medium term, the multi-recycling of plutonium and TRU could represent an additional step in the recovery of used fuel and the saving of uranium resources, up to 40% compared with an open cycle.

The French nuclear industry's mastery of the full range of nuclear expertise is a competitive advantage for many companies in the export market and makes a major contribution to France's energy independence. The work and projects underway to continue operating the existing fleet, to build new reactors and to develop innovative nuclear power are mobilising the industry's industrial

[35] Mixture of plutonium oxide and depleted uranium oxide resulting from the enrichment of natural uranium.

players. The industry is well prepared, notably through initiatives that complement the performance plans of major contractors, such as the "MATCH" programme of the French nuclear energy industry group GIFEN and the work of the University of Nuclear Professions (UMN), which should enable the French nuclear industry to meet the challenge of revitalising itself and ensuring a competitive supply of low-carbon electricity in the coming years.

ACTION NUC.1

CONTINUE TO OPERATE NUCLEAR POWER REACTORS AFTER 50 YEARS AND THEN 60 YEARS, AS LONG AS ALL APPLICABLE SAFETY REQUIREMENTS ARE MET.

Existing nuclear power reactors will continue to operate, taking into account international best practice, including allowing them to operate after 50 years and then 60 years of operation, as long as all applicable safety requirements are met. In accordance with the law, the ten-yearly safety reviews will periodically validate the ability of each reactor to continue operating. EDF will conduct studies, in conjunction with the French Nuclear Safety Authority (ASN), to clarify the operating prospects for the existing nuclear fleet after 50 and 60 years, including the necessary considerations on adapting reactors to climate change.

ACTION NUC.2

INCREASING THE AVAILABLE POWER OF EXISTING REACTORS AND RESTORING THE HIGHEST LEVELS OF OPERATIONAL PERFORMANCE.

EDF is carrying out a programme of work to increase the available power of existing reactors during scheduled maintenance, in compliance with the applicable nuclear safety provisions. Nuclear production forecasts for the coming years will take into account the increase in nuclear capacity that would result from the implementation of this programme. The French government has asked EDF to set itself the objective of restoring the highest levels of operational performance, with the target of restoring nuclear generation to 400 TWh by 2030. The central scenario of the EPP assumes generation of 360 TWh.

ACTION NUC.3

CONFIRM THE LAUNCH OF EDF'S INDUSTRIAL PROGRAMME TO BUILD THREE PAIRS OF EPR2 REACTORS.

EDF is carrying out a programme to build 6 new EPR2 nuclear reactors, with two reactors on the Penly site, two on the Gravelines site and two reactors on the Bugey site. The French government confirms its support for this programme and is looking forward to a final investment decision by EDF's Board of Directors, with a view to launching the project by 2026 at the latest.

ACTION NUC.4

FURTHER STUDY OF A POSSIBLE REINFORCEMENT OF THE ELECTRONUCLEAR PROGRAMME.

The French government will study in greater depth the possibility of strengthening the nuclear power programme with EDF and the operators concerned, in order to examine questions relating to the sizing, the right needs and the adaptation of the EPR2 design, so as to be in a position, by 2026, to take a decision on the construction of a possible second stage of at least 13 GW, corresponding to the capacity of 8 EPR2s in their current design.

ACTION NUC.5

ENCOURAGING THE DEVELOPMENT OF SMR AND SMALL INNOVATIVE REACTORS.

The French government will continue to support breakthrough innovation through the France 2030 plan, with aim of achieving a first concrete design for a small modular pressurised water reactor and launching at least one prototype of an innovative small nuclear reactor using a different technology by 2030. This target may be updated between now and that date. The French government will continue its work to assess the appropriateness of deploying such reactors in France, particularly in terms of their contribution to heat production, hydrogen production and fuel cycle closure. The government will also prepare, where appropriate, the identification of relevant sites and will complete the review of the applicable legislative and regulatory framework, with a view to preparing any adjustments that may be considered necessary to ensure that the framework is appropriate to the issues at stake.

ACTION NUC.6

PURSUE THE NUCLEAR FUEL REPROCESSING AND RECOVERY STRATEGY AND COMPLETE WORK ON RENEWING BACK-END CYCLE FACILITIES.

The nuclear fuel reprocessing and recovery strategy will be pursued over the period of the EPP and beyond. With a view to renewing downstream nuclear cycle facilities, the nuclear industry will, by the end of 2026, under the supervision of the French government, carry out work aimed at defining the most appropriate industrial scenarios for the future of the post-2040 fuel cycle, the financing arrangements and the associated decision-making timetable, while taking care to promote the sustainable management of radioactive substances, security of supply and cost control.

ACTION NUC.7

DEFINE A NEW ROADMAP AND BEGIN WORK ON CLOSING THE CYCLE AND SETTING UP A FLEET OF RNR IN FRANCE.

The development of fast neutron reactors (RNR) would make it possible to become permanently independent of natural uranium supplies by reprocessing all the associated spent fuel. The production of radioactive waste would also be reduced.

However, the existing facilities can neither industrially manufacture fuel for use in fast breeder reactors nor industrially reprocess spent fuel from fast breeder reactors. What's more, their

operation is scheduled to end in 2040. However, the time between the introduction of a fuel into a reactor and the recovery of the materials resulting from its reprocessing is around 20 years.

The industry will continue its work on multi-recycling in PWRs and will include it in a roadmap that it will define by 2026 at the latest, in conjunction with the CEA, with a view to identifying the technological and decision-making milestones that will make it possible to set up a fleet of PWRs and associated fuel cycle facilities in France by the end of the century at the latest.

In addition, the industry will work with the CEA to qualify the fuel requirements associated with new innovative nuclear reactor concepts and the fuel cycle adaptations to be considered, with a view to identifying the relevant time horizons. The CEA and the nuclear industry will also ensure that their work on closing the fuel cycle is consistent with the work being carried out by the nuclear industry on the future of industrial facilities downstream of the nuclear fuel cycle.

ACTION NUC.8

IMPLEMENT A EUROPEAN INDUSTRIAL PROCESS FOR THE CONVERSION AND ENRICHMENT OF REPROCESSED URANIUM.

The French industry will continue its work on the installation of a TRU conversion plant in Europe, with a capacity enabling EDF to cover its needs from 2030.

ACTION NUC.9

MAINTAIN A CUTTING-EDGE NUCLEAR RESEARCH CAPABILITY ACROSS THE FULL RANGE OF GOVERNMENT NUCLEAR POLICY PRIORITIES.

In conjunction with the French nuclear industry, the CEA will carry out a programme of investment in nuclear research infrastructure to maintain a cutting-edge nuclear research capacity across all the priorities of the French government's nuclear policy.

During the future EPP, the national radioactive materials and waste management plan (PNGMDR) will continue to be the planning document in this area, whose guidelines (in particular the implementation of Cigéo) will be followed. The current plan covers the period 2022-2026 and is due to be updated at the end of this period.

3.5.4. Thermal power plants

The 2019 energy-climate law provided for regulatory tools to enable the last coal-fired power plants to be closed. The Gardanne coal-fired power station will close in 2021, as will the Le Havre plant. In addition, in accordance with the provisions of article 8 of the decree of 21 April 2020 relating to the multi-annual energy programme (PPE 2), no new fossil-fired power station of more than 20 MW (10 MW for power stations using fossil fuels other than natural gas and coal as their main fuel) may be authorised.

Following the energy crisis linked to the war in Ukraine and the drop in availability of the French nuclear fleet in 2022, Law 2022-1158 of 16 August 2022 on emergency measures to protect purchasing power authorised the Cordemais and Saint-Avold power stations to operate **under** a

derogation from the 2019 energy-climate law, with an obligation to fully offset the carbon emissions linked to these activities.

Even with these derogations, total coal-fired electricity generation in 2022 remained lower than in 2021 (2.9 TWh or 0.6% of total generation) and at a significantly lower level than that observed up to 2017 (9.7 TWh).

While the exceptional measures taken in 2022 **do not call into question the objective of closing coal-fired power stations, it is important that this transition is made while preserving France's security of energy supply** (see section 5.3.2).

RTE's analyses show that the use of peak fossil-fired generation (oil-fired combustion turbines, coal-fired power stations) will remain very limited during winter peak demand periods, and compatible with current emission ceilings. In its latest projections, RTE confirms that closure by 2027 is compatible with compliance with the security of supply criterion, given the development of generating capacity envisaged by that date and in a context where electricity consumption increases in a controlled manner. The decarbonisation of the fossil-fired fleet will therefore require the cessation of coal-fired power generation by 2027.

On the other hand, existing gas-fired power stations and combustion turbines remain necessary for security of supply. While some of the oldest combustion turbines may have to be closed, the objective for the rest is to use low-carbon fuels to replace fuel oil by 2030.

ACTION THERM.1

DECARBONISING THE FOSSIL FUEL FLEET

→ No new power stations will be built to produce electricity exclusively from fossil fuels.
→ **Remove the regulatory obstacles** to decarbonising existing oil-fired combustion turbines by using biofuels (in particular hydrotreated vegetable oil), paying particular attention to the conversion of production facilities in overseas France and to the availability and sustainability of the biofuels used.
→ **Launch studies and/or pilot sites** for the conversion and, where appropriate, construction of other peak thermal power stations using 100% decarbonised energy sources, paying particular attention to the availability of biomass.
→ **Organising and supporting the** end of coal-fired electricity generation.

•4. Security of supply, optimisation of the electricity system and development of networks

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

In addition to this objective of balancing supply and demand, the French strategy fully integrates the objective of energy sovereignty, to free ourselves from our current dependence on imported fossil fuels. Strengthening domestic production on the one hand, and diversity of supply sources on the other, are key.

As far as natural gas is concerned, the rapid decline in Russian gas exports from mid-2021 has created tensions across Europe. A large part of Europe's supply, historically provided by Russian gas imports by pipeline, has had to switch to imports of liquefied natural gas (LNG) by ship. France mobilised all

its resources to ensure that as much natural gas as possible could be exported to neighbouring countries (Belgium, Germany) that had been hard hit by the reduction in Russian gas exports.

In March 2022, at the Declaration of Versailles, the Member States of the European Union agreed to phase out their dependence on Russian gas, oil and coal imports as soon as possible. France has supported a ban on Russian coal imports, as well as a progressive ban on imports of crude oil and petroleum products originating in Russia, and supports work towards a ban on Russian gas imports.

This new PPE reassesses the relevance of gas storage infrastructures in the light of changes in our consumption and the new context of natural gas supply.

At the same time, the challenges of maintaining the existing nuclear generation fleet mean that we need to be even more vigilant about the security of our electricity supply, especially given the future growth in electricity consumption. Compared with the previous EPP, EPP 3 will focus on studying and promoting the resilience and optimisation of our electricity system, in particular by means of stress tests. It will also pursue the objective of controlling peak consumption. In addition to the objective of developing load shedding, it will be based the development of a range of flexibility options: demand management (consumption modulation), battery storage, controllable generation resources such as nuclear power plants, pumped storage power stations (STEP), decarbonised thermal power plants and interconnections.

4.1. Security of supply for liquid fuels

Security of fuel supply consists of ensuring continuity in the distribution of liquid fuels produced locally from crude oil processed in refineries and imported, taking into account the various risks facing the oil system, in particular climatic hazards and loss of supply sources, as well as the continuity of oil logistics.

In oil logistics, the aim of security of supply is to ensure the continuity of flows and the building up of stocks by oil operators.

The level of strategic stocks in mainland France, reassessed annually, is slightly higher than European regulations (Directive 2006/67/EC) and France's commitment to the International Energy Agency.

Throughout the energy-climate trajectory, the government is ensuring that oil logistics evolve to support the energy transition, with the aim of ensuring the country's sovereignty:

- developments in refining to ensure the production of alternative fuels in France and to reduce the use of fossil fuels in processes,
- adapting transport, storage and distribution infrastructures and changing the business model for service stations to reflect changing usage patterns, while maintaining a sufficient network of service stations to avoid the creation of "white zones".

Increased local production of biofuels will help reduce France's current heavy dependence on imports of crude oil and refined products.

The actions planned to adapt the networks are presented in section 4.6.2 below.

4.1.1. National issues: refining and strategic stocks

- **Refining**

Refining in France (see section 3.3.2 Refining) is a factor of energy resilience, particularly in the face of geopolitical uncertainties.

Refining in mainland France is on a downward trend, with the closure of 6 refineries since 2011, but it deserves not to decline too quickly, as it makes a major contribution to national energy security and to the supply of downstream petrochemicals, producing the main platform molecules that feed into industrial value chains. Operators are also being encouraged to anticipate the consequences of climate change by adapting their infrastructures in advance.

- **Strategic stocks**

Strategic petroleum stocks are built up to enable a collective response to major disruptions in the supply of petroleum products. They are made up of the following products: crude oil, diesel, petrol, domestic heating oil and jet fuel

With the reduction in the use of fossil fuels and the development of the production of so-called "advanced" biofuels and synthetic fuels (see section 3.3.3 "Biofuels and synthetic fuels"), measures to guarantee the security of fuel supply will have to evolve and take account of the energy transition, in consultation with the dedicated governance of the European Union and the International Energy Agency.

It does not appear necessary to build up specific stocks of low-carbon liquid fuels (LCLC) in the short term, particularly for diesel, excluding non-substitutable fuels, given the limited share of LCLC in road fuels. However, it should be noted that some fuels benefit from special tax and regulatory provisions, and that the fuel mix will change as part of the energy transition. Changes in consumption will influence the need for strategic storage, which contributes directly to security of supply.

The reduction in diesel consumption in favour of petrol has already been taken into account.

ACTION LOG PET 1

MONITORING TRENDS IN THE CONSUMPTION OF LOW-CARBON FUELS WITH A VIEW TO BUILDING UP STRATEGIC STOCKS

→ To monitor the situation of liquid fuels, particularly non-substitutable fuels, in the light of the increase in the release of certain qualities for consumption, with a view to providing input for consultation with the European Union and the International Energy Agency on changes to strategic oil stocks obligations.

Lastly, a national strategic stock location plan is updated annually to ensure the distribution of strategic storage, which helps to maintain intermediate fuel depots at regional level.

ACTION LOG PET 2

MONITORING THE NETWORK OF STRATEGIC STOCKS TO ENSURE THAT THEY ARE PROPERLY DISTRIBUTED

→ Maintain annual monitoring of the location of strategic oil stocks, to ensure security of supply within the territories.

4.1.2. Local issues: intermediate logistics and service stations

- **Intermediate logistics**

During the energy transition, care must be taken not to suddenly disrupt oil logistics in France, and in particular the intermediate depots, which provide a national network, to enable a gradual transition. In fact, fuel consumption needs will gradually decline, making it necessary, at least until 2040, to maintain a petroleum product storage and distribution infrastructure that is appropriate and capable of meeting environmental and security of supply challenges. With fossil fuels set to decline, all infrastructure is subject to regulatory constraints (in particular to limit industrial risks and environmental impact), requiring financial investment that could become less profitable

- **Service stations**

Service stations also require special attention to ensure that they are properly distributed across the country, both in terms of maintaining a fuel distribution service and in terms of their role in deploying alternative energies and maintaining services in rural areas.
Those that distribute more than 500 m3 of fuel per year are required to declare the prices charged at their stations (decree of 8 July 1988) on the "prix-carburants.gouv.fr" website, which gives the authorities detailed knowledge of most of the French network.

Recent projects aimed at helping service stations in difficulty to modernise and diversify their infrastructures involve identifying service stations likely to benefit from financial aid.

ACTION LOG PET 3

SUPPORTING SERVICE STATIONS IN THEIR TRANSFORMATION

Measures are planned to support the independent service stations that are essential to the regional network:
→ Provide long-term support for independent service stations as they diversify their activities (installation of IRVEs[36] , new non-energy activities).
→ Initiate discussions on the "socio-economic" models of "service stations of the future", integrating the diversity of mobility and the associated services adapted to independent service stations.

In addition, in order to provide the authorities with a complete picture of the network, particularly in areas where the network is less dense, work is underway to create an obligation to declare the existence of refuelling outlets open to the public on the prix-carburant.gouv.fr website, which could also be used to collect information that would give the government a better picture of all the stations (energies distributed and volumes distributed, type of stations[37] , non-fuel services offered).

Finally, regular studies are carried out by the government to ensure that a dense network is maintained and to anticipate the creation of "white zones", based on a number of indicators, in particular the accessibility (measured in minutes) of stations for people with combustion-powered vehicles. The distribution of service stations across the country is currently satisfactory, and although a few départements remain to be monitored, they all comply with the accessibility criterion set out in the previous PPE, i.e. that 90% of private individuals in the département are less than 25 minutes from a service station.

36 Electric vehicle recharging infrastructure.

37 Oil groups, supermarkets and hypermarkets, independent retailers...

ACTION LOG PET 4

MONITOR THE NETWORK OF SERVICE STATIONS TO ANTICIPATE THE RISK OF WHITE ZONES APPEARING

→ Improve knowledge of service stations and their characteristics by making it compulsory for all stations to be listed.

→ Carry out regular studies on the current network and the future development of the network, taking into account changes in usage and strategies for closing, maintaining or transforming retail outlets, and interacting with local public bodies to identify essential stations.

4.2. Security of supply for gas products

4.2.1. Level and criteria of security of gas supply

Security of natural gas supply means ensuring the continuity of gas supply in the face of the various risks to which the gas system is exposed, in particular the vagaries of the weather and losses of supply sources, as well as the continuity of natural gas transmission on the network, in particular in the face of the risks of congestion.

The objective of security of supply of natural gas corresponds to the possibility of ensuring the supply of natural gas consumers, with the exception of consumers who have contractually agreed to a supply that is likely to be interrupted, when :

- A cold winter of the kind that statistically occurs once every fifty years;
- Extremely low temperatures over a period of three days, such as statistically occur once every fifty years.

This level of security of supply is stricter than the minimum level provided for in Regulation (EU) 2017/1938. In view of the uncertainties associated with the reorganisation of the gas system, following the reduction in Russian gas exports to the European Union, it is proposed not to amend the current criterion mentioned above.

The tools used to ensure security of natural gas supply can be divided into three main categories:

- Tools for sizing the gas system with a view to the future;
- Obligations assigned to gas players, in particular suppliers;
- Safeguard measures in the event of a gas crisis.

4.2.2. Sizing the gas system

Over the last decade, the gas system has undergone major improvements to facilitate the flow of natural gas.

The gas system currently has seven main interconnection points and five LNG terminals located on three seaboards, providing access to diversified sources of gas.

Since 2021, the Russian government's unilateral decision to limit natural gas exports has had a major

impact on the operation of the European gas system. The supply of natural gas to Germany and Belgium has been severely affected, and the possibility of importing natural gas from these two countries to France has disappeared. The temporary installation of a floating LNG terminal in the port of Le Havre, for a maximum period of five years, has made it possible to recover redundancy margins, so as to be able to preserve natural gas supplies and transit capacities in the event of the unavailability of a major gas infrastructure. The continued decline in natural gas imports should enable us to regain the flexibility margins needed to achieve this objective by 2028, without having to resort to the additional capacity of the floating LNG terminal.

Within mainland France, gas flows are ensured by a network of transmission and distribution networks, operating in synergy with natural gas storage infrastructures. The possibilities for natural gas flows within the French gas system are considered sufficient to allow the implementation of a single balancing zone, effective since 1 November 2018.

The current size of the gas system is sufficient to supply French consumers. Given that natural gas consumption is expected to fall, efforts will be made to optimise the use of existing infrastructure, or even to reduce it. This optimisation of the use of existing infrastructures particularly concerns underground natural gas storage infrastructures. Article L. 421-3-1 of the Energy Code provides for the definition, as part of the multi-annual energy planning, of storage infrastructures that guarantee security of supply in the medium and long term.

In view of the uncertainties associated with the reorganisation of the gas system, following the reduction in Russian gas exports to the European Union, it is proposed to ensure that the current storage infrastructures remain in operation, while adjusting their capacity.

The underground natural gas storage facilities that must remain in operation to guarantee security of supply in the medium and long term are those listed below, representing a working volume of 133.4 TWh HCV and an offtake capacity of 2,196 GWh HCV/d, with filling corresponding to 45% of the working volume:

Infrastructure	Operator	Year of commissioning	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	Salt
Germigny-sous-Coulomb	Storengy	1982	Aquifer
Gournay	Storengy	1976	Aquifer
Lussagnet / Izaute	Teréga	1957	Aquifer
Manosque	Geomethane	1993	Salt
Saint-Illiers-la-Ville	Storengy	1965	Aquifer
Tersanne / Hauterives	Storengy	1970	Salt

4.2.3. Obligations assigned to gas operators

Continuity of supply obligations

Natural gas suppliers are obliged to ensure continuity of supply for all their customers, with the exception of customers with interruptible contracts, at the level corresponding to the security of supply objective mentioned in 5.2.1.

In addition, natural gas suppliers must be able to ensure continuity of supply to these same

consumers, including in the event of the main source of supply disappearing for up to six months under average weather conditions. The supply of gas on the French market is subject to ministerial authorisation. Proof of compliance with continuity of supply obligations may be requested when supply authorisations are updated each year.

Diversification bonds

Above a certain market share, a natural gas supplier is obliged to diversify its supply entry points on the national territory. The details of this obligation are set out in article R. 121-1 of the Energy Code. In order not to penalise new entrants, this measure does not apply below 5% market share.

Continuity of transmission obligations

The natural gas transmission and distribution system operators must size their infrastructures in such a way as to be able to ensure the transmission of natural gas at the level corresponding to the objective of security of supply.

Infrastructure operators are also required, as part of their public service obligations, to give advance notice of the dates on which their facilities will be unavailable, so that suppliers can ensure continuity of supply.

Obligation to fill subscribed storage capacity in essential infrastructures

In order to avoid strategies for monopolising the capacity of essential underground natural gas storage infrastructures, article L. 421-7 of the Energy Code stipulates that gas suppliers who have subscribed storage capacity in these infrastructures are obliged to ensure a minimum filling level on 1 November.

Obligation to market natural gas stocks

Articles L. 421-3 and L. 431-9 of the French Energy Code stipulate that natural gas suppliers are obliged to offer unused and technically available stocks of natural gas held in essential underground natural gas storage facilities and unused and technically available stocks of liquefied natural gas held in LNG terminals, during market calls organised by natural gas transmission system operators for network balancing purposes.

4.2.4. Safeguard measures in the event of a gas crisis

In the event of a crisis, and when preventive measures are not sufficient to guarantee the supply of natural gas to French consumers, specific measures may be activated:

- the recommendation by public authorities to moderate energy demand;
- activation of interruptibility contracts for natural gas consumption ;
- as a last resort, load shedding of consumers by the network operator to which they are connected;
- a call for European solidarity if these measures are not sufficient to maintain supplies to residential consumers and essential social services.

A general review of these measures will be carried out in 2022 and 2023.

Interruptibility of natural gas consumption

The law on the energy transition for green growth provides for the possibility of implementing interruptibility mechanisms whereby certain consumers make a commitment to network operators to reduce their consumption when necessary. If an additional need for flexibility is identified, interruptible capacity can be contracted.

Natural gas load shedding

If there is a shortage of natural gas at a given point on the network, the network operator may decide

to load shed certain consumers. These measures, which may be local or national in nature, are designed to force consumers to reduce or suspend their consumption. As it is not possible to carry out automatic load shedding remotely, the network operator contacts the natural gas consumer directly to ask him to reduce or stop his natural gas consumption.

A call for European solidarity

Regulation (EU) 2017/1938 provides for the establishment of a European solidarity mechanism in the event of a gas crisis. In extreme situations, if demand from residential consumers and essential social services cannot be met, even after all other consumers have been disconnected, France could call on this mechanism to obtain the necessary natural gas from neighbouring Member States. Conversely, Germany, Belgium or Spain could call on this mechanism, which would lead to industrial consumers being disconnected and compensation being paid in return.

4.3. Security of electricity supply and optimisation of the electricity system via a range of flexibilities

Security of electricity supply is defined as maintaining a balance **between electricity production and demand at all times, particularly during peak consumption full stops.** This balance is subject to various hazards: excess demand, for example due to weather conditions, unavailability of generation capacity, etc. A balancing fault can instantly affect the entire European grid connected. The balance is maintained by RTE, which is responsible for balancing the French electricity system.

The main challenge is therefore to design the power system so that it can cover not only annual energy needs, but also the power required to meet peak demand, while at the same time decarbonising the system. The passage of consumption peaks depends first and foremost on the "flexibility" of the power system, i.e. the ability of the power system to adapt to the variability of production and consumption patterns and to the availability of the network, according to the relevant market deadlines[38] . This means adjusting consumption and generation upwards or downwards, to ensure a balance between these two quantities at all times. This flexibility can be mobilised both on the supply side (production resources such as hydroelectric power stations, for example) and on the demand side (interrupting consumption at peak times, shifting consumption to off-peak times), and also includes storage (including, in particular, electric batteries and pumped energy transfer stations (PETS)) as well as interconnections between neighbouring countries.

As highlighted in chapter 6 on the supply-demand balance and flexibilities in RTE's 2023 Generation Adequacy Report published on 16 July 2024[39] **, the development of renewable energies, which is necessary to achieve the objective of carbon neutrality, will have to be accompanied by increased use of flexibilities** from 2030 onwards, which may be provided by different combinations of consumption and generation control, referred to in the remainder of this chapter as "flexibilities packages".

4.3.1. The security of supply criterion

The French security of supply criterion is the **main regulatory tool used to size the electricity system** to ensure medium-term security of electricity supply.

[38] According to European Parliament and Council Regulation 2023/0077/A(COD) on improving the organisation of the EU electricity market, which will be transposed into national law.

39 https://assets.rte-france.com/prod/public/2024-07/BP2023-chapitre6-Equilibre-offre-demande-flexibilite.pdf

Since the publication of the PPE 2 decree in 2020, it is now defined as a **dual criterion stipulating that the risk of supply-demand imbalance may not exceed three hours per year on average and that the average annual duration of load shedding must remain less than two hours.** The "failure" of the electricity system is thus defined as the need to resort to back-up resources (excluding market mechanisms) and, as a last resort, to load shedding.

This definition appears in the Energy Code (article D. 141-12-6) and its level is set by the minister responsible for energy by regulation on the basis of RTE studies. It is the result of a **trade-off in the general interest between the benefits consumers derive from a reduced risk of power cuts and the cost to the community of developing additional means of generation supply and consumption curtailment to reduce this risk**.

The determination of the security of supply criterion has been harmonised at European level since 2019. The study published by RTE in 2022[40] **confirmed that the method used in France complies with European requirements, and led to the Order of August 2022[41] confirming the level of the current criterion, at the suggestion of CRE[42]** . It is therefore **against this standard that RTE conducts its security of supply analysis.** It should be noted that this security of supply criterion is currently one of the most demanding in Europe.

ACTION APPRO ELEC.1

PURSUE DISCUSSIONS AND WORK ON POSSIBLE CHANGES TO OR ADDITIONS TO THE SECURITY OF SUPPLY CRITERION, IN CONJUNCTION WITH RTE, CRE AND AT EUROPEAN LEVEL

→ When considering changes to the security of supply criterion, take into account the development of storage in significant proportions and the depth of failures and energy not distributed (i.e. the number of customers cut off and not just the duration of the outage) to better meet the challenges of the energy transition and society's expectations.

→ Continue the analysis of various stress-tests to study compliance with the criterion in order to better assess the resilience of the power system in line with RTE's work (part 6.2.1.4 of RTE's 2023 BP).

40 RTE, *Proposal for updating the security of supply criterion for the French electricity system*, 2022

41 Order of 5 August 2022 on the security of electricity supply criterion

42 CRE Deliberation n°2022-152 of 25 May 2022 proposing a value for the security of electricity supply criterion for mainland France

4.3.2. Developments in security of supply over the horizon of the EPP

Over the past fifteen years, the risk to security of supply has increased, in particular due to the reduced availability of nuclear power plants and the closure of thermal power plants, with an increased risk between 2020 and 2023. However, the actual conditions have been favourable (fall in consumption from the end of 2022, good weather conditions, contribution from interconnections) and have made it possible to avoid resorting to load shedding measures.

Focus: Experimentation with a device to limit electricity meter power in the event of a

Following the high levels of tension observed by RTE during the winter of 2022-2023, affecting electricity supply and the balance between production and consumption, the public authorities have asked Enedis to work on a new safeguard measure that could reduce the risk of load shedding, i.e. the temporary interruption of the entire household electricity supply. Load shedding is the ultimate measure for securing the electricity network.

Enedis has identified a new collective measure to reduce electricity consumption in France during tense situations (EcoWatt orange or red): temporary power limitation. Faced with the risk of a power cut in France, this measure would aim to preserve a minimum power supply for all private customers by limiting it to essential uses with a power of 3kVA. This operation would be carried out via the Linky meter during peak consumption periods on a working day (6.30am-1.30pm and 5.30pm-8.30pm), for a limited period of time for each customer (2 hours maximum), in shifts.

Limiting consumption by individual customers can be restrictive. But it is a new option for trying to avoid the risk of temporary power cuts on a day of high tension between production and consumption, or failing that, if that were not enough, to significantly reduce the number of households affected by scheduled load shedding.

For the time being, this system has only been tested on an experimental basis, in February 2024, in a single département: Puy-de-Dôme. The trial went satisfactorily, with orders to limit and then restore nominal power being correctly transmitted. An assessment of the trial was carried out by Enedis in July 2024, in particular to identify the technical feasibility and benefits of this measure if it were deployed on a large scale.

ACTION APPRO ELEC.2

STUDY THE INTEGRATION OF THE ELECTRICAL POWER LIMITATION DEVICE INTO THE RANGE OF MEASURES OF THE ELECTRICITY NETWORK PROTECTION PLAN

Carry out this study in the light of the conclusions of the trial conducted in 2024 (see focus above), and the technical feasibility of applying such a measure throughout the metropolitan area.

In its 2023 Generation Adequacy Report, RTE states that **the French power system has now passed the most delicate period identified in past studies**. **Over the coming years, the risk of imbalance between electricity supply and demand will diminish and should meet the regulatory criterion.** This gradual improvement will be made possible mainly by the increased availability of nuclear power, even if it is not expected to return to its level of the early 2010s. It is also the result of the development of renewable energies, in particular the commissioning of the first offshore wind farms,

which is essential for security of supply. Interconnections with neighbouring countries will continue to play a favourable role, just as they were decisive in helping us through the winter of 2022-2023.

For the period 2024-2027, RTE indicates that extending the production capacity of the last coal-fired power plants for a few years offers additional security to go beyond the criterion, particularly in the event of a particularly deteriorated situation. Their early closure is possible, but subject to certain conditions in terms of security of supply: high availability of the nuclear fleet, a moderate increase in electricity consumption and nominal operation of the Flamanville EPR, prior to the closure of the Cordemais power plant because of the specific constraints on supply to Brittany. In all cases, RTE concludes that should the need for thermal capacity be proven, this "insurance contribution" would be limited and would concern a small volume of hours on average, compatible with the emission ceilings currently provided for by law and regulation.

By 2030, the acceleration of decarbonisation will create a need for additional capacity, which can be met by various solutions, from consumption management to the conversion or construction of decarbonised thermal power plants. RTE analyses that the need for capacity is not limited to capacity contributing to the coverage of short, one-off episodes during peak full stops (load shedding, battery storage), but extends to production capacity that can be mobilised over longer periods (decarbonised thermal power plants, STEP, etc.) given the characteristics of the various failures.

By 2035, the level of security of supply will depend on France's ability to implement a number of measures by 2030 (electrification, flexible use of energy, energy saving and efficiency measures) and on the success of industrial challenges (extending nuclear power, developing offshore wind power, making electrolysis more flexible). Requirements for security of supply over this timeframe are more uncertain, but should in principle decrease. In RTE's view, **the capacities deployed as part of the flexibility mix for 2030 represent a no-regrets choice for ensuring security of supply in 2030 as well as in 2035 and over the longer term.**

4.3.3. Strategies for meeting the need for additional capacity by 2030

As indicated in chapter 6 "Supply-demand balance and flexibilities" of RTE's 2023 Generation Adequacy Report published on 16 July 2024[43] , various "flexibility packages" will be able to cover the need for additional capacity between now and 2030.

Figure 6.22 Solutions pour assurer l'équilibrage en puissance au sens du critère réglementaire à l'horizon 2030 : les différents « bouquets de flexibilité » possibles

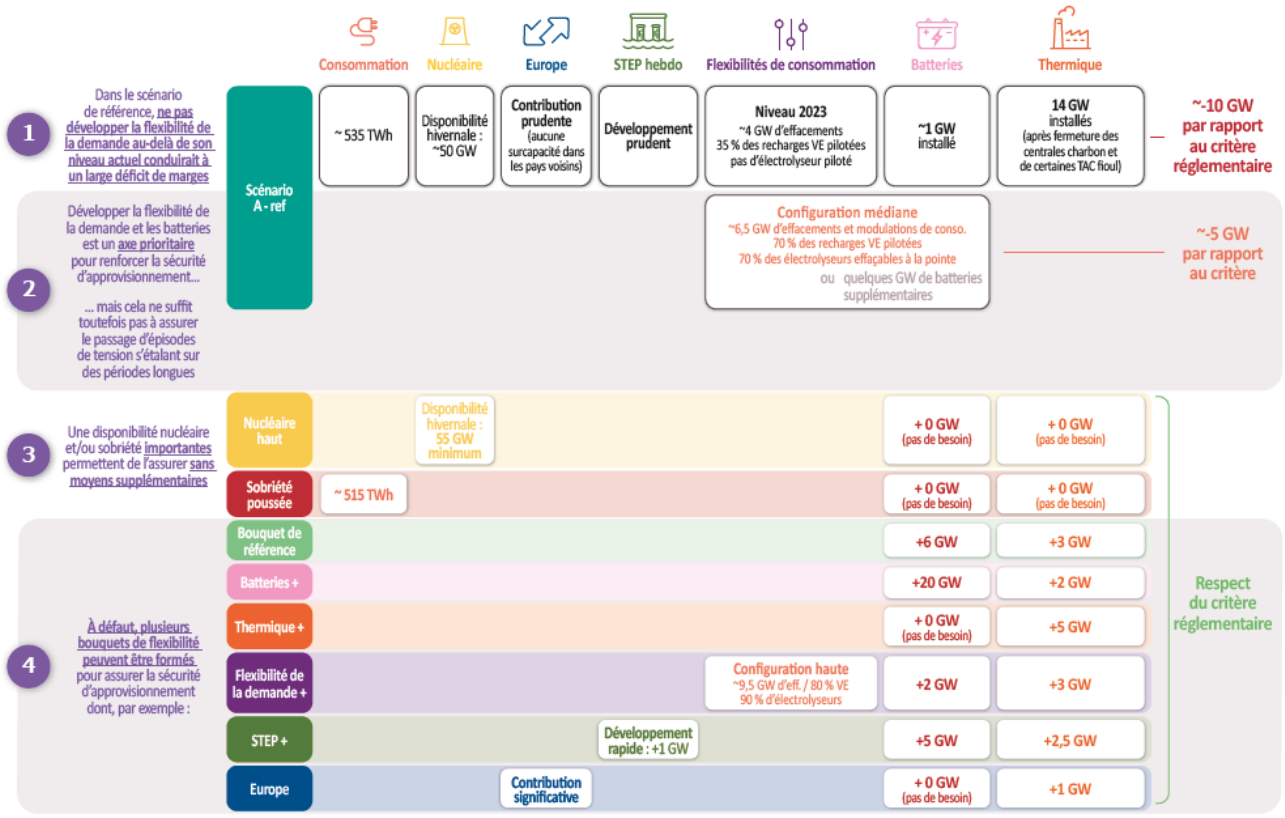


Figure31 . Solutions to ensure power balancing within the meaning of the regulatory criterion by 2030: the various possible "flexibility packages" (RTE)

Specific support measures have already been put in place in recent years, such as the call for tenders for load shedding, under which RTE contracts for load shedding capacity every year between 2018 and 2023. On 21 December 2023, for the period from 2024 to the first quarter of 2026, the Commission approved new support scheme under the State Aid rules, via a call for tenders open to decarbonised flexibilities (including load shedding and storage). In the same way as electricity generation facilities, load shedding also participates in market mechanisms (balancing mechanism, reserves, NEBEF mechanism). The capacity mechanism, operational since 2016 and authorised until 2026, is currently being overhauled for the winter of 2026-2027 and should support the development of the new flexibilities required for security of supply.

According to RTE's BP, the need for additional thermal power amounts to 3 GW in the reference mix and between 2 and 5 GW in the other mixes. Technically, this need can be met by maintaining power stations that are due to close (the last coal-fired power stations) or that are likely to close (the oldest combustion turbines and cogeneration plants, etc.), by converting some of these units to biomass,

43 https://assets.rte-france.com/prod/public/2024-07/BP2023-chapitre6-Equilibre-offre-demande-flexibilite.pdf

or by building new thermal units that run on low-carbon fuels from the outset. In other configurations (with a high level of sobriety or with nuclear power availability in excess of 55 GW in winter), there may be no need for additional thermal power.

ACTION APPRO ELEC.4

CONTINUE **THE ANALYSIS AND WORK WITH RTE AND ADEME[44] TO IDENTIFY OBJECTIVES AND MEASURES RELATING TO FLEXIBILITIES AND THE FUTURE OF THE THERMAL FLEET, IN PARTICULAR IN LINE WITH THE IMPLEMENTATION OF THE ELECTRICITY MARKET REFORM.**

- **Consider flexibility as a whole**, i.e. the ability to modulate[45] , simultaneously or not, the national load curve, in order to meet the needs of the electricity system in 2030 and 2035, whether for security of supply, optimisation of the electricity system or management of the network.
- **Define appropriate flexibilities and potential indicators** (e.g. "residual consumption") in order to characterise the control needs of the electricity system.
- **Encourage the development of new backup flexibilities, using the Ecowatt signal, for example, to automatically limit the consumption of certain equipment in the tertiary sector or in private homes**.
- **To perpetuate the capacity mechanism after 2026 and study the need to adapt it** so that it responds to changes in the electricity mix and the future needs of the system, while ensuring that the security of supply criterion is met and supporting the economic viability of the necessary flexibilities.

- **Developing flexible demand**

Demand flexibility, which consists of reducing or increasing the electricity consumption of a given site or group of sites, on a one-off or structural basis, to meet the needs of the power system, is emerging as **a priority area for reducing the risk of short-term imbalances at lower cost**.

Managing peak consumption means being able to call on both **one-off reductions in consumption that respond to short-term market signals (load shedding), and more structural reductions in consumption** that enable larger volumes to be shifted at the best time for the electricity network to function properly, while protecting the consumer through, for example, time-seasonal supply offers, mobile peak offers or peak/off-peak hours. **The time-seasonality of the tariff for the use of public electricity networks (TURPE)**, defined by the Commission de régulation de l'énergie and paid by all users of the electricity network, is an incentive for suppliers to send more differentiated signals to end customers.

44 Ademe expert opinion on power system flexibility of March 2024 and expert opinion on storage of March 2024: https://librairie.ademe.fr/ged/8635/Avis-d-expert-Flexibilite-electrique-vf.pdf
https://librairie.ademe.fr/ged/8626/Avis_d_Experts_Stockage_vf.pdf

45 Modulation of electricity consumption (resp. production) refers to any action by the end consumer (resp. producer), whether regular or one-off, aimed at voluntarily increasing or decreasing the level of effective extraction (resp. injection) of electricity on the public transmission or distribution networks of one or more consumption sites.

ACTION APPRO ELEC.5

DRAW UP A "PLAN FOR SCALING UP FLEXIBLE DEMAND" BY STRENGTHENING ECONOMIC INCENTIVES TO MANAGE AND POSITION CONSUMPTION

- **Encourage the optimal placement of off-peak time slots in the next TURPEs (TURPE 7 and 8)** in a context of continued development of renewable energies, in particular photovoltaic energy, creating new constraints and opportunities for the electricity system.
- **Encourage the development of tariff offers that make the most of flexibility of use** while providing the best possible protection for the consumer, such as mobile peak offers (load shedding that cannot be dissociated from the supply (EIF)) and time-seasonal tariffs, while encouraging the development of new market products.
- **Develop economic incentives or regulatory requirements for controlling new equipment,** in particular water heaters, electric vehicle charging points and heating and air conditioning systems.
- Study the technical and economic conditions necessary for the development of peak shaving of electrolysers.
- **Encourage and monitor the regular publication by RTE of a "demand flexibilities barometer"**, which will make it possible to define flexibilities development indicators year after year.

- **Battery storage and STEP**

By 2030 and 2035, batteries and STEPs combined with demand-side flexibilities will be able to meet three quarters of intraday modulation needs.

ACTION APPRO ELEC.6

ADAPTING THE REGULATORY AND ECONOMIC FRAMEWORK FOR STEP DEVELOPMENT

Adapting the regulatory and economic framework to achieve at least an additional 1.7 GW of STEP by 2035, for example by launching calls for tenders (see Hydroelectricity section 3.5.1.4).

ACTION APPRO ELEC.7

CONSOLIDATING THE BATTERY CELL PRODUCTION INDUSTRY

France is aiming to consolidate the industrial sector with a target production of 100 to 120 GWh/year of battery cells by 2030, enough to equip the equivalent of all the electric and hybrid vehicles produced in France. The National Battery Strategy has supported around forty innovative projects as part of the France 2030 programmes and the Strategic Project Guarantee (GPS), generating €8.2 billion in investment. France is also supporting the ramp-up of the battery industry through the PIIEC, whose French member projects will generate a total of more than €3.5 billion in investment.

- **Interconnections**

Interconnections will continue to play a major role in ensuring security of supply and optimising the operation of the national and European electricity system: they enable the least costly generation resources to be called upon at any given time across Europe, and make a major contribution to reducing greenhouse gas emissions from electricity generation in Europe. The use of imports avoids additional costs and the construction of additional flexibility resources in France (in particular new thermal power stations) to cover very high consumption periods.
However, their contribution is envisaged in a deliberately cautious way, on the assumption that the mixes of neighbouring countries will be sized as accurately as possible in relation to their own security of supply criteria (i.e. without excess capacity). In RTE's studies, this leads to a relatively stable contribution from interconnections to France's security of supply, despite the increase in exchange capacity.

ACTION APPRO ELEC.8

CONTINUING TO DEVELOP INTERCONNECTIONS AND SETTING NEW TARGETS

Continue this work in line with projected needs, taking into account the cost/benefit ratio, prudent assumptions and cooperation with our neighbours (see electricity networks section).

Study the cost-benefit of an interconnection or connection between mainland France and Corsica in terms savings for the community and security of supply.

4.4. Security of uranium supply

The French nuclear fleet uses different types of nuclear fuel to meet its nuclear generation needs, based on natural uranium or uranium from reprocessing, in the form of UOx or MOx. Security of uranium supply is the responsibility of EDF, which manages all French nuclear power plants.

An electric utility's uranium requirements depend mainly on :

- changes in the nuclear fleet and its operating methods;
- the spent fuel recycling strategy, which is likely to meet the objectives of energy independence and sovereignty, since it offers the potential to reduce France's need for natural uranium by 10% using MOx and by a further 15% using ERU, giving a total reduction of 25%. The multi-recycling of plutonium and TRU could, in the medium term, represent an additional step in the recovery of spent fuel and the saving of uranium resources, up to 40% compared with an open cycle.

EDF uses several levers to strengthen its security of supply:

- geographical and commercial diversification of supply sources for each stage of the fuel cycle (mining, conversion[46] , enrichment and assembly manufacture). This diversification is particularly important for the mine, since EDF obtains its supplies from several countries (including Niger, Kazakhstan, Canada and Australia)[47] ;

46 The conversion of TRU on an industrial scale is currently only possible in Russia. EDF is examining the possibility of setting up a European industry.

47 EDF no longer imports uranium from Russia.

- long-term contractual security. As a general rule, EDF's requirements for each stage of the cycle are covered for around ten years by its main suppliers;
- inventory management. EDF maintains large stocks of uranium throughout the nuclear fuel cycle (mining, conversion, enrichment, new fuel, reactor fuel, reserve fuel). These stocks ensure that the reactors in France's nuclear power fleet can operate for several years, thereby meeting the risks of supply disruptions.

ACTION APPRO U.1

ENSURING A SECURE SUPPLY OF URANIUM

The French industry will guarantee the availability of uranium needed to operate France's existing nuclear power plants and the new capacity planned, in particular by continuing efforts to diversify supply sources geographically and to secure supply chains.

4.5. Security of supply for biomass

A non-intermittent renewable energy source, biomass was identified in the National Low Carbon Strategy (SNBC2) published in 2020 as **a key element in the energy mix by 2050, revealing a specific challenge in terms of the balance between supply and demand.** In fact, in the SNBC2, the consumption of biomass resources, which was on the rise in most sectors, exceeded domestic resources by around 7%.

The latest modelling work on the energy-climate scenarios carried out for the SNBC3 supports the idea that the transition will mobilise more biomass (products, waste and residues of biological origin). In particular, these scenarios forecast an increase in the consumption of biomass for energy purposes. In particular, the deployment of biofuels in the road transport sector and for international bunkers will mobilise a significant amount of biomass, and industry will also increase its consumption of biomass, for both energy and non-energy purposes. This trend requires monitoring and dedicated governance (see below).

Biomass resources (livestock manure, dedicated crops, intermediate crops for energy, wood, bio-waste, etc.) and the challenges associated with biomass will be detailed in the documents relating to the SNBC in order to provide visibility for each of the sectors and to work on the mobilisation conditions, which differ from one resource to another.

The first issue is the **availability of resources in France**. With a view to ensuring **sovereignty of supply**, the challenge is to define the **appropriate** assumptions and **production trajectories for the different types of biomass** that will make up the available supply: wood, intermediate crops, livestock effluents, etc. Based on its modelling, the SNBC3 has a proactive vision that would lead to an increase of around 40% in the biomass energy resource mobilised by 2035 compared with 2019.

The second, more complex issue is **the optimal 'allocation' of biomass between user sectors,** with the aim of ensuring the best possible match between the nature of the biomass available and the type of energy carrier (solid, gaseous or liquid) required by each sector. Strategic choices therefore need to be made as to the importance attached to the use of biomass in the various sectors, in particular by calibrating more precisely the systems of public support for sectors that base their

model on the mobilisation of biomass resources. These decisions need to be taken in the light of various criteria (environmental and socio-economic impacts, the possibility of using co-products in

short circuits, etc.), including the individual capacities of each sector to replace fossil fuels with other vectors, in particular by examining the possibility of electrification as a viable alternative to the use of biomass. In particular, in the individual mobility sector, long-term priority is given to the development of electric vehicles rather than maintaining a fleet of thermal vehicles consuming biofuels. An initial guideline for prioritising the resource has been established: it prioritises, among energy uses, those uses for which there is no better alternative.

Table1 Hierarchy of uses of biomass resources[48]

USES OF BIOMASS	EXPLANATION
USES TO BE CONSIDERED FIRST	
HUMAN FOOD	Food sovereignty.
ANIMAL FEED	The challenge of protein autonomy - up to the needs of a lower consumption of animal proteins consistent with the overall scenario of transition in diets.
CARBON SINKS - WOOD AND FOREST PRODUCTS	Up to the requirements determined by the SNBC to ensure the GHG balance.
SOIL FERTILITY (RETURN OF RESIDUES AND COVER CROPS TO THE SOIL)	As needed to maintain yield.
INDUSTRY - HIGH °C AND NON-ENERGY HEAT	No low-carbon alternatives.
HEATING NETWORKS	There are few alternatives for decarbonising the heat mix.
ENERGY CONSUMPTION BY AGRICULTURE AND THE FORESTRY AND WOOD INDUSTRY	Particularly for agricultural machinery. Possibility of short circuits and making the most of agricultural energy production (also the possibility of considering more electrification). Forestry and wood industry: self-consumption of own resources and on-site energy production.
HEAVY CONSTRUCTION EQUIPMENT	Few carbon-free alternatives. Consistency to be ensured with the SNBC scenario for the building and public works sector.
USES TO BE DEVELOPED REASONABLY AND SUBJECT TO CONDITIONS	
AIR TRAFFIC (DOMESTIC AND INTERNATIONAL)	Possibility of reducing traffic through price signals, modal shifts and sobriety. Limitation of biomass allocated to this sector, which will have to finance more e-fuel.
MARINE BUNKERS	Possibility of using e-fuels (in particular e-diesel produced from e-kerosene). The question of traffic levels, with a desire to re-seed in France on the one hand, and a drop in imports as a result of re-industrialisation on the other.
TRANSPORT - PL, BUS AND COACH, AND RIVER AND RAIL TRANSPORT	Possibility of further electrification (including via H2), question of having two coexisting infrastructures for H2 and CNG.
TRANSPORT - LIGHT VEHICLES	Through controlled rates of incorporation, and by maintaining the priority given to the gradual electrification of the fleet.
INDUSTRY - LOW-TEMPERATURE HEAT	Existence of low-carbon alternatives (heat pumps, solar thermal, RCU[49] , geothermal energy, etc.).

[48] NB: the lines within the 3 blocks of the table ("priority" / "to be developed reasonably" / "to be moderated") are not ranked in order of importance.

[49] District heating network

RESIDENTIAL AND COMMERCIAL - SOLID BIOMASS FOR EFFICIENT HEATING AND HOT WATER	Possibility of prioritising the use of solid biomass in efficient (post-2005) and very efficient (post-2015) appliances by encouraging the replacement of inefficient appliances. Prioritise appliances that replace fossil-fuelled equipment (oil/LPG) in rural areas.
OVERSEAS (MAYOTTE, GUYANA, CORSICA)	Questions about the sustainability of importing biomass from mainland France into the OM. Possibility of further developing electric RE.
USES WHOSE DEVELOPMENT SHOULD BE MODERATED	
ELECTRICITY GENERATION	Favour other technical solutions (e.g. H2, batteries) to ensure peak thermal production.
RESIDENTIAL AND COMMERCIAL - NON-EFFICIENT HEATING AND HOT WATER	Reduce the use of inefficient appliances (installed before 2005) that consume solid biomass.
RESIDENTIAL AND TERTIARY - COOKING	A more efficient and less dangerous electrical alternative (induction in particular).

Over and above the issue of matching supply and demand, we need to consider all the **environmental and socio-economic implications** of using biomass.

The first objective is ensure **the sustainability of** both agricultural and forestry **biomass production conditions**, in order to limit undesirable effects. To do otherwise could have a number of consequences: degradation of forest sinks, soils and water quality, loss of soil carbon stocks, deforestation and erosion of biodiversity. It is vital to analyse and fully integrate these environmental implications into the biomass use strategy, particularly with regard to impacts on air quality. This may lead to a preference for using biomass in one sector rather than another, depending on its ability to manage these impacts. For example, in industry, which is subject to stricter standards for filtering biomass emissions. The second objective, bearing in mind that agricultural land cannot be extended indefinitely without undesirable effects (particularly in that such an extension could lead to the transformation of natural ecosystems, either within the country or in third countries), is to avoid **competition with food uses.**

Global food security has been the focus of specific attention for a number of years, and in 2009 **this** led to the introduction of a framework for the "sustainability of bioenergy" in the European directive on renewable energies (known as the "RED"). The production of conventional biofuels from resources competing with food has been capped in this directive, as has the use of food crops for methanisation in the Environment Code. This directive, which was supplemented in 2018 and 2023, covers much broader issues than just competition between food and energy uses.

Finally, the **technical and economic constraints weighing on the production and use of biomass** (transaction costs, inertia of agricultural systems, stability of outlets and prices, etc.) must also be taken into account in order to make the most reliable projections possible.

ACTION BIOMAS.1

BALANCING BIOMASS SUPPLY AND DEMAND FOR THE ENERGY SECTOR

→ To strengthen supply, update the national biomass mobilisation strategy adopted in 2018, ensuring dialogue and consistency with the Regional Biomass Schemes;

→ In order prioritise demand and ensure the best possible allocation of biomass supply, implement principles of prioritisation (compliance with the principle of cascade use of biomass within the meaning of the RED for wood, for example, prioritisation of uses, etc.),

by applying it in particular to the system of public aid to biomass-consuming sectors and by strengthening the conditionality of this aid, in line with the European framework;

→ Strengthen the governance of these various issues, transparency and dialogue with the stakeholders concerned through the "bioeconomy" Interfilières Thematic Commission as reformed in July 2024 ;

→ Improve understanding, monitoring, projections and scenarios on supply and demand, as well as anticipating and preventing environmental impacts, by building on the "biomass" scientific interest group announced in March 2024, and on the work of the regional biomass cells.

→ Ensuring the sustainability of biomass production systems (agricultural, forestry, etc.) through the rapid application of recently voted European framework measures that are easy for operators to understand.

4.6. Energy infrastructure and networks

The energy transmission and distribution networks have undergone major changes in recent years, and these are set to accelerate.

Electricity networks will undergo structural changes in the coming years, both nationally and internationally. The European Union's electricity network action plan, presented at the end of November 2023, highlights the need for €580 billion in additional investment in networks between now and 2030. At the global level, the International Energy Agency (IEA) is highlighting the need to double the pace of this investment by 2030, from the current level of around 300 billion dollars per year to 600 billion dollars per year. The number of installations to be connected to the grid is increasing significantly with the energy transition, both on the producer side (for example, in France in 2023, around 207,000 renewable energy installations were connected to the public distribution grid, compared with 61,000 in 2021) and the consumer side (connection of charging points for electric vehicles, decarbonisation of industry, etc.). In this respect, the next EPP will involve a change of approach for structural network developments, in order to improve the anticipation of these developments and thus accelerate connections, while ensuring that the planned massification of investments is sustainable for network operators and consumers.

The gas networks will have to evolve in terms of both their structure and their pricing approach in order to take account of the profound consequences of the decarbonisation of our energy system: allowing the connection of new renewable or low-carbon gas production projects, while at the same time seeing their use fall as a result of the overall reduction in gas consumption. This will mean giving operators the means to support the transition of gas-using territories as a priority, as they represent the largest fixed costs.

At the same time, a review of the development of new gas networks (hydrogen and CO2 in particular) needs to be carried out by developing their regulatory framework, which will have to take account of the new European framework (Gas Package) but also of the issues specific to these infrastructures (high volume risk, which means that the basic approaches to regulated assets need to be supplemented)

4.6.1. Heating and cooling networks

See section 3.1.5.

4.6.2. The liquid fuels network

Throughout our energy-climate trajectory, the government is making sure that oil logistics will evolve to support the energy transition with the aim of ensuring the country's sovereignty: changes in refining to ensure the production of alternative fuels in France and to reduce the use of fossil fuels in processes, adaptation of transport, storage and distribution infrastructures with a change in the business model for service stations due to changes in usage.

ACTION CARB.2

PREPARING FOR THE TRANSFORMATION OF THE LIQUID FUELS NETWORK

→ OBJ These include the co-processing of crude oil and bio-based oils, the replacement of fossil hydrogen by electrolytic hydrogen, CO2 capture and electrification.

→ OBJ The adaptation of current cross-border pipeline networks to the transport of synthetic fuels and biofuels, as well as the reduction in the transport of crude oil where necessary, will have to be carried out in conjunction with the beneficiary countries (mainly Germany and Switzerland) and the North Atlantic Treaty Organisation.

4.6.3. The gas network

The gas network transports natural gas from import points, LNG terminals and renewable and low-carbon gas production facilities to consumers and export points. It comprises transmission pipelines, compressors and distribution networks, operating in synergy with underground natural gas storage facilities.

The gas network consists of :

- the transmission network used to transport large volumes of natural gas over long distances. It represents almost 40,000 km of pipelines in France. LNG terminals, interconnection points with networks in neighbouring countries and natural gas storage facilities, as well as several hundred very large consumers of natural gas, are connected to the transmission network;

- distribution networks, which carry natural gas to end consumers at lower pressure and over short distances. They represent more than 200,000 km of pipelines. The natural gas distribution networks are owned by local authorities and operated under concession by network operators. A third of France's municipalities, home to almost 80% of the population, have a natural gas distribution network.

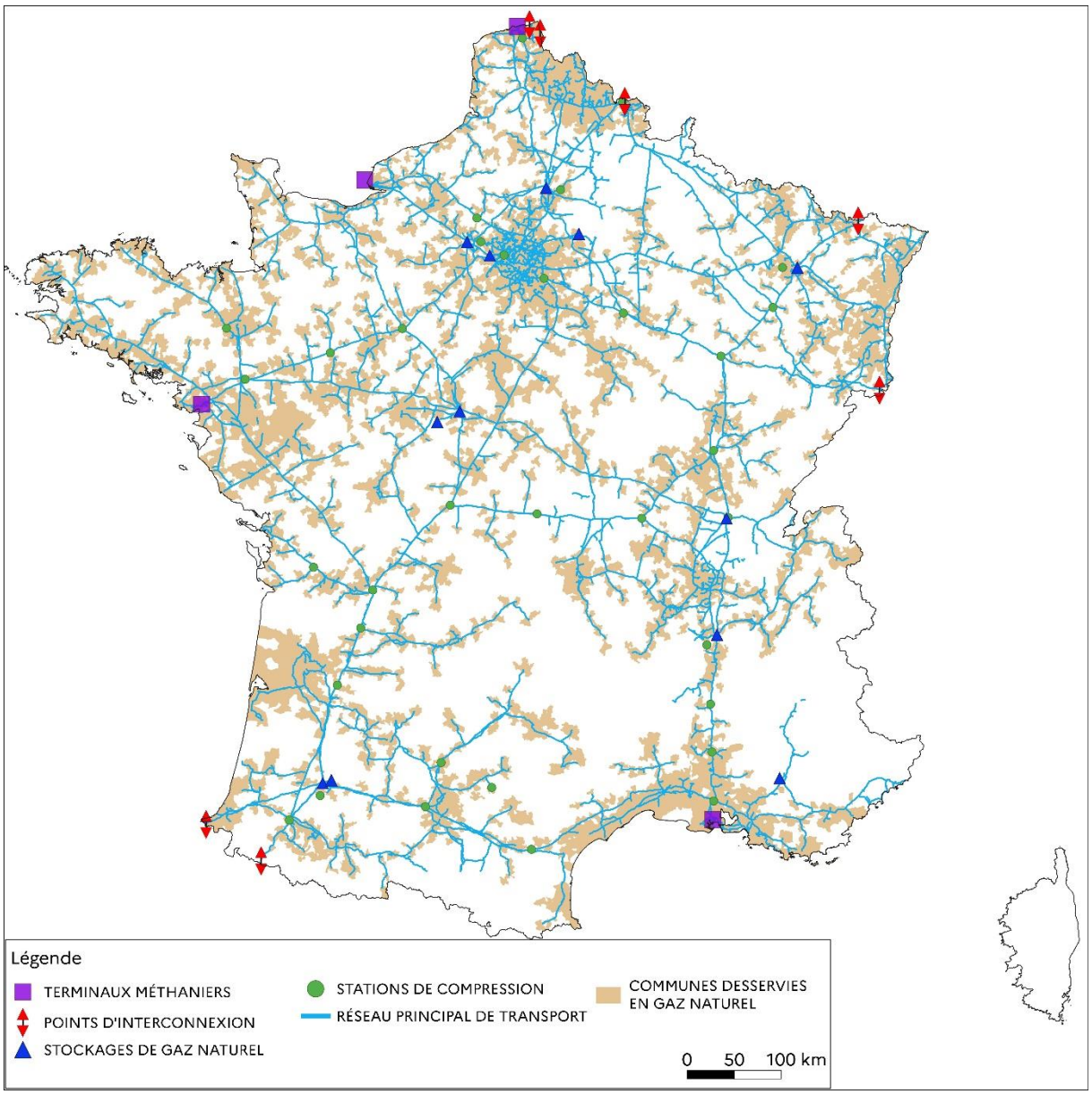


Figure 32. The French gas network in 2024

Adapting the gas network to the drop in Russian gas exports to the European Union

The supply of natural gas to the European Union and France has been disrupted by the reduction in Russian gas exports, which began in 2021 before accelerating in 2022, following Russia's invasion of Ukraine.

The French gas system has historically been designed to enable natural gas suppliers to ensure diversified and flexible supplies, with the Franpipe pipeline enabling direct imports of Norwegian gas, LNG terminals providing access to the global liquefied natural gas (LNG) market and interconnections with the German, Belgian, Spanish and Swiss networks.

This flexibility in the French gas system has enabled natural gas suppliers to set up alternative supplies to compensate for the fall in Russian gas exports, thereby preserving supplies for their customers and contributing to supplies for Europe. The fall in Russian gas exports was offset by an increase in LNG imports.

Since 2021, a number of adjustments have been made to the French gas system to take account of the new supply context:

- Export capacity to Germany and Switzerland has been increased in the interests of solidarity, in order to facilitate supplies to countries to the east of France, which were previously more dependent on Russian gas supplies;

- LNG terminal capacity has been increased, by optimising the use of existing facilities, in order to adapt to the increase in LNG imports;

- a floating LNG terminal has been temporarily installed in the port of Le Havre, for a maximum period of five years, to restore redundancy margins, in order to be able to preserve natural gas supplies and transit capacities in the event of the unavailability of a major gas infrastructure. The continuing fall in natural gas imports should make it possible to regain margins of flexibility by 2028, enabling this objective to be achieved without having to resort to the additional capacity of the floating LNG terminal (see section 4.2.2 The sizing of the gas system).

The upheaval in natural gas supplies has also led to a change in the gas flows observed within the French network. Whereas gas flows used to come mainly from the north-east, the reduction in Russian gas exports and the increase in LNG imports at LNG terminals are now leading to flows from the west and south. This inversion of dominant flows can lead to congestion on the French natural gas transmission system. Until now, such congestion has been dealt with by activating a combination of mechanisms, without any new investment. The prospects for a fall in methane gas consumption mean that we need to optimise the use of existing infrastructure. The frequency and extent of congestion on the French natural gas transmission system will continue to be monitored in the coming years.

Adapting the gas network to the development of renewable and low-carbon gas production

The natural gas network has historically been designed to transport natural gas from a limited number of import and production points to consumers. Historically, most natural gas distribution networks have been located in urban areas, particularly metropolitan areas. In particular, this location enabled the costs of these networks to be amortised more effectively over a wider consumption base.

The development of renewable and low-carbon gas production is leading to an increase in the number of injection points in natural gas networks, spread throughout the country, and particularly in more rural areas where methanisation facilities are located. Connecting renewable and low-carbon gas production facilities requires investment in network extension and reinforcement, as well as the construction of reverse flow facilities enabling methane gas to flow, in contrast to the usual flows, from the low-pressure networks to which certain production facilities are connected to the high-pressure networks.

The investment needed to integrate renewable and low-carbon gases is estimated at between €6 billion and €10 billion between now and 2050.

Adapting the gas network to lower methane gas consumption

The fight against climate change and the move away from fossil fuels will result in a drop in methane gas consumption. This raises the question of the relevance, and even the economic sustainability, of maintaining and significantly developing a methane gas network. The reduction in methane gas consumption reduces the basis on which fixed network costs are passed on, thereby increasing unit costs, i.e. the proportion of network costs per volume of gas consumed.

A study has been carried out by CRE and DGEC in 2022 to identify the challenges associated with gas infrastructures in a context of falling methane gas consumption.

This study concludes that almost the entire natural gas transmission network will continue to be needed in the medium term to manage seasonal and regional differences between production and consumption and transit between Member States, as few pipelines can be converted to transport other gases (H2, CO2, etc.).

The natural gas distribution network has been extensively upgraded in recent years, and will have a role to play in integrating biogas. There is little scope for significantly reducing the cost of using natural gas distribution networks between now and 2030.

In the absence of specific measures, the allocation of fixed costs to a declining methane gas consumption base could lead to an increase in the unit costs associated with gas infrastructures.

ACTION RES GAZ 1

PREPARING THE GAS NETWORK FOR THE DROP IN METHANE GAS CONSUMPTION

→ Carry out a local assessment of the decline in consumption in order to identify areas where network costs are likely to represent disproportionate costs, based in particular on the trend in consumption and the possibilities of substitution by other energies.

→ Drawing on feedback from initiatives that have been carried out, in France and abroad, to support the reduction in methane gas consumption, and conducting an experiment, at local level, on planning the development of the natural gas distribution network.

→ Take account of the expected fall in methane gas consumption when setting tariffs for the use of gas infrastructures.

4.6.4. The electricity network

4.6.4.1. Structural changes in the years ahead

Because they transport electricity from production centres to consumers, electricity grids are at the heart of the power system and a key link in the energy transition. The network is made up of :

- the public electricity transmission network, designed to transport large quantities of energy over long distances, operating at voltage levels of between 50 and 400 kV and comprising around 100,000 km of lines;

- and the public distribution network, designed to deliver electricity to end consumers in smaller quantities and over shorter distances. The public distribution network operates at lower voltage levels (below 50 kV), and represents almost 1.4 million kilometres of lines.

Issues

The number of electricity generation facilities is set to grow significantly over the next few years, both for projects connected to the transmission grid (nuclear power stations, offshore wind farms, large onshore renewable energy farms) and to the distribution grids (small and medium-sized renewable energy farms). These commissionings will change the type of flows historically observed on the grids, with an increase in centralised generation (from coastal areas and nuclear production basins) and more diffuse locations (although with marked regional dynamics, for example for solar power in the southern half)

At the same time, the needs generated by the electrification of processes, particularly in industry and mobility, will lead to a sharp increase in connection and reinforcement requirements. The decarbonisation drive alone in France's main industrial areas (particularly in the industrial port areas of Dunkirk, Fos-sur-Mer and Le Havre-Port-Jérôme) implies a demand for connections of around 13 to 15 GW between now and 2030.

These developments will therefore require rapid structural changes in network development strategies and associated investments. By way of illustration, for industrial decarbonisation zones, RTE has started a "race against the clock" from 2022 to plan pooled and priority infrastructures and launch studies and administrative procedures, with a significant acceleration in the upstream consultation phases, in parallel with legislative changes (acceleration laws and green industry).

For the transmission network, they will be presented in the future ten-year development plan for the transmission network, which RTE will publish shortly. For the distribution network, they have been detailed by Enedis in 2023 in its preliminary network development plan.

The associated challenges are manifold. For the electricity transmission network, RTE presented four technical priorities: (i) launching a programme for the industrial connection of low-carbon resources, (ii) strengthening the network structure, (iii) renewing the network and adapting it to climate change and (iv) putting in place systems to ensure network security.

On the one hand, achieving the targets set for the decarbonisation of the energy sector will necessarily require an increase and acceleration in connections, particularly of electric renewable energies to enable their large-scale integration, charging infrastructures for electric vehicles, and projects to decarbonise industry.

Between now and 2035, RTE will have to connect 18 GW of offshore wind farms, in addition to developing structural projects to adapt the transmission system to meet demand in major industrial areas and continuing to develop interconnections between France and its neighbours. Enedis, for its part, has connected 3.8 GW of renewable energy production facilities in 2022 and 4.4 GW in 2023, and expects the total capacity of these facilities to double between now and 2032, rising from 35.5 GW at the end of 2023[50] to 70 GW in 2032 .[51]

In addition, the emergence of new production and consumption areas means that the main transmission network (400 kV lines) needs to be adapted to meet the increase and general change in flows within France and between European countries. These adaptations will involve both minor

50 Wind and photovoltaic projects only.

51 Enedis projection in the *Network Development Plan, preliminary document 2023:* https:

changes (e.g. changing conductors) and major restructuring of the network, with the creation of new routes in the years ahead.

In this context, better planning and anticipation of network developments is essential to the success of the energy transition. That's why the law to accelerate the production of renewable energies has introduced the first legislative changes in this direction, particularly as regards the regional grid connection plans for renewable energies, drawn up by RTE in conjunction with the distribution system operators.

These needs also arise in a context where a large part of the existing network needs to be renewed to take account of the challenges of adapting to climate change (increased heat waves, flooding, etc.) and ageing (the transmission network, for example, was mainly built in the post-war period and during the development of first-generation nuclear power plants)

The stakes are also high financially, with increased investment over the coming years, as well as in terms of manufacturing and human resources (recruitment).

RTE estimates that, due to the acceleration of the energy transition, some of the investments planned between 2035 and 2050 and described in "Energy Futures 2050" will actually be brought forward to the period 2030-2040. **As a result, the new SDDR will provide for significant increases in investment, with a total of around 100 billion€ between now and 2040**. By way of comparison, the SDDR drawn up in 2019 provided for €33 billion€ but only up to 2035 and on the basis of less ambitious climate objectives. As regards the distribution network, Enedis is planning to increase its annual investments by 25% between now and 2032[52] , rising from €4.4 billion/year in 2022 to more than €5 billion/year by 2032, i.e. a total programme of around €100 billion between now and 2040.

While the stakes in terms of investment are very high, it should be emphasised that they are financed by network users, on the one hand via the connection contribution and on the other via the tariff for use of the public electricity network (TURPE). They are therefore not a burden on the state budget, but they do have a cost for electricity consumers.

The revision of the network tariff (TURPE 7) currently underway will enable the network to better meet its financing needs, by providing visibility for the coverage of costs and new investments, and by striving to control the financial impact of this massive network transformation effort on the energy system as a whole.

Finally, from an industrial point of view, several factors are putting pressure on the overall supply of the electrical networks sector. Demand for equipment is rising sharply overall, and there is strong competition between electricity network operators on a global scale. The limited number of suppliers of certain critical equipment (cables, transformers, converter stations) can also drive up prices.

These tensions are already affecting supply times and costs for network operators, and thus the pace of the energy transition, which means that network operators need to adapt their supply policy or standardise their catalogue.

Interconnections, essential for a well-integrated European electricity market

Metropolitan France is interconnected with all neighbouring countries, which means that, thanks to its geographical position and low-carbon electricity production, it is able to export power on a

52 Network development plan, preliminary document 2023

structural basis, to the benefit of its trade balance. The historical record for exports is 20.3 GW, and for imports 18.7 GW (recorded in 2024)

Its interconnection capacity is set to increase significantly between now and 2030, with at least five interconnection projects already underway (with Ireland, Spain, Germany and Belgium) totalling around 5 GW of additional exchange capacity. Beyond 2030, several gigawatt interconnection projects are planned with Spain and the United Kingdom, and are currently at the study stage. The costs associated with an interconnection project are shared between the different countries on the basis of the estimated benefits of the project for each of them, in accordance with procedures decided jointly by the national regulators (in France, the Commission de régulation de l'énergie). Adaptation of the internal network is an essential prerequisite for these additional projects.

RTE's 2024 network development plan will refine the need for additional interconnection capacity according to the investment priorities established therein.

ACTION RESELEC 1

CONTINUE TO IMPLEMENT LONG-TERM PLANNING FOR THE ELECTRICITY NETWORK, THROUGH THE TEN-YEAR TRANSMISSION NETWORK DEVELOPMENT PLAN (SDDR) AND NETWORK DEVELOPMENT PLANS FOR PUBLIC DISTRIBUTION NETWORK OPERATORS

→ Deploy a framework adapted to the anticipation of network developments, based on the changes introduced by the APER law:

- Launching reviews of the regional grid connection plans for renewable energies in order to extend their timeframe, make planning more robust by encouraging producers to register with grid operators upstream, and by providing that certain priority investments can be committed as soon as they are deemed to have "no regrets" in order to speed up the provision of facilities
- Deepen the provisions made possible by the APER law (e.g. management of queues) and move away from the historical approach of responding to connection requests on an ad hoc basis to a supply approach in certain priority areas (such as industrial zones), with facilities and investments shared between consumers, as envisaged by RTE in its new SDDR.

→ Strengthen the network structure to enable new generation facilities to be evacuated, new consumption areas to be supplied, and to ensure the economic and environmental performance of the electricity system.

→ Gradually adapt the network to climate change and renew outdated infrastructure.

→ Ensuring that investments are sustainable for network operators through the public network usage tariff (TURPE), while taking care to control the impact on consumers.

→ Secure and strengthen the industrial value chain associated with electrical materials and equipment by developing the French and European offer.

→ Encourage the installation of flexibilities that can help to overcome network constraints.

→ Initiate new interconnection projects, as identified in the SDDR 2025-2040, on condition that the economic, environmental and industrial benefits of these projects are demonstrated, and that

the internal network reinforcements needed to maintain the associated exchange capacities are planned.

4.6.4.2. Developing the electricity network to integrate a growing proportion of non-controllable generation

The evolution of the electricity mix will be based on a reduction in controllable thermal energy sources at French and European level, and the development of renewable energies with low controllability, particularly wind and photovoltaic. In the long term, these renewable energies with low controllability will account for a significant proportion of the electricity mix, supplemented by hydroelectric power and nuclear generation.

The electricity system is faced with increasing episodes of overabundant production of electricity that is either unavoidable or has low variable costs (nuclear, renewable) compared with demand, at certain times of the day, particularly in spring and summer. This situation is reflected in more frequent episodes of low or negative prices, and in very sustained exports to neighbouring countries to ensure that the grid is balanced.

For example, balancing the electricity system today relies mainly on the corrective actions implemented by RTE as part of the balancing mechanism, which in the event of overproduction consists of ordering actions to reduce production by activating "downward" balancing offers submitted to this mechanism. However, RTE is regularly faced with a shortage of downward offers on the balancing mechanism, forcing it to use exceptional corrective actions not based on the market.

ACTION RESELEC 2

STRENGTHENING THE TOOLS FOR ADJUSTING GRID OPERATION TO A GROWING PROPORTION OF NON-CONTROLLABLE GENERATION

→ **modify the legislative provisions relating to the balancing mechanism**: historically, the balancing mechanism was designed to deal with situations of production deficit (upward adjustment) and only concerned producers connected to the transmission network. The plan is therefore to make it compulsory for all facilities connected to the public network to offer all available capacity on the balancing mechanism, through both downward and upward adjustments.

→ **initiate a review of the changes that need to be made to the various production support mechanisms** (remuneration supplement contracts, feed-in tariffs) in order to develop incentives for the facilities concerned to shut down or offer production at its variable cost during periods of excess production.

→ **massively develop flexibilities on the consumption side**, in order to shift consumption to the most opportune periods of the day and absorb production surpluses: this action makes it possible to optimise the operation of the electricity system at a lower cost, while providing tangible

economic and environmental benefits, by taking advantage of the abundance of low-carbon and inexpensive energy during the midday periods (see § 4.3)

4.6.5. Recharging infrastructure for alternative fuels

Note: for more details on this subject, please refer to the clean mobility development strategy in Appendix 1.

Regulation (EU) 2023/1804 of the European Parliament and of the Council of 13 September 2023 on the deployment of infrastructure for alternative fuels and repealing Directive 2014/94/EU, known as AFIR, came into force in April 2024.

Electric vehicle recharging infrastructure (IRVE) for road vehicles

Since 2020, there has been very strong growth in the deployment of IRVEs open to the public, particularly for high-power recharging, which allows vehicles to be recharged in less than 30 minutes, facilitating long-distance roaming. By 2023, all service areas on the concessionary road network will be equipped with fast-charging stations for light vehicles, and rest areas are also starting to be equipped. In addition, large commercial areas, often close to major roads, have launched programmes to install high-power IRVEs.

In particular, the AFIR regulation sets deployment targets along the TEN-T road network (central and global), as well as output power targets for charging stations. This latter objective, which breaks with the objective of the repealed 2014 directive, which set an objective in terms of the number of charging points, illustrates the importance of charging power, in particular the connection power of charging stations and the adaptation of the electricity distribution network. In addition, the DGITM is finalising (for the first half of 2025) a Master Plan for Electric Vehicle Charging Infrastructure for Roaming on the National Road Network (SDIRVE-RRN), which will set out the needs over the coming years along the entire national road network.

Generally speaking, the massive increase in the number of electric vehicles should not weaken the French electricity system. The total energy consumption of electric vehicles over the next 10 or 15 years can be absorbed without difficulty, given the changes in production capacity and other consumption anticipated at that time. The challenge is more one of power demand, particularly because of the growth in the number of electric vehicles, but also because of the arrival of electric heavy goods vehicles, which will adopt the MCS, or megacharging system, which can exceed one MW per charging point. The development of recharging control solutions will be necessary to avoid an excessive impact on peak consumption; moreover, in certain cases, the restitution of energy by the vehicle's battery, known as "vehicle to X", could provide network balancing services.

ACTION CARB ALT

Anticipating the deployment of charging points on major national roads

Set targets for the deployment of charging points for light and heavy vehicles by 2035 (in terms of connection capacity to meet the number of charging points required) for the main routes on the national road network, through a master plan for charging infrastructure for electric vehicles (SDIRVE-RRN) involving :

- For road network managers, and in partnership with electricity network managers, set and refine targets for power and charge points at area level, based on local characteristics and electricity network constraints;
- For electricity network operators, better planning and anticipation of the necessary network adaptations thanks to greater visibility of medium-term requirements.

4.6.6. Interactions between networks

The electricity and gas sectors are already closely linked, as the peak resources needed to ensure security of electricity supply are generally gas-fired generation facilities. Similarly, the electricity and natural gas markets are closely linked, with the price of electricity quite heavily dependent on the price of gas. In order to take account of the new dynamics of consumption and their daily, weekly or annual profile, the transitions and transformations between vectors and in particular between electricity and gas, or between electricity and heat, should increase. The different vectors therefore need to be considered in a more global way: this is sectoral coupling.

These discussions are currently taking place at several levels, from the European level, with the strategy for coupling sectoral systems, to the local level, with the development of smartgrids, collective self-consumption or the coupling of several systems on the same site (cogeneration, recovery of waste heat, development of electrolysers associated with industrial processes, etc.).

In addition to optimising consumption, taking sectoral coupling into account will have direct implications for infrastructure sizing and planning (ten-year network development plans), in particular to ensure security of supply.

The development of flexibilities is also a challenge for the resilience of energy systems. Indeed, disruptions to one energy system can lead to disruptions to other systems, whether in terms of prices or the operation of these other systems themselves, and lead to shifts in consumption from one energy source to another. The interplay between natural gas and electricity supplies is no longer in doubt: the aftermath of the invasion of Ukraine and the energy price crisis have underlined the interdependence of the two energy systems.

•5. Research and innovation for the development of new energy technologies

Research and innovation policy, an essential lever for accelerating and achieving the low-carbon energy transition.
Research and innovation are a major focus of the energy transition policy, helping to consolidate the positioning of competitive industries that will create the jobs of the future, creating the conditions for society to take ownership of this transition, and addressing environmental issues throughout the innovation cycle for emerging technologies and those currently being deployed, while working together to decarbonise the energy mix and reduce consumption.

The profound transformation required for the transition to a low-carbon society can only be achieved through a complex combination of technological breakthroughs, innovation and changes in behaviour, from individual consumers to industrial designers. Research can provide solutions to these social, economic and technological challenges. To nurture research on these different issues over the long term, it is essential to maintain a balance between skills in key disciplines such as chemistry, mathematics, biology and the human and social sciences.

Public investment in R&D for energy is around €1,725m, following two years of strong growth: +12% in 2021 and +11% in 2020. The top two areas are nuclear power (€962m, 56%) and new technologies (€614m, 36%), followed by fundamental research (€133m).

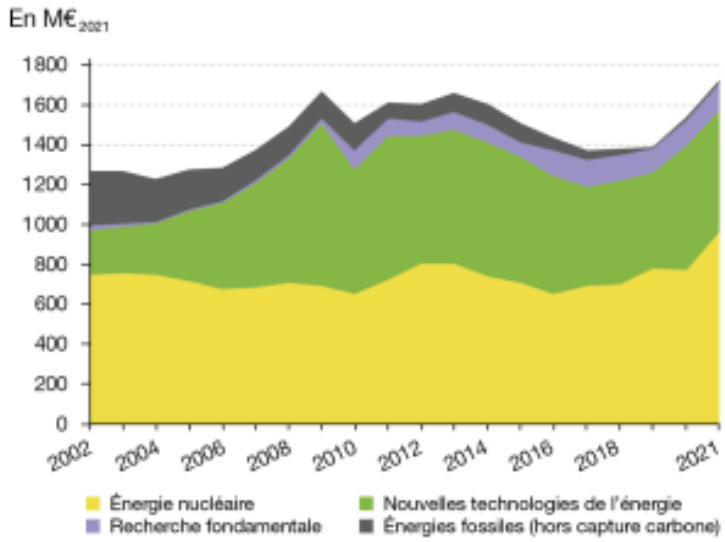


Figure 33. National public R&D expenditure on energy by field from 2002 to 2021 - Source SDES (publication October 2023)

In addition to funding public research establishments, the French government supports collaborative research projects between public and private R&D players and innovative business projects, and encourages the transfer of research to industry. Given the specific nature of the energy sector, all the scientific, technological, economic and societal barriers can only be overcome through actions supported by both public and private research, and through a collaborative approach between the various players.

Technological challenges

In the technological fields, whatever the specific features of each scenario for achieving carbon neutrality, which will contribute to meeting France's climate commitments by 2050, both on the demand side and the supply side, solutions resulting from research are expected in the decarbonisation of industrial processes, energy efficiency, large-scale deployment of low-carbon energies, particularly renewable and nuclear, the development and control of storage resources for the various energy carriers (electricity, heat, gas, etc.), intelligent management of the transport and distribution networks for the energy carriers, large-scale development of carbon capture and storage solutions, the development of recycling, the preservation and supply of natural resources, the development of renewable energies, the development of renewable energies, the development of renewable energies, the development of renewable energies and the development of renewable energies.), intelligent management of energy transmission and distribution networks, large-scale development of carbon capture and storage solutions, development of recycling, preservation and supply of natural resources, development of bio-based products, in particular biochemicals and biomaterials, and support for organisational innovations.

To detect the emergence of new technologies and guide public policy accordingly, France is adopting a proactive, multi-dimensional approach. A number of local players are involved in this, for example through the networks of SATTs (Sociétés d'Accélération du Transfert de Technologies), competitive clusters, university innovation clusters and the presence of ADEME and BPI France in our regions. This monitoring enables us to keep an eye on trends and prospect for new technologies, so that we can feed into the work of drawing up public innovation policies for the future development of energy technologies.

Social and organisational issues

Research in the humanities and social sciences has its part to play in the technological issues surrounding the ecological transition, because changes in usage and questions of social acceptability and appropriation arise as a result. Changes in lifestyles towards a low-carbon economy require work on forms of social organisation, institutions and economic models. The aim is to decompartmentalise the sciences and create beneficial exchange relationships between the humanities and social sciences and the formal and natural sciences. The benefits are manifold:

- A cross-disciplinary approach between research and social sciences and humanities players, to ensure that research areas and innovation paths correspond to the real needs of society.
- Facilitating the industrial deployment of new energy technologies, in particular by addressing issues of acceptability.
- Bringing research establishments closer to civil society with the aim of winning over a wider audience
- Anticipating possible rebound effects (Jevons effect) linked to the deployment of new energy technologies

Investments in France 2030

The France 2030 plan has supplemented the existing resources of the Programme d'Investissement d'Avenir with additional funding, representing an unprecedented effort in research and innovation to support highly innovative and ground-breaking projects, with a major focus on supporting the ecological transition.

For research activities, the Priority Research Programmes and Facilities (PEPR) provide support for research, with the aim of building and consolidating French excellence in priority scientific fields at national level. These PEPRs support the energy transition through technological, economic, societal and environmental transformations. The Agence Nationale de la Recherche (ANR - National Research Agency) is the State's operator for this upstream research (technologies that are not yet mature, associated with low TRLs).

Since 2021, a number of PEPRs have been launched in emerging energy-related scientific and technological sectors, focusing on energy systems to accelerate the decarbonised production of electricity and heat, promote decarbonised hydrogen, new-generation batteries, decarbonisation of industry, advanced materials, understanding biogeochemical cycles, more responsible management of water, the subsoil as a common good, recycling, biosourced products and biotechnologies, among others.

In the field of energy transition, it is then a question of demonstrating technologies and their uses in real-life conditions, and then ending up with products that can be deployed. The government's support for the various acceleration strategies accompanies the various key stages, from identifying the barriers to be overcome in research and development, to the transition to industrial scale, right through to the opportunities for mass deployment with the first commercial capacities

Game changers
An ANRT working group has undertaken a SWOT-type approach, based on the identification of market strengths, weaknesses, opportunities and threats, to qualify various potential disruptions to energy supply and demand by 2030-2040 (wind, solar, nuclear, biomass, networks, digital, hydrogen, low-carbon fuels, vehicles, aviation, industry, buildings) and thus define research and development priorities.

AI, or emerging technologies in Artificial Intelligence
While artificial intelligence offers significant opportunities for combating climate change, and will contribute to our economy and society as an embedded solution in mobile devices (autonomous cars, logistics robots, agricultural robots, personal assistance robots, etc.), each of these solutions will have to be high-performance, robust and resilient if they are to be accepted and therefore easily and widely deployed.

The results of this research, ranging from hardware to software, from energy consumption to the development of new architectures, will have an impact on all energy sectors and links.

Ambition at European level
To ensure greater visibility in the medium and long term, French research players are mobilising both at national level and as part of collaborative European programmes.

In the field of energy, France has an academic fabric, research and innovation bodies and training structures that are often at the top of international rankings (CEA, IFPEN, CNRS). There are strong links with major international industrial players in the energy sector, as well as with SMEs and ETIs.

In the light of international competition and to enhance the attractiveness of the European Union, the possibilities for structuring European energy industries are being examined. This cooperation and consultation is taking place at several levels through the SET PLAN (**Strategic Energy Technology Plan**) committee. The SET Plan aims to put in place a Community cooperation policy to accelerate the development and deployment of low-carbon technologies. To this end, it helps to coordinate national research and innovation activities in the field of low-carbon energy development between Member States and associated countries, and to align national research and innovation programmes with each other.

This space for dialogue between researchers and their research ecosystems is of geopolitical and strategic importance for the European Union. With the aim of maximising the effectiveness and impact of these actions, in the long term they will create more socio-economic opportunities in established and emerging markets.

Indicators for monitoring research and innovation policy

Several players are working to develop indicators in this area. In collaboration with the ministries and the four operators (ADEME, BPI France, ANR and the Caisse des dépôts et de consignation) of the France 2030 investment programme, the SGPI is developing indicators to assess the impact of support for innovation. The CGDD also collects data on public investment in energy research and development (R&D) for the IEA (International Energy Agency), providing a comparable framework for IEA member states.

•6. Socio-economic and industrial issues, consumer purchasing power and competitive energy prices

6.1. Macro-economic issues and socio-economic impacts of the EPP

6.1.1. Macro-economic issues of the EPP

The Three-ME[53] and IMACLIM[54] models are used to assess the macro-economic impacts of the joint reference scenario of the SNBC and the PPE. This macro-economic assessment is carried out by comparing the "AME" or "with existing measures" scenario with the "AMS" or "with additional measuresscenario. **It provides valuable information in terms of the social and economic impact of the assumptions and orientations adopted in the SNBC and the PPE.**

For the SNBC and PPE 3, this assessment of the final scenario will be included in the report accompanying the SNBC. It will help to inform the operational planning of the SNBC 3, and will thus complement the issues identified in the report "Les incidences économiques de l'action pour le climat" by Jean Pisani-Ferry and Selma Mahfouz published in May 2023[55] on the economic impact of the transition:

- The **climate transition is on the scale of an industrial revolution**, but will have to be twice as fast
- The **transition is based on three economic mechanisms**: the **reorientation of** technical **progress** from brown to green, the beneficial effects of which will materialise in the medium to long term; **sobriety**, which presupposes a change in practices and collective norms and can be conducive to well-being; the **substitution of capital** (public and private investment) for fossil fuels (the main mechanism over the next 5 to 10 years).
- While the transition may result in a fall in business productivity growth in the short term, an orderly transition that is sufficiently predictable for households and businesses to be able to anticipate the measures and adapt accordingly could **generate gains in activity in the long term.** These gains will only materialise under the following good conditions: absence of friction in the reallocation of capital and labour, international coordination of transition policies, orderly transition, etc. The transition also presents an inflationary risk, which public policies will have to seek to control. In any case, the cost of action is much lower than the cost of inaction.
- **The competitiveness of European industry is at stake**. We need to support the development of green industries. So too is support for the energy competitiveness of businesses in relation to other major economic powers, given the differences in energy prices.

53 Three-ME is a Keynesian computable general equilibrium model developed since 2008 by OFCE and ADEME. It is a hybrid multi-sector model.

54 IMACLIM is a multi-sector hybrid general equilibrium model of the French open economy developed by CIRED.

55 https://www.strategie.gouv.fr/publications/incidences-economiques-de-laction-climat

- **Transition raises issues of equality and just transition**. Transition presupposes the ability to finance public and private alternatives. Even if they can sometimes be profitable in the long term, some green investments may not be financeable without public support for low-income households or even the middle deciles. Consequently, the French strategy will continue to provide the necessary public support to households, particularly the most vulnerable, to ensure that the transition is feasible for all. The problem of financing green investments will also arise for businesses, particularly the smallest ones, which will not necessarily be able to finance all the costs of decarbonisation. They will also need support. Finally, sobriety efforts will have to be shared by all players.

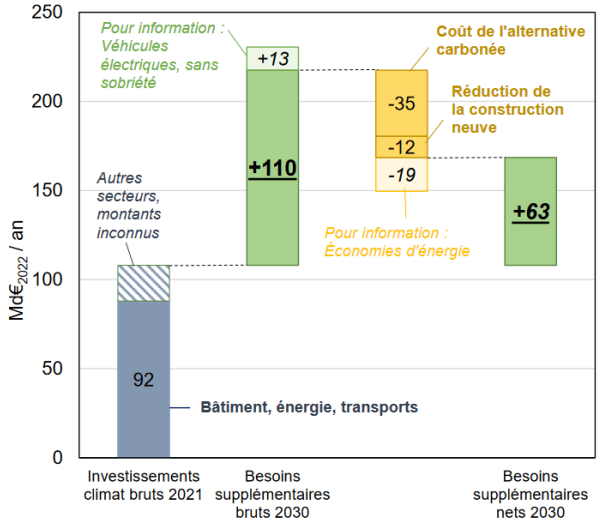
  Support will continue to be provided for the far-reaching changes associated with the transition, including support for energy-efficient home renovation, support for paying energy bills, incentives for converting the most polluting vehicles, support for purchasing electric vehicles, etc., **with greater targeting.**

  The macroeconomic assessment of the SNBC3 currently underway is intended to build on the work of the report "Les incidences économiques de l'action pour le climat" by Jean Pisani-Ferry and Selma Mahfouz, published in May 2023. According to this report, the ecological transition would ultimately generate economic and environmental co-benefits compared with a scenario of climate inaction, i.e. without sufficient mitigation policies to prevent the deleterious effects of climate change from materialising. However, the ecological transition could lead to a slowdown in economic growth, particularly over the next decade. The report also includes an *ex-ante* assessment of the macroeconomic impact of several additional decarbonisation measures (fiscal measures and sectoral measures in construction, road transport, industry and energy production). In the presence of a negative shock to productivity justified by the crowding-out effects that additional investment in decarbonisation could have on productive investment, these additional measures could lead to a fall in activity and inflationary effects compared with a reference scenario incorporating the existing measures. Overall, this report highlights the uncertainty surrounding the macroeconomic impact of transition policies and calls for further evaluation work.

6.1.2. Issues surrounding investments to combat climate change

Achieving the objectives of the ecological transition will require substantial financing, primarily from the private sector, but also from the public sector. In 2022, according to the latest edition of I4CE's climate finance overview[56] , private and public climate investments will reach €100 billion, up 9% on 2021 (driven by energy-efficient home renovation and low-carbon vehicles).

In a working paper published in April 2024 (based, among other things, on the report "Les incidences économiques de l'action pour le climat"[57] by Jean Pisani-Ferry and Selma Mahfouz and the 2023 edition of the I4CE climate financing overview[58]), the French Treasury estimates that decarbonisation will require additional private and public investment that could amount to around €110bn/year in 2030 compared with 2021. This could be limited to around +€63bn/year in net additional annual investment (after subtracting the reduced investment in carbon alternatives and the fall in new construction). By way of example, the increased use of electric vehicles would reduce gross investment in internal combustion vehicles by around €29 billion a year in 2030. Energy efficiency measures also play a key role in moderating these investment requirements: without them, investment requirements for electric vehicles would be €13 billion higher per year. However, investment requirements for 2050 are not yet known. These investments will lead to energy savings that could partly cover these additional costs.



Secteur		Présent document de travail[1]
Total	**Bruts**	**+110 Md€/an**
	Nets	***+63 Md€/an***
Bâtiment	Bruts	+39 Md€/an avec redirection vers des investissements coût-efficients
	Coût de l'alternative carbonée	*−6 Md€/an*
	Baisse construction neuve	*−12 Md€/an*
	Pour information : Économies énergétiques (résidentiel)	*−10 Md€/an*
Transport	Bruts	+43 Md€/an
	Coût de l'alternative carbonée	*−29 Md€/an*
	Pour information : Économies énergétiques (véhicules routiers)	*−9 Md€/an*
	Pour information : véhicules électriques évités par des mesures de sobriété	*−13 Md€/an*
Énergie		+17 Md€/an
Industrie		+5 Md€/an avec Opex
Agriculture et forêt		+5 Md€/an
Déchets		+1 Md€/an

Sources : Résidentiel, transport hors infrastructures et renouvellement forestier : chiffrage des auteurs ; Tertiaire et construction neuve : I4CE (2023a) SNBC3 ; Infrastructures de transport : JPF-SM (2023) ; Énergie : borne haute RTE (2023) ; Industrie : DGE (2023) dont investissements à l'achat pris en non supplémentaires ; Agriculture : borne inférieure des chiffrages mobilisés ; Forêt hors renouvellement forestier : moyenne des chiffrages disponibles ; Déchets : Rexecode (2022).

[56] Institute for the Economy and Climate

[57] The additional investment needed between now and 2030 to help the climate is estimated by the report at €101bn/year in low-carbon investment and €66bn/year net of reductions in carbon investment (€35bn/year in brown investment). The report will be published in May 2023 and can be accessed at the following link: https://www.strategie.gouv.fr/publications/incidences-economiques-de-laction-climat

[58] The Institut de l'économie pour le climat (I4CE) estimates that each year on average between 2024 and 2030, an additional €58bn/year will need to be invested in climate protection compared with 2022. By 2030, on the same sectoral basis, these needs are close to those identified by Jean Pisani-Ferry and Selma Mahfouz.

*Figure 34. Additional low-carbon investment requirements in 2030 compared with 2021, estimated by the French Treasury's working paper (Source: "Quels investissements pour les objectifs français de décarbonation en 2030", **April 2024, Logan Gourmand**).*

These investment requirements are estimated on the basis of a bottom-up, sectoral approach describing a chronicle of investment in gross fixed capital formation and in the consumption of low-carbon durable goods, making it possible to meet the objectives of the SNBC 3 and therefore of the PNIEC. Most of the time, the requirements are calculated in current euros and do not allow for the internalisation of price variations resulting from macroeconomic mechanisms.

Sectoral analysis of investment requirements for 2030

The French Treasury estimates that the need for additional investment in the building sector by 2030 is particularly high, in line with the Pisani-Ferry-Mahfouz report and I4CE estimates. This would amount to +€39bn/year, including +€22bn/year for the renovation of residential buildings, based on the assumption that renovations will be targeted at cost-efficient measures. The total amount of investment to be made in this sector is likely to be affected by investment in new construction, which could lead to a reallocation of investment between construction and renovation.

In the transport sector, climate investments will have to be increased by €43 billion per year in 2030, mainly for the acquisition of zero-emission vehicles (an additional €27 to €33 billion per year for passenger cars, and €7 to €12 billion per year for LCVs and HGVs) and for transport and recharging infrastructure (€6 to €15 billion per year). The sobriety assumptions have an impact on total investment, since in a scenario with a smaller fall in total vehicle registrations, investment in electric vehicles would be around €13 billion a year higher and investment in combustion vehicles would be €6 billion a year higher.

In the energy sector, the need for additional investment by 2030 is estimated at €17 billion per year, mainly in electricity generation (to meet rising demand and low-carbon production) and low-carbon fuels, as well as in networks (transmission, distribution and flexibility). As part of the EPR2 programme, the French government has evaluated the investment costs involved in building 6 new nuclear reactors, with the first reactors due to be connected to the grid by 2035. These are estimated at €51.7 billion, spread over a total construction period of 25 years, corresponding to average annual investment of around €2 billion per year.

The need for additional investment in decarbonising industry is estimated at between +€2 and +€3 billion/year on average for 2024-2030 in order to achieve the objectives of the SNBC2, compared with the observed emissions reduction trend. They could reach up to +€4bn/year in 2030 if the SNBC-3 targets are met, and +€5bn/year if operating costs (maintenance and energy costs) are included, which are highly uncertain but could reach +€1bn/year.

There have been few recent studies of the additional gross investment needed in agriculture and the forest and land sector. Existing figures identify minimum additional gross investment needs of around €1bn/year for agriculture[59] , driven by the acquisition of new low-carbon machinery, and

59 These figures need to be looked at in more detail, as they are mostly partial, targeting the sector's energy transition. Furthermore, they do not include all the costs of the environmental transition for the sector: costs linked to certain changes in agricultural practices and training, research and development, investments required to meet specific non-CO2 targets (in particular non-energy emissions, such as those linked to methane). Agriculture's needs could increase by around €5 billion per year by 2050, including personnel costs and current consumption.

around €1bn/year for forestry on average by 2030 compared with today in order to achieve the SNBC2 objectives, based on a limited scope of investments. Restoring the storage capacity of the forest carbon sink, which has fallen by two-thirds since 2000, would alone require up to €28bn in gross non-additional investment, i.e. +€3bn/year between now and 2030, bringing the additional needs for the forest to around +€4bn/year.

Financing instruments and breakdown by player

A collective effort is needed involving businesses, local authorities, the State and the French people as a whole. To this end, the Comité du financement de la transition écologique (CFTE) has been tasked with coordinating the efforts of manufacturers, financiers and public authorities to mobilise the financial resources needed for France's ecological transition. **Against a backdrop of budgetary constraints, the government's priority will be to mobilise private funding and to target public funding according to criteria of efficiency, incentives and social justice, with a multi-year perspective**, as well as to reduce certain "brown" expenditure.

To provide this visibility and a multi-year perspective, article L. 100-1 A of the Energy Code stipulates that the Government must now submit a "multi-year strategy defining the financing of the ecological transition and national energy policy" (SPAFTE) to Parliament each year. The first edition of this strategy, published on 21 October 2024[60] , provides information on the breakdown of investment between the public sector, businesses and households. Financing for decarbonisation now appears to be on the increase for all players, and this dynamic must be strengthened and continued. The public sector is currently investing more than the private sector in decarbonisation, in proportion to its total investments. In 2022, it will have invested 20% of its total investments in low-carbon assets[61] , compared with 13% for the private sector (households and businesses). If the private sector were to align its share of low-carbon investments by 2027[62] with that of the public sector in 2022, and if the public sector were to continue the upward trend in its own share, then low-carbon investments could increase by €63 billion between 2022 and 2027 and move closer to the investment targets needed to achieve the decarbonisation objectives.

To make such a scenario a reality, a wide range of public policies are needed to ensure that private and public funding is efficiently mobilised to support investment in the ecological transition. Public intervention needs to be as effective as possible, for example by enabling the financing of essential public goods and support for vulnerable households and businesses. A combination of tools can be used to redirect the flow of private finance towards projects for the ecological transformation of the economy. Regulatory levers help to trigger investment by certain households and businesses, for example in greening vehicle fleets, reducing energy consumption in buildings, reducing pollutant emissions from industry or protecting biodiversity. Carbon pricing tools can be used to encourage economic players to steer their production and consumption decisions towards less carbon-intensive alternatives. In addition, the redirection of private finance flows is encouraged by the introduction of 'green' bonds, labels and targeted government guarantees, as well as by the development of 'green' savings products. Public subsidies and targeted taxes are useful tools to complement these different levers in certain cases.

In line with this multiannual strategy, the Finance Bill (PLF) for 2025 consolidates the ecological course set in 2024, reaching an unprecedented level of spending in favour of the transition. State funding

[60] https://www.economie.gouv.fr/files/files/directions_services/economie-verte/SPAFTE-2024.pdf?v=1729513896

[61] Based on a perimeter defined in the SPAFTE and covering the building, transport and energy sectors.

[62] The first edition of SPAFTE focuses on the 2027 horizon

for decarbonisation will thus increase in 2025[63] by €4.4 billion compared with 2024 (after implementation of the cancellation decree) and by €7.6 billion compared with 2023, with a sharp rise in State support for renewable energies, in line with the increase in installed volumes and the fall in electricity market prices. The content of this support will evolve in line with the needs and maturity of each sector, with greater emphasis on the most efficient schemes. In particular, the State's financing will focus on the energy renovation of buildings, the greening of the vehicle fleet, the development of public transport, the decarbonisation of industry, the acceleration of renewable energies and the agricultural transition. Caisse des Dépôts Group is also mobilising to help finance the transition for local authorities and businesses, and has announced an unprecedented contribution of €100 billion to the ecological transition over the period 2024-2028. As part of the green reindustrialisation programme, it has also been decided to step up Bpifrance's support for the ecological transition. The government's action includes its own investments, but above all support for other players to encourage them to make the transition: support for private individuals through grants for home renovation and the purchase of clean vehicles; support for businesses, notably through calls for projects to decarbonise industry, the heat fund, and so on.

In the process of making investments greener, the **redirection of household savings will be encouraged**, in particular through new schemes such as the Plan d'Epargne Avenir Climat (PEAC) provided for in the Green Industry Act. Asset management companies could also be supported in this redirection with the creation of Transition Bonds (OT), also provided for in the 2024 Finance Act (article 185). In addition, a new financial support mechanism for investments in decarbonisation is being prepared in line with the status report and outlook for the deployment of the CCUS in France[64] , including calls for tender in favour of major industrial decarbonisation, electrification or carbon capture projects by covering, for example, part of the costs associated with capture units, the gradual implementation of new transport infrastructures or access to storage.

Alongside these investments, **innovative financing solutions are being developed**:

- For example, **the low-carbon label**[65] **provides an incentive to reduce national greenhouse gas emissions** by providing a framework for and officially recognising emission reduction and carbon sequestration projects in France, the final balance of which is recorded as "Emission Reductions" (ER), where 1 ER corresponds to one tonne of CO_2eq[66] . The low-carbon label is a scheme that provides tangible funding for the emergence of climate-friendly projects. It has also established itself as one of the benchmark schemes for climate offsetting in Europe, and could inspire the European framework currently being developed by the *Carbon Removals Certification Framework* (CRCF). Last but not least, the scheme is highly localized to meet the expectations of financiers to get involved in local, exclusively French, offset projects.
- For building renovation, innovative financing schemes such as third-party financing, financial leasing and Energy Performance Contracts have been developed. Third-party financing was

[63] The amounts presented here are based on the initial text and the detailed annexes to the Budget Plan.

[64] https://www.entreprises.gouv.fr/files/files/industrie/etat-des-lieux-et-perspectives-de-deploiement-du-ccus-en-france.pdf

65

66 To date, more than 2 $MtCO_2$eq could be avoided and/or sequestered over the next 30 years by certified projects, and we can expect to reach a potential of 15 $MtCO_2$eq in 2030 (which will therefore be avoided and/or sequestered between 2030 and 2060).

opened up to the State, public institutions and local authorities on an experimental basis by the law of March 2023[67] on third-party financing.

- With regard more specifically to **the obligation to finance low-carbon projects**, a number of measures have been introduced recent years that have increased demand for the financing of low-carbon projects with high environmental integrity in France and around the world. These include
  - The progressive obligation to finance low-carbon projects in line with greenhouse gas (GHG) emissions from domestic flights for aircraft operators subject to the EU Emissions Trading Scheme and generating more than 1,000 tonnes of CO_2 per year on national territory (Climate and Resilience Act);
  - The obligation to finance low-carbon projects up to the level of emissions from coal-fired power stations extended to deal with the energy crisis linked to the war in Ukraine (MUPPA law[68]);
  - The commitment to finance low-carbon projects to the extent of the GHG emissions of all flights made by employees of State services and public establishments, whether national or international (Eco-responsible Public Services circular).

In addition**, the reform of the European Union Emissions Trading Scheme** (EU ETS) provides for an accelerated reduction in the emissions cap (-62% in 2030 vs. 2005, compared with -43% before the review), the inclusion of the maritime sector and a trajectory for the abolition of free allowances for the aviation sector as well as for certain sectors at risk of carbon leakage as the border carbon adjustment mechanism is gradually ramped up. This should **result in an increase in the revenue that Member States derive from the European carbon market**, and a strengthening of the Innovation Fund, which **finances innovative low-carbon technology projects in European industrial sectors**. One of the challenges in the coming years will be **to make effective use of these increased resources for France's ecological transition**, while respecting the principle of budgetary universality and meeting the target set for all Member States of devoting 100% of the revenue from the EU ETS, or its equivalent in financial value, to climate-related expenditure (compared with 50% before the reform). Since 2013, France has been earmarking part of its EU ETS revenue (€2.1bn/year in 2023) to fund the Agence nationale de l'habitat (ANAH), in particular to finance the MaPrimeRénov' home energy renovation programme (€700m/year in 2023 and 2024).

6.2. Preserving household purchasing power

6.2.1. Combating fuel poverty

The fight against fuel poverty is based on preventive measures (such as support for energy-efficient home renovation or the introduction of the tariff shield during the recent crisis) and assistance for households in fuel poverty (help with paying bills with the energy cheque).

6.2.1.1. Preventive measures

ENERGY RENOVATION

[67] Law no. 2023-222 of 30 March 2023 aimed at opening up third-party financing to the State, its public establishments and local authorities to promote energy renovation work.

68 Law on "emergency measures to protect purchasing power", known as the "MUPPA law".

A number of energy renovation support schemes place particular emphasis on low-income households and aim to get rid of "energy flaws":

→ The Energy Savings Certificates scheme requires energy suppliers to finance a certain volume of energy renovation work among French households, including some among households in fuel poverty. From 2016, when the "energy poverty" obligation was created, to 2022, around €6.7 billion worth of work[69] has been financed under the "energy poverty" CEE scheme, 23% of it since the beginning of 2022. The CEE obligation has been increased by 25% for the 5th period 2022-2025, bringing it to 3,100 TWhc (including 1,130 TWh for the most vulnerable households).

→ In 2023, 67% of the projects financed by MaPrimeRénov' (a grant for private individuals to finance energy renovation work: insulation, changing the heating system, installing ventilation, carrying out an energy audit, and assisted overall renovation) concerned low-income and very low-income households, out of a total budget of €3.1bn. Since 1 January 2024, MaPrimeRénov' aid for very low-income households wishing to carry out a major renovation of an energy sieve can reach up to €63,000. The continued roll-out of France Rénov', the public home renovation service, the continued funding from 1 January 2025 and the ramping up of Mon Accompagnateur Rénov' from 1 January 2024 will help to improve the identification of households in fuel poverty, as well as providing advice to all households, with a particular focus on low-income and very low-income households,

→ The renovation obligations in the rental market, introduced by the Climate and Resilience Act in 2021, will encourage landlords to undertake energy renovation work to ensure that their homes are energy decent. More than 40% of the private rental housing stock (in its current state)[70] is affected by the gradual extension of energy decency criteria by 2034. Since January 2023, 1.7% of the private rental housing stock (DPE label G+) has already been affected; a further 6.3% (label G) will also be affected from January 2025. In January 2028, a further 10.5% of homes (label F) will be affected, before an extension to 22.4% of homes (label E) in 2034. Exemptions are provided for owner-landlords (i) because of heritage or historical constraints, or (ii) in the event of blockage of the necessary work in co-ownership. In addition, the energy decency criteria (and their extension to 2025, 2028 and 2034) also apply to social housing, where 26.9% of the stock will gradually be affected .[71]

→ The MaPrimeRenov' energy renovation subsidy, which has a budget of €2.7 billion in 2023 (see §6.5.1. *below*), is particularly targeted at low-income households: in 2023, 67% of the projects financed were intended for low-income or very low-income households[72] . This targeting is made possible by a high subsidy rate for major renovations for low-income and very low-income households (subsidy rates of 60% and 80% respectively) and (ii) an energy sieve exit premium equivalent to 10% of the cost of the work for the overall renovation of a very run-down dwelling, for low-income households only.

→ In order to better finance the remaining costs and facilitate households' access to bank loans, in addition to existing financial tools such as the zero-rate eco-loan (écoPTZ), the Renovation Advance Loan (PAR) is a mortgage loan created in March 2022, which allows the remaining costs

69 1358 TWhcumac of "fuel poverty" CEE registered on the national CEE register.

The term cumac (for cumulated and discounted) takes into account the energy over the lifetime of the action concerned (product, equipment, etc.), for example 15 years for a freezer or 30 years for the insulation of a house. 100 TWh cumac is equivalent to the residential energy consumption one million French people over 15 years.

[70] The energy performance of the private rental housing stock at 1 January 2023 | Statistical data and studies (developpement-durable.gouv.fr)

[71] 0.4% (G+), 1.9% (G excluding G+), 5.8% (F) and 18.8% (E). Source: Le parc de logements par classe de performance énergétique au 1er janvier 2023 | Données et études statistiques (developpement-durable.gouv.fr), additional data.

[72] 2023 Activity Report (anah.gouv.fr)

to be repaid at a later date, for example when the home is sold or as part of an inheritance, with a guarantee from the Guarantee Fund for Energy Renovation (FGRE) of up to 75% of any loss incurred. As part of the Finance Act for 2024, this scheme has been strengthened with the creation of a zero-interest renovation advance loan for a maximum term of 10 years, available to households on a means-tested basis.

THE WINTER TRUCE AND THE MINIMUM ELECTRICITY SUPPLY SERVICE

A number of energy renovation support schemes place particular emphasis on low-income households:

During the winter truce, between 1 November and 31 March, energy suppliers are obliged to maintain the supply of natural gas and electricity to customers in arrears. However, electricity supply may be reduced, except for the most vulnerable households, defined as those eligible for the energy voucher scheme. Outside the winter truce, if a supply interruption is envisaged, its implementation is subject to strict controls for all households (reminder letters, deadlines, notification of social services by the supplier if the supply has not been restored within five days of the interruption).

In addition, since 1 April 2023[73] , a minimum 60-day electricity supply period has been in place for beneficiaries of the energy cheque and the housing solidarity fund, prior to any disconnection in the event of unpaid bills, including outside the winter truce. During this period, the electricity supply is maintained at 1kVA, to give the consumer and the supplier time to find a solution to the household's situation.

6.2.1.2. Support measures

HELP WITH PAYING BILLS: ENERGY CHEQUES

Generalised in 2018, the energy voucher is a government subsidy for low-income households to help them pay their energy bills, whatever their heating method (electricity, gas, wood, fuel oil, LPG, etc.) or energy renovation work. State aid earmarked for household energy expenditure, this is the tool that helps to mitigate the cost of the transition on low-income households and is an essential element in ensuring a fair transition.

Based on the income and composition of the household (all the people living under the same roof), it is granted according to the reference tax income per consumption unit (RFR/ UC). Households do not have to do anything to obtain it: it is sent to them automatically on the basis of data held by the tax authorities. In 2023, 5.6 million households benefited from the energy voucher, receiving between €48 and €277. More than 83% used it.

In 2024, households receiving energy cheques for 2023 automatically received an energy cheque in April. 5.5 million households benefited.

For households whose 2022 situation enables them to be eligible for the energy cheque, or to have a cheque for a higher amount, a specific application window has been set up.

The ways in which the energy voucher scheme will evolve after the abolition of the taxe d'habitation are currently being studied, with a view to preserving in the long term the protection afforded by this scheme and its advantages over other approaches (free choice of supplier, neutrality between energies, incentives to control consumption). Improvements to the scheme may also be studied as

73 Article 35 of law no. 2022-1158 of 16 August 2022 on emergency measures protect purchasing power and decree no. 2023-133 of 24 February 2023 on the minimum electricity supply period and amending decree no. 2008-780 of 13 August 2008 on the procedure applicable in the event unpaid electricity, gas, heat and water bills.

part of this reform, in particular to make it even more accessible and easier to use for the most vulnerable households.

In addition, in order provide more information about the scheme and support for beneficiary households to make it easier to use the energy voucher and the associated rights, the energy voucher has been integrated into France services since 2024

6.2.2. Ensuring that everyone is informed and transparent about energy costs and prices

Knowing and communicating energy prices and their various cost components is an important transparency issue. Since 2020, the energy markets have been marked by a succession of shocks to demand and supply, as a result of the health crisis and then the war in Ukraine, which have had a major impact on the prices paid by consumers. In addition, promoting energy sobriety with the aim of reducing energy consumption and the resulting emissions means helping households and businesses to understand prices so that they can play a more active role in their consumption.

The website of the Ministry of Energy provides the public with an annually revised guide to energy taxation, as well as oil product prices, which are updated weekly, and the major components of these prices (Brent crude oil prices, refining costs, transport and distribution costs), which are updated monthly or annually.

In order to encourage the use of alternative motorisations, the Ministry of Energy carries out a quarterly comparison of the cost of purchasing the fuel needed to travel 100 km using alternative fuels (LPG-c, electricity, natural gas for vehicles and hydrogen), E10 petrol and diesel. These costs must be displayed at all major service stations.

Lastly, the www.prix-carburants.gouv.fr website gives the public real-time access to the prices charged by most service stations, with a geolocated search function for stations charging the lowest prices around a given road.

In the case of electricity and gas, a free public offer comparator is available to everyone on the website of the National Energy Ombudsman (https://www.energie-info.fr). This comparator enables consumers to find out about all the gas and electricity supply offers available, so they can choose the one that best meets their needs.

Furthermore, in the event of a dispute with their energy supplier (electricity, natural gas, LPG gas in bottles or tanks, fuel oil, wood or heating networks), the distribution network operator or their electricity purchaser (in the case of individual self-consumption), consumers or their representatives (consumer associations, lawyers, etc.) can refer the matter to the National Energy Ombudsman free of charge to help them settle the dispute. The consumer may be an individual, a micro-business (with fewer than 10 employees and a turnover of less than €2m) or a non-professional (co-ownership, association, etc.). Complaints may be made to the ombudsman within a period of between 2 months and one year following a written complaint to the operator. Complaints may be submitted by post or electronically.

Commercial communications play a powerful, day-to-day role in influencing consumer behaviour and, beyond that, their lifestyle aspirations and desires. Through advertising, companies can help to promote products or modes of consumption that have a lesser impact in terms of greenhouse gas emissions, air, water and soil pollution, waste production and the use of raw materials. Several recent regulations provide a framework for commercial communications in the context of the ecological transition: since 1 January 2023, carbon neutrality claims for products and services have been heavily regulated by Article 12 of the Climate and Resilience Act. To be used, these claims must comply with

a strict regulatory framework in order to combat greenwashing. Another example: vehicle advertisements are required to communicate the importance of soft and active modes of transport, and to show the greenhouse gas emissions of vehicles. Finally, climate contracts have committed a number of companies to responsible communication.

In addition to providing a framework for commercial communications, the French strategy for energy and the climate aims to enable a fairer and more inclusive transition. By improving the framework for energy supply offers and supply authorisations, it will provide greater guarantees for consumers and greater resilience for suppliers, to the benefit of their customers.

Finally, in order to achieve the objective of ending the consumption of fossil petroleum products for energy purposes (excluding international bunkers) by 2045, any public support from the State will have to ensure a cost differential that is unfavourable to the fossil fuel solution compared with decarbonised solutions.

6.2.3. Competitiveness of electricity supply

REVISION OF ELECTRICITY MARKET RULES

The current European market framework for electricity is based on remunerating generating capacity according to its marginal cost, i.e. the cost of producing an additional MWh by the most expensive plant in operation. This way of working has ensured the efficient use of facilities throughout Europe at the lowest cost to guarantee short-term security of supply, and the most appropriate use of interconnections between national markets, for more than 20 years, and is therefore an important element in European energy integration.

On the other hand, this market framework does not allow for the emergence of a long-term price signal that is necessary for producers to invest in decarbonised means of electricity production, and for consumers to invest in decarbonising their consumption.

The rules of the electricity market therefore need to be supplemented to enable this long-term signal to emerge, triggering investment and bringing the electricity prices paid by consumers closer into line with the real costs of the French electricity system, which will be almost 90% decarbonised by 2022.

This work is taking place first and foremost at European level, with a legislative package for the reform of the European electricity market, Electricity Market Design (EMD), published in the EU's Official Journal on 26 June 2024, with the aim of enabling Member States to better control electricity prices while decarbonising their mix. Several measures will be transposed into national law.

This reform makes it possible to develop instruments for regulating long-term prices, such as :

→ Direct contracts between producers and consumers (Power Purchase Agreements - PPA) ;

→ Bi-directional Contracts for Difference (CfDs), which guarantee a stable income for electricity producers by setting a floor price, and redistribute income from the sale of electricity to consumers when market prices exceed a ceiling price.

The reform also provides for a strengthening of the prudential management framework for energy suppliers, with the aim of guaranteeing a high level of consumer protection.

This package, adopted in particular at France's instigation, explicitly mentions the possibility of applying long-term regulatory instruments to existing nuclear power plants. It reaffirms that these instruments must respect fair conditions of competition between Member States.

At the same time as this European work, the French government is carrying out work at national level that fits into this framework, particularly on the regulation of existing nuclear power. The system of regulated access to historical nuclear electricity (Arenh) comes to an end on 31

December 2025. Future regulation of nuclear power, the details of which were set out by the Government on 14 November 2023, will aim to ensure that all consumers benefit from the competitiveness and cost stability of existing nuclear power, while preserving EDF's financial capacity to maintain and renew its generating fleet.

This regulation could take the form of a mechanism that (i) deducts a fraction of the revenue from nuclear generation above a certain threshold, and (ii) redistributes this amount to all consumers. Medium and long-term contractualisation tools to guarantee long-term protection against price volatility will also be developed.

ACTION MAR.1

PROVIDE LONG-TERM SIGNALS TO TRIGGER INVESTMENT AND GUARANTEE ACCESS TO COMPETITIVE, LOW-CARBON ENERGY

→ In the context of the ongoing reform of the European market, complete the reform of the French electricity market in order to provide greater protection for all consumers against changes in market prices and to better reflect the full costs of the electricity mix in the prices they pay. In particular, to provide a framework for regulating nuclear power post-Arenh, or to set out the fundamental principles, in order to ensure that all French consumers continue to be exposed to the production costs of the French nuclear fleet;

→ Encourage suppliers to adopt prudent, long-term sourcing practices, to strengthen their resilience to a market shock.

→Encourage structural flexibilities enabling larger volumes to be moved at the best time for the system to function properly while protecting the consumer via, for example, time-seasonal supply offers, mobile peak offers or peak/off-peak hours.

6.3. Industrial issues

The industrial sector is essential to the implementation of the ecological transition, through its own decarbonisation and its key role in producing the technologies needed to decarbonise other sectors of the economy. We need to continue and step up the pace of industrial recovery to prepare France for the future, support economic development and strengthen our sovereignty. Re-industrialisation also benefits the climate by reducing France's carbon footprint (by ensuring that re-industrialisation does not increase production emissions by more than the reduction in imported emissions, and by controlling rebound effects), taking advantage in particular of France's largely decarbonised electricity mix.

The decarbonisation of industry and reindustrialisation must be supported by the entire energy system, and in particular requires a substantial increase in the production of low-carbon electricity, while maintaining prices that ensure the competitiveness of industry, in a context of growing competition in certain sectors from production in China or the United States. Tomorrow's energy mix, and in particular the electricity mix, is based on a reindustrialisation scenario that has been incorporated into the baseline scenario of this multi-annual energy plan.

Various business support programmes and schemes, such as France Relance and France 2030, aim to make France a leader in the technologies needed to decarbonise the economy. In addition, the Green Industry Act aims to boost France's industrial attractiveness, skills and capacity for innovation.

Low-carbon energy production, transport and consumption industries need to be strengthened across the entire value chain - from raw materials to equipment production and recycling, right through to residual waste treatment - to meet energy targets while reducing dependence on the international market. This development is being carried out with public support to guarantee a sustainable base and growth, and to ensure a *level playing field*. It also requires the use of tools to ensure the conditions for the development and sustainability of green industries, particularly in the context of the European Net Zero Industry *Act,* by making greater use of resilience, cybersecurity, environmental and social criteria in invitations to tender, in line with France's commitments in the World Trade Organisation.

In addition, a "green industry investment" tax credit (C3IV) was introduced in 2024 to provide support for productive investment in factories producing solar panels, wind turbines, heat pumps and batteries, as well as the key sub-components and materials needed to manufacture them.

- **With regard to critical metals**, France has adopted a strategy to secure supplies of raw materials, including ores and metals, for its industrial value chains, in line with the European regulation on critical raw materials. This concerns both primary raw materials, extracted from the mine and then processed, and secondary critical raw materials obtained through recycling. The strategy aims to improve knowledge of French value chains and identify the needs of the industrial sectors that are essential for France, develop the broadest possible national production offer (from extraction to processing and recycling), and secure and diversify supplies through bilateral partnerships with producer countries and the creation of a dedicated investment fund with a budget of €2 billion, to which the State will contribute €500 million
- **With regard to biomass-based energy products and sustainable fuels**, France has adopted a strategy to promote research, contribute to the emergence of production sectors, support industrial demonstrators and investment, encourage deployment and anticipate medium- and long-term biomass requirements, as well as developing initial and continuing training.

6.4. Ensuring competitive energy prices

6.4.1. Choosing the electricity mix: optimising costs while taking into account environmental impacts and technical constraints

The electricity mix scenario chosen for the EPP was based in particular on RTE's "Energy Futures 2050" report, published in 2021, and its 2023-2035 Generation Adequacy Report, published in 2023.

In Energy Futures 2050, RTE presents 3 electricity consumption scenarios for 2050 and 6 electricity generation mix scenarios, based on rigorous scientific and technical simulations. These simulations make it possible to cover a very wide range of possibilities and to reproduce a broad spectrum of electricity systems compatible with achieving carbon neutrality in 2050. The study explored several consumption variants, ranging from greater sobriety to major re-industrialisation leading to a greater increase in consumption; and several production variants, exploring systems ranging from 100% renewables to systems where nuclear power has a lasting presence in the electricity mix at levels of almost 50%. It makes it possible to consider the various options available for each sector, not in isolation but by integrating them into a coherent overall vision that meets the challenges described above. Finally, the study provides a detailed description of the structure of the electricity system for each of the scenarios, its costs and its environmental impact.

The "100% renewables" scenarios without the construction of new nuclear reactors require, on the one hand, a high degree of acceptability of renewable energies and, on the other hand, faster rates of development of new renewable installations than those of the most dynamic European countries today. These scenarios are not only the most costly from an integrated perspective, but they also require major technological investments.

The scenarios based on maintaining the historic nuclear fleet appear to make sense, both economically and environmentally. In fact, the addition of renewable and nuclear generation capacity enables the electricity system to accelerate decarbonisation by 2030, by accentuating reductions in greenhouse gas emissions in the short and medium term. In these scenarios, the means of flexibility are reduced, as are the levels of investment required in the electricity networks. Extending existing reactors beyond the age of 60 also poses major technical challenges.

In the Generation Adequacy Report published on 23 September 2023, which covers the period 2023-2035, a period marked in particular by an acceleration of ambitions in terms of decarbonisation and reindustrialisation, RTE has updated its assessment by modelling several scenarios to 2035 "successful acceleration" (prospective exercise), partial achievement" scenario and "globalisation thwarted" scenario (risk analysis exercises) with trajectories of up to 640 TWh by 2035 (depending on energy savings and the actual rate of electrification), consistent with the guidelines of the PPE.

In addition to the challenges of decarbonisation and security of supply, the choice of electricity mix is also based on an economic rationale in order to limit the cost of the electricity produced and the burdens on the community. Since 2017, RTE has been carrying out an economic analysis of its various scenarios as part of the Generation Adequacy Report, making it possible in particular to estimate the full costs of the electricity system associated with different electricity generation mix scenarios. This full-cost analysis makes it possible to take into account the costs that are not reflected in the discounted costs of the various means of generation, in particular the costs of connection to the grid and the associated need for flexibilities

With regard to the nuclear fleet, RTE points to the economic profitability of reinvesting in nuclear power, whether through the extension of existing nuclear plants or the construction of new nuclear generation units. RTE's previous analyses (in particular Energy Futures 2050) show that it makes economic sense to continue operating existing reactors up to 2030-40, a conclusion that was confirmed in the 2023 Generation Adequacy Report despite an upward re-evaluation of the full cost of existing nuclear power.

Furthermore, the analysis carried out by RTE in its 2021 "Energy Futures 2050" report shows the economic advantage of scenarios including new nuclear reactors, even when compared with fully economically optimised renewable generation mixes. This analysis is confirmed despite the higher long-term production cost of new nuclear power compared with mature renewables, due to its controllable nature, which reduces the need for flexibility in the electricity system.

As far as renewable electricity is concerned, all RTE's scenarios are based on onshore wind power, offshore wind power, ground-based photovoltaics and large-scale hydroelectricity, which are considered to be the least costly technologies, regardless of the nuclear capacity developed.

However, certain technologies that have been identified as having a higher unit cost, such as rooftop photovoltaics and floating offshore wind power, should also be mobilised in order to limit the environmental impact and technical constraints of electricity production. They make it possible to take into account the limited space available in shallow areas that are suitable for offshore wind

farms, to make use of areas that have already been developed, and to disseminate renewable energy sources in a way that facilitates public acceptance. What's more, the scope for developing ground-based photovoltaics has been considerably restricted since RTE's last estimates, notably as a result of article 54 of the APER law. It will be necessary to mobilise other sectors, such as photovoltaics on roofs and shaded areas, as well as agrivoltaics.

In the light of these factors, France has chosen to give priority to developing nuclear, offshore wind, photovoltaic and onshore wind power, while continuing to support a residual share of diffuse production, and strengthening its consultation tools to take the best possible account of issues relating to land use, industrial hazards and social and local expectations regarding projects.

6.4.2. Major work is being carried out on the gas networks to limit their long-term cost to consumers.

Consideration needs to be given to the development of natural gas networks in order to study the possibilities of limiting future increases in the unit amount of tariffs for using natural gas networks, and therefore in the price of natural gas for consumers. These changes to the natural gas networks would aim to reduce the overall costs associated with the natural gas networks, in order to limit the increase in the unit amount of tariffs as natural gas consumption falls ("price squeeze).

The first step in considering the future of natural gas networks will be to identify the professional consumers who are likely to continue to use natural gas, even if the price rises. Feedback from the first few years of biomethane production shows that, regardless of gas network tariffs, biomethane production costs are much higher than fossil gas supply costs, and that there is no prospect of a significant reduction in production costs. The gradual substitution of biomethane for fossil gas will therefore lead to an increase in the price of natural gas for consumers.

This identification of consumers who are likely to continue to consume gas in the long term, at a higher price, is essential if we are then to be able to study the possibilities of optimising gas networks to continue to serve these consumers, while reducing the rest of the network. A CRE study[74] shows that, assuming a uniform fall in natural gas consumption, the natural gas networks needed to supply all consumers would remain unchanged overall despite the fall in consumption, which would lead to a further increase in the unit amount of tariffs for using the gas networks.

The final stage in the process would be to test these possibilities for optimising gas networks with volunteer local authorities. The aim would then be to estimate the reduction in overall costs that could be achieved, as well as the policies needed to ensure this optimisation

6.4.3. Regulating the price of electricity from existing nuclear power plants, a competitive factor

Since 1 July 2011, the current regulation of electricity prices, based on Regulated Access to Historic Nuclear Electricity (ARENH), has enabled all French consumers to have access to the competitiveness of the existing nuclear fleet, for part of their consumption, while allowing competition to operate on the supply market. However, this regulation has shown its limitations, particularly due to the lack of incentive for suppliers and customers to enter into medium- to long-term contracts, and the fact

[74] Commission de régulation de l'énergie - Avenir des infrastructures gazières aux horizons 2030 et 2050, dans un contexte d'atteindre la neutralité carbone - April 2023

that the regulated price at which EDF buys nuclear electricity has not been updated since 2012. This scheme will expire in 2025 and will not be renewed.

In his speech on energy policy in Belfort on 10 February 2022, the President of the French Republic stated that France would implement "*a new regulation for nuclear electricity (to replace the ARENH) so that French consumers, households and businesses, can benefit from stable prices, close to the production costs of electricity in France. This is essential if we are to reap the full benefits of the nation's historic investment and the investment we are in the process of making*".

Against this backdrop, the French government has launched a public consultation with all stakeholders on a revised market framework to take effect from the end of ARENH on 1 January 2026. This new organisation would be based on 2 pillars:

- On the one hand, encouraging the development of long-term contracts negotiated between market players and tailored to their needs,
- On the other hand, a mechanism to regulate EDF's income from existing nuclear power plants, protecting consumers in the event of high prices. This mechanism would consist of (i) deducting a fraction of the income from nuclear generation above a certain threshold, and (ii) redistributing this amount to all consumers.

This economic regulation of existing nuclear power aims to strike the right balance between :

- preserves EDF's ability to invest in extending the existing nuclear fleet and developing the new nuclear programme in France called for by the French President in his Belfort speech;
- strengthens consumer protection by encouraging them to take out longer-term insurance cover and ;
- allow the competitiveness of the nuclear fleet to be shared between EDF and consumers.

6.4.4. Industry: a sector whose competitiveness is supported

Access to low-carbon, stable and competitive electricity is a major challenge if we are to support reindustrialisation while at the same time pursuing strong objectives for the decarbonisation and electrification of industry, particularly for the most electricity-intensive activities exposed to international competition. In addition to the measures put in place temporarily during the energy price crisis (electricity shock absorber, help desk for payment of gas and electricity bills), several schemes are helping to limit the cost of electricity for these consumers:

- Regulated Access to Historic Nuclear Electricity (ARENH), which allows customers to purchase a proportion of their consumption at a regulated price. This system will come to an end on 31 December 2025, and a new economic regulation of existing nuclear power will be put in place (*see* section 6.3.3) in compliance with the new European rules;
- compensation for the cost of indirect CO2 emissions, which reimburses part of the cost of the European system of carbon quotas incorporated into the price of electricity for companies in the most electricity-intensive sectors exposed to international competition. In this way, it contributes to combating the risks of carbon leakage and the competitiveness of these companies;
- a reduction in the tariff for use of the public electricity transmission network (TURPE) for sites that consume a lot of electricity and have a predictable and stable or anti-cyclical consumption profile, and sites that store energy for subsequent return to the network,

which can benefit from a reduction in the tariff for use of the public transmission network provided they implement an energy performance policy;

- reduced rates of excise duty on electricity depending on electro-intensiveness and exposure to international competition;
- the interruptibility call for tenders, which makes it possible to manage critical situations in the operation of the power system: the winners make themselves available to RTE, which can cut them off in less than five seconds if necessary.
- direct support for improving energy efficiency, in particular via energy saving certificates (CEE) and via France Relance and France 2030 (calls for BCIAT, IndusEE and DECARBIND projects)

ACTION MAR.2

MAINTAINING COMPETITIVE ELECTRICITY PRICES FOR BUSINESSES OVER THE LONG TERM, ESPECIALLY ELECTROINTENSIVE BUSINESSES EXPOSED TO INTERNATIONAL COMPETITION

→ Maintain over the long term the measures that help to preserve the competitiveness of companies exposed to international competition

6.5. Assessing the impact on jobs and professional skills requirements and adapting training to these requirements

The gradual disappearance of certain jobs, the emergence of new professions, the enrichment of skills, the raising of qualification levels, the encouragement of new career paths and new bridges between professions will be strategic for the low-carbon transition. This will lead to a reallocation of jobs and profound changes in the labour market, which will need to be supported in order to limit the negative effects. The aim of ecological planning is to set out ecological objectives in a way that is consistent and articulated with the reality of implementing the levers to achieve them.

In this context, this strategy should incorporate a genuine industrial and skills dimension. This means identifying the underlying industrial sectors and associated value chains, then identifying the investment needs in the French economic fabric and human resources required for this transition, and finally providing the means to attract, train and recruit the people who will contribute to it. As part of the "employment and skills" workstream of ecological planning, this work of identifying and building the necessary actions, which has already given rise to an initial publication by the SGPE, is underway, for the entire spectrum of the ecological transition. In particular, the following sectors will require a very large number of jobs, some of which require specific skills, for example :

→ Energy-efficient renovation of buildings,
→ Development of low-carbon energies (nuclear and renewable energies),

→ Development of electric vehicles and conversion of combustion vehicle production sites, which will be accompanied by the mobilisation of new skills,

→ Re-industrialisation, particularly for "green" industries,

→ Converting and removing the infrastructure needed to distribute fossil fuels.

According to Ademe, 15% of jobs are directly affected by the ecological transition. The ecological transition is creating new markets and increasingly demanding cross-disciplinary skills.

Just as the energy sector is showing signs of tension and a shortage of manpower, so it will be vital to help people in declining professions find new jobs. The issue of attractiveness and the need to remove obstacles to "gendered" occupations are also identified and shared by most sectors. Meeting these skills challenges will require a major mobilisation of all training systems and organisations, both initial and continuing, in order to offer the new or enhanced training courses called for by the multi-annual energy programme.

Skills management is therefore a key issue for the energy transition. An initial diagnosis was drawn up as part of a mission led by Laurence Parisot in 2018. Since then, a number of measures have been designed to support the development of training and skills in sectors linked to the ecological transition. **In the case of the electricity and gas industries (IEG**), an amendment to the training and work-linked training agreement signed on 26 May 2023 for the IEG branch has strengthened support for employees faced with these changes by giving them the opportunity to follow a training course leading to a qualification as part of the retraining or promotion by work-linked training scheme known as Pro-A within their company. It thus meets the objective set by the social partners and employers in the Branch Agreement on training and work-linked training of 1 December 2020.

Pro-A enables employees to change jobs or professions, or to benefit from social or professional advancement. This can be achieved not only through training but also through the validation of acquired experience (VAE). In addition, Pro-A can be used to acquire the knowledge and skills base.

The work carried out under the aegis of the Commission Paritaire Nationale de l'Emploi et de la Formation Professionnelle (CPNEFP - National Joint Committee for Employment and Vocational Training) was finalised in 2022, making it possible to list the qualifications eligible for the Pro-A scheme for each profession covered by the defined criteria. This represents a portfolio of more than 100 qualifications, all of which are listed in the RNCP.

This work, which is included in the addendum, also made it possible to :

- Understand the different sectors of activity in the industry and the trends likely to have an impact on professions,
- Analysing changes in skills requirements by business sector,
- Identify shortage occupations and/or occupations whose activity is undergoing major change and for which there is a risk of skills shortages or obsolescence,
- For each of these professions, determine which qualifications are eligible for the Pro-A scheme.

The Strategic Committee for the New Energy Systems **Sector** (CSF Nouveaux systèmes énergétiques) will be responsible for creating a "Schools for Energy Transition" label, which will bring together the country's training provision in transition-related professions. This label will help to raise the profile of existing training courses at all levels of study, which sometimes struggle to recruit, and to encourage the creation of new initial and continuing training courses to support the reindustrialisation of renewable energy industries.

In addition, there are the diagnoses of skills and training needs, financed as part of France 2030 (AMICMA - AMI Compétences et métiers d'avenir). This has enabled sectoral assessments to be carried out estimating needs qualitatively and often quantitatively, by skill level and by region, and proposing strategies to meet them. These analyses can then be used to plan the introduction of

training courses, the creation of new places for learners and the development additional modules for existing courses. In particular, the following diagnostics could be used: "COMED" for decarbonated energies, "F2H-PDL" and "DEF'HY" diagnostics for hydrogen, or regional diagnostics such as "Diagtase" on smartgrids, floating wind power and photovoltaics in Occitanie, or GEPECT-EOF on floating wind power in the Mediterranean. The EPP will provide for the continuation of this anticipation and programming effort.

France 2030 will support the development of an attractive training offer, particularly in the fields of renewable energy and nuclear power. France 2030 aims to encourage the development of a French industry for new energy technologies capable of responding to the growing development of renewable energies and the electrification of uses. To this end, the PIA4 "Skills and Professions of the Future" call for expressions of interest operated by the ANR and Caisse des Dépôts aims to support the attractiveness of training in these fields and to strengthen existing training and, where appropriate, to create new training channels for the fields and professions of the future that are experiencing the greatest recruitment pressure.

To complete the diagnosis, three area-based studies were launched this year:

- In the nuclear sector, the Groupement des Industriels Français de l'Énergie Nucléaire (GIFEN) has launched the MATCH programme. This is a deliverable of the nuclear industry's Employment and Skills Development Commitment Programme (EDEC), which is now a dynamic steering tool to ensure that the industry's capacities are in line with its future needs and challenges. Its conclusions were submitted in April 2023. They forecast skills requirements amounting to around 10,000 jobs per year for 10 years, i.e. a need to recruit more than 100,000 people in the industry over the next decade, including 60,000 in the 20 'core' business segments considered in the MATCH programme. This programme is reviewed annually. A detailed skills action plan, coordinated by the Université des métiers du nucléaire and developed jointly with the French government, was submitted to the ministers for energy, industry, vocational training and higher education at the beginning of June 2023 26. It includes concrete actions from September 2023, including the creation of a single platform for training, internships and jobs in the industry, the creation of new training courses or nuclear colourations of existing courses. This work is complemented by a multi-year nuclear training strategy currently being developed by the relevant ministries.

- In the networks sector (i.e. the manufacture of equipment, cables, connection materials, installation, operation, maintenance, transport and distribution), the sector, which currently represents nearly 1,600 companies and almost 100,000 employees in France, estimates that it will need to fill around 8,300 jobs each year, 3,300 of which will be on sandwich courses. The players in the electrical networks sector have signed a partnership agreement on the creation of a training programme called "Les Écoles des réseaux pour la transition énergétique", with the aim of anticipating and supporting the massive recruitment needs of the sector in a context of strong growth in electrical network activities driven by decarbonisation and the electrification of uses.

- As far as renewable energy is concerned, marine renewable energy currently accounts for more than 6,500 jobs. The offshore wind pact signed between the industry and the French government forecasts more than 20,000 jobs in offshore wind energy by 2035. The photovoltaic and onshore wind energy sectors accounted for around 18,000 jobs in 2019.

The government has also set up two task forces: the first, the conclusions of which were delivered in July 2023, aims to draw up an inventory of the current situation and to formulate recommendations for dealing with the pressures on the workforce and skills in industry, with a focus on the role of training ; the second, launched in May 2023 to mirror the MATCH programme (see below), aims to implement a national strategy to mobilise skills for the energy transition and consists of producing an overall study projecting the employment and skills needs of all the

renewable energy sectors (solar, wind, geothermal, biogas, networks, etc.) to 2035 and 2050.), with a precise identification of the risks to achieving the objectives of the EPP and reindustrialisation. The conclusions of these two missions will be incorporated into the EPP3, in order to ensure that the skills sectors are properly structured to meet the targets that will be set.

In addition**, the issue of attractiveness, employer brand and the need to remove obstacles to "gendered" professions** have also been identified and are the subject of measures and action plans in agreements on professional equality and direct actions aimed at schools, through communication initiatives within most sectors.

In conclusion, there is an abundance of suitable work, assistance and offers, but the question and the challenge that remain is how to coordinate the work:

There seems to be a general consensus that we cannot envisage a transfer of "brown" jobs to green jobs. This has been emphasised by the industry and a number of studies. The work of the ONEMEV also emphasises the absence of any communicating effect between the two.

It should be noted that **the cumulative effect of skill distance** (skills gap) means that inter-job bridges need to be put in place, with the **difficulty associated with jobs with technical skills and qualifications that are sometimes very far apart, and the lack of geographical proximity between jobs that are becoming extinct and very localised** (e.g. automotive/coal sector) and **new jobs** (ENR), which are better distributed across the region.

Avenues for responding to these constraints may be found in the EDECs (forward-looking and action plan sections), which should be generalised to sectors identified as being impacted by the transition and cross-referenced with GPEC T approaches (forward-looking management at territorial level) and the work of the Cereq (linking training to jobs and work). The modelling resulting from the Support for Prospective Dialogues (SDP) experiment for energy renovation proposed by Ademe, which conceptualises the notion of a skills territory, should also be taken into account. The 4 territorial pacts have a systematically identified focus on the development of skills in order to adapt them to the future needs of the territories and thus facilitate the redeployment of employees at the level of the employment basin, all types taken together (energy industries, ports or subcontractors).

The transition and the major projects associated with it (EPR2, acceleration of renewable energies and energy renovation, etc.) are accentuating these tensions, in a context of changing practices and the end of fossil fuels, which is difficult for some companies and employees

The challenge of adapting initial training to renewables and access to vocational training, especially in SMEs, remains. The situation is very different between the large companies in the energy sector (e.g. IEG branch above), and the more fragile subcontractors and service providers with very specific skills, especially as the energy renovation sector is more dominated by small businesses and craft trades, for which the digital transition is also a challenge.

The national dynamic and the social dialogue (EDEC channel bringing together professional employers' organisations and trade unions with OPCO2i) need to be combined with a regional approach (GPEC T method / regional governance) and by sector

The approach by employment area / sector in extinction and staff to be redeployed is necessary given the real obstacles to geographical mobility (example of the 4 "territorial pacts" accompanying the closure of coal-fired power stations).

The issue of strengthening interministerial steering, already highlighted in the Parisot report, still seems to be prevalent, along with the need to simplify processes and the problems of divergent timetables. The issue of improving the visibility of existing aid schemes and the difficulty of mobilising these schemes could also be improved.

Making the most of local initiatives, carrying out RETEX and modelling the first examples of redeployment that work seem to be other initiatives that should be pursued.

6.6. Assessment of public resources devoted to achieving the objectives of the EPP

6.5.1. Cost of supporting energy management

In the building

Reduced VAT

To achieve the objectives of the PPE, a tax incentive is currently in force, set out in article 278-0 bis A of the French General Tax Code, in a version rewritten for the initial Finance Act for 2023: the reduced VAT rate of 5.5% for energy renovation work. The work must be carried out in residential premises, completed at least two years previously, and involve the installation, fitting or maintenance of materials, equipment, appliances or systems designed to save energy or use energy produced from renewable sources. The cost of the scheme was estimated at €2.0 billion[75] in 2023 for all public administrations.

MaPrimeRénov' (MPR - ANAH grants)

The Agence Nationale de l'Habitat (ANAH) finances work to improve the energy performance of private homes. In 2023, the ANAH financed the energy renovation of 569,243 homes, thanks to the €2.74 billion in aid distributed.

In 2024, MaPrimeRenov' underwent a major overhaul to enhance its effectiveness, with the creation of two pillars:

(i) The "MaPrimeRénov' Accompanied Journey" pillar, which finances major renovation work (improvement of at least two energy classes), in addition to personalised support via Mon Accompagnateur Renov' (MAR);

(ii) the "MaPrimeRenov' by gesture" pillar, which finances "single gesture" renovations and which will be refocused from 1 January 2025 (ban on single gesture aid for energy passoires, obligation to change heating method);

In addition, MaPrimeRenov' Copropriétés specifically targets work carried out on the communal areas of condominiums and requires that the work carried out results in energy savings of at least 35%.

Zero rate eco-loan (éco-PTZ)

Introduced in April 2009, the zero-rate eco-loan is an interest-free loan, available on a means-tested basis, designed to help finance work to improve the energy performance of a dwelling occupied as a principal residence, whether the work involves a "one-off" renovation or a major refurbishment.

An improvement introduced by the Finance Act for 2022 has enabled the creation of a new category of eco-PTZ to cover the remaining cost of work that has benefited from the MaPrimeRenov' scheme. In addition, article 71 of the Finance Act for 2024 extends the eco-PTZ scheme until 31 December

[75] Source: Budget 2023, Ways and Means (Volume 2) (link), tax expenditure 730223. The figures in the Ways and Means section of the 2024 Budget €1.0bn) for 2024 only concern the State (link)

2027, in order to maintain the support provided to households carrying out energy renovation work on their homes. The cost was €45m in 2023 and is expected to rise to €119m in 2024 (State scope) .[76]

Finally, it should be noted that there is also a co-ownership ecoPTZ to finance energy renovation work on communal areas and equipment, or on private areas in the case of work of collective interest.

Social housing eco-loan (éco-PLS)

The main incentive for energy renovation in social housing is the social housing eco-loan, a subsidised loan distributed by the Savings Fund, managed on behalf of the State by the Caisse des dépôts et consignations (CDC). This scheme is aimed at social landlords. It was introduced following the Grenelle Environment Forum (2009) and is designed to encourage the renovation of the most energy-intensive homes in the social rented housing stock.

A new agreement on the implementation of the "social housing eco-loan" for improving the energy performance of social housing was signed on 12 April 2023 for the period 2023-2027.

The objectives of this new social housing eco-loan agreement are to :

- contribute to the target of eliminating all thermal flaws from the social housing stock by 2027;
- Encourage and support high-performance renovations in line with the Climate and Resilience Act;
- to make the social housing eco-loan the leading tool for reducing energy consumption in the sector and to combine these objectives in a simple, easy-to-understand scheme for the social housing sector.

To achieve these objectives, the social housing eco-loan envelope has been set at €6 billion over the term of the agreement (2023-2027), compared with €4 billion for the previous agreement.

The social housing eco-loan is a loan of between €6,500 and €33,000 per home, available to social landlords. The amount can be increased by €2,000 per home if the work carried out qualifies for a statutory energy performance label, by €3,000 per home if there is asbestos in the building, by €3,000 if greenhouse gas emissions are reduced by at least 70% and there is no gas heating system after the work, by €2,000 if there is no gas heating system after the work, and by €2,000 if the homes are exposed to noise black spots on the road and rail networks. The amount of new social housing eco-loans signed in 2023 will reach almost €800 million, up sharply on the previous year (+29%), enabling the thermal renovation of 48,000 social housing units that same year ().

Second life for social rental housing" scheme

The "second life for social rented housing" scheme is an experiment launched in 2023 and renewed in 2024, designed to support the major renovation of social rented housing with high energy consumption (class F and G of the energy performance diagnosis (DPE)).

For energy-efficient renovations that achieve at least class B on the DPE (Diagnostic de Performance Energétique) energy performance test, the scheme provides for a reduced VAT rate of 5.5% and a

[76] Budget summary appended to the draft finance law for 2024.

total exemption from property tax (taxe foncière sur les propriétés bâties - TFPB) for 25 years. The latter exemption, which is not available for the renovation of conventional housing, gives second-life projects a tax advantage similar to that of new build.

The cost of this measure is €15m[77] in 2023, financed by the Fonds national des aides à la pierre (FNAP).

Major works - compliance and refurbishment of State buildings

The Energy Efficiency Directive (EED - now 2023/1791/EU) requires the renovation of 3% of the heated and/or cooled surface area of buildings over 250 m^2 owned by a public body.

The renovation of State buildings mobilises several budget vectors, in particular programme 723 "Real estate operations and maintenance of State buildings", which contributes to the financing of real estate projects and the maintenance of the owner within the real estate special appropriation account (CAS), as well as other Ministry support programmes. Since 1 January 2018, a new programme 348, "Performance and resilience of State buildings and its operators", with a budget of €650m in 2024, is specifically involved in reducing the State's energy consumption through the major renovation of existing buildings and the financing of targeted actions on energy performance and changes in working methods.

Support is also provided for improving the performance of local authority buildings. Programme 119 "Financial assistance to local authorities and their groupings" has been allocated €2 billion to support local authority projects, including the thermal renovation of buildings. Lastly, the Green Fund, announced in the summer of 2022 and effective since the beginning of 2023, is an unprecedented mechanism for accelerating the ecological transition in local and regional authorities. Endowed with €2 billion in 2023, just over a third of the applications accepted (for around €764 million) in 2023 concerned the energy renovation of local public buildings[78]

Energy saving certificates

The energy savings certificate (CEE) scheme requires energy suppliers (known as obligated parties) to carry out or initiate energy savings operations based on the volume of energy they sell, particularly in the building sector (see action cons.3).

In transport

Contribution to the financing of the acquisition of clean vehicles and the withdrawal of polluting vehicles

Programme 174 finances aid schemes for the purchase of clean vehicles, including the ecological bonus, leasing aid for electric cars and the conversion premium (which is conditional on the withdrawal of a polluting vehicle). The budget for these schemes €1.5 billion in 2024. Between 2020

[77] Announcement of the "Second life of social rental housing" experiment, in May 2023.

[78] Press release on the 2023 assessment of the Green Fund.

and 2023, the ecological bonus supported the purchase of more than one million clean vehicles, including 357,000 in 2023 alone (from December 2023, the bonus will be subject to eco-conditionality and will only be awarded to vehicles with the highest environmental performance). Over the same period (2020-2023), the conversion bonus has supported the replacement of 448,000 old, polluting vehicles with low-pollution vehicles (including bicycles). Finally, the leasing scheme, launched on 1 January 2024, will cover around 50,000 electric passenger cars in its first wave.

Regulation (EU) 2023/851, adopted in 2023, sets a target for the end of sales of new internal combustion passenger cars and vans from 1 January 2035

With regard to heavy mobilityProgramme 174 has also financed aid schemes to support the deployment of heavy electric vehicles. To this end, two calls for projects (AAP) for "Ecosystems of heavy electric vehicles", managed by the French Agency for Ecological Transition (Ademe), were opened in 2022 and 2023, enabling the acquisition of 545 heavy electric vehicles (HGVs, buses and coaches) in 2022 for a budget of €65m, and more than 1,000 new or retrofitted heavy electric vehicles (HGVs and coaches) in 2023 for a budget of €60m

For the 2024 financial year, public aid is based on financing in the form of energy saving certificates (CEE). As part of this, the E-TRANS programme run by Ademe, which will be launched in May 2024, is expected to support the purchase of at least 2,100 heavy goods vehicles (HGVs, buses and coaches), with a budget of €130m.

6.5.2. Cost of supporting renewable energy through public energy service charges

Support schemes for renewable energies whose production is sold on the market, i.e. renewable electricity and biomethane, provide producers with secure and stable remuneration for the energy they produce. **They are adapted to the level of costs and risks involved in each sector and cover producers against changes in market prices**.

The resulting additional costs are borne by the operators responsible for purchasing the energy produced under the feed-in tariff scheme, or by the operators responsible for paying the additional remuneration under the remuneration supplement scheme. **This additional cost is compensated by the State through programme 345 as part of the public energy service charges (CSPE) assessed annually by the Energy Regulation Commission (CRE).**

The cost of support for the State is therefore **sensitive to changes in market prices**: when market prices rise, the costs incurred by these installations fall until they become negative (the situation observed at the peak of the energy crisis between late 2021 and early 2023), and vice versa.

The budget cost must therefore be assessed on the basis of the forecast costs of the sectors and the projected changes in the market selling price of the renewable energy produced. This amount is broken down between the costs already incurred prior to EPP3 and the new costs of supporting new capacity under EPP3.

The costs already incurred prior to EPP3 correspond to all the costs of supporting renewable energies that have already been committed to by the State (contracts signed before 31 December 2023 or tenders that have already been awarded), or that will be incurred between now and 2025 on the basis of EPP2.

The estimates will be submitted to the Electricity Public Service Charges Management Committee for its opinion.

6.5.2.1 Market price and production cost trajectories

Two average wholesale energy price scenarios were studied to estimate the costs of public support for the development of renewable electricity:

- **A low scenario with a wholesale electricity price of €52 in 2024/MWh and a wholesale gas price of €23 in 2024/MWh HCV in 2030**.
- **A high scenario with a wholesale electricity price of €94 in 2024/MWh and a wholesale gas price of €50 in 2024/MWh HCV in 2030**.

The average selling prices of electricity produced by renewable electricity generation facilities in the above-mentioned sectors are lower than the average market prices of electricity, due to the correlation of electricity production between facilities in the same sector. Solar power, for example, is produced at the same time of day for all the facilities, leading to a drop in the market price of electricity during these hours, reducing the average price received by the facilities. A discount must therefore be taken into account in relation to the average market price when calculating public support for production facilities.

The following trajectory for the tariffs of the new support contracts for the various sectors has been taken into account in estimating the costs of public support for the production of renewable energy, assuming that the current support mechanisms remain unchanged:

Support contract tariff (€$_{2024}$/MWh)	**2025**	**2030**	**2035**
PV - AT building	160	155	150
PV - AT small floor	88	84	80
PV - AO sol	80	75	70
PV - AO building	100	94	88
Onshore wind	90	85	80
Offshore wind power - installed	50	50	-
Offshore wind - floating	90	75	-
Biomethane	148	133	133

In addition, a constant inflation rate of 2% has been used to estimate the cost of public support for renewable energy production.

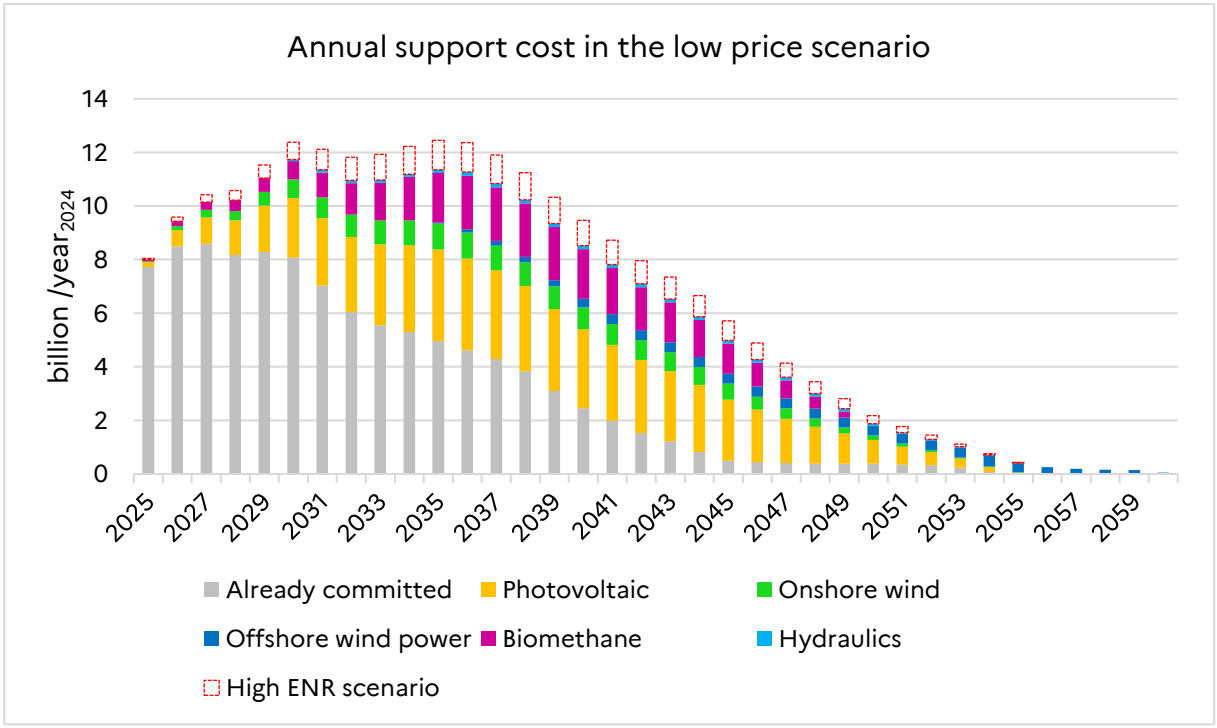
6.5.2.2 Estimated costs of public support for renewable energy production

Modelling the costs of public support for renewable energy production leads to an estimate of **€114.2bn to €133bn$_{2024}$** in public energy service charges under the EPP3 between 2025 and 2060, **in the low price scenario**, and **a negative amount of -€31.9bn to -€27.5bn$_{2024}$ in the high price scenario.**

Estimated support costs between 2025 and 2060 (€bn$_{2024}$)	**Low price scenario**	**High price scenario**
Photovoltaic	59,6 à 73	5,4 à 6,1
Onshore wind	16,2 à 21,5	-20,3 à -15,2

Offshore wind power	7,4	-39
Hydraulics	2,5	1
Biomethane	28,5	21
Total PPE 3	**114,2 à 133**	**-31,9 à -27,5**
Already committed before the PPE 3	105,5	37
Total	**219,8 à 238,5**	**4,8 à 9,2**

The following graphs show the annual change in these costs under the two price scenarios modelled:



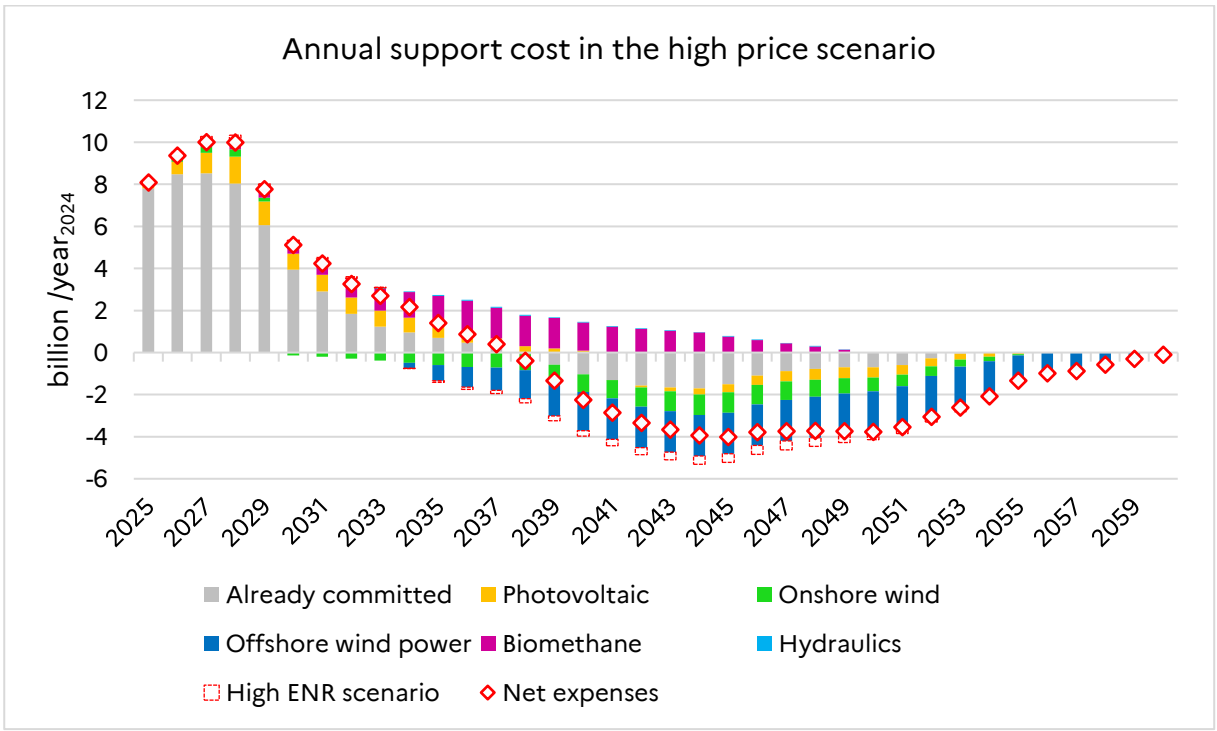


Figure32 . Annual support costs in the low and high price scenarios

ACTION COST.1

SETTING UP SUPPORT SYSTEMS TAILORED TO THE DIFFERENT CHALLENGES OF ENERGY DEVELOPMENT

Scale the support systems to achieve the renewable energy development targets set out above while limiting the exposure of the State budget (see dedicated sections).

6.5.3 Investments to revive the nuclear sector

EDF's programme to build new nuclear reactors using EPR2 technology will represent lower annual investment than the existing fleet, renewable energies or grids. However, the difference between this programme and other energy projects lies in three cumulative characteristics:

- a particularly long construction period of around 10 to 15 years;
- the project has complex characteristics, whatever the underlying technology, and in particular a specific safety framework, which is found in a very small number of sectors;
- EPR2 technology nuclear reactors are scheduled to operate for 60 years.

These particularities mean that the cost of financing represents a very large proportion of the total cost of the programme. The International Atomic Energy Agency estimates that financial costs can represent more than 50% of the total cost of the project in some cases. For these reasons, governments intervene in almost all new nuclear reactor construction projects, through regulation, public financing or both, to reduce the cost of financing or to make up for the difficulty of finding private investors. In the case of the programme supported by EDF, the French government and EDF will study the financing conditions with a view to defining the most appropriate economic intervention by the French government.

Finally, the France 2030 plan earmarks €1 billion in public funding to support the development of innovative nuclear reactors and the emergence of new players.

7. Involving local and regional authorities in energy planning and implementation

Local and regional authorities, with their expertise in territorial planning and sustainable development, occupy a central position in France's energy strategy. Under decentralisation laws such as MAPTAM[79] , LTECV[80] , and the NOTRe law[81] , their ability to draw up and implement local strategies tailored to the specific characteristics of their regions has been strengthened. Local and regional authorities are at the heart of the energy transition, whether in terms of energy efficiency, renewable energies, storage or networks. The impetus provided by local and regional authorities is therefore essential if we are to respond effectively to today's energy and environmental challenges.

7.1. Territorial planning documents: strategic tools for achieving objectives

- **The regional plans for spatial planning, sustainable development and territorial equality (SRADDET[82]and the master plan for the Île-de-France region (SDRIF[83]**give spatial planning its strategic role (prescriptive, integration of sectoral plans, co-construction).

The regional plans strengthen the role of the regional institution, which is invited to formulate a political vision of its priorities in terms of regional planning, sustainable development and environmental protection

In terms of energy, the SRADDET must set medium and long-term objectives for :

- energy management, particularly through energy renovation,
- the development and use of renewable and recovered energies, in particular biogas production, wind energy, biomass energy and agri-voltaics, where appropriate, by geographical area

These objectives can be broken down into prescriptive rules with accompanying measures aimed at other players in regional planning and sustainable development. As far as energy is concerned, the rules must at the very least cover measures to encourage the development of renewable energies, and be consistent with the waste planning measures set out in the SRADDET (or PRPGD, depending on the region), particularly as regards CSR heating plants and waste-to-energy plants.

79 Act no. 2014-58 of 27 January 2014 on the modernisation of territorial public action and the affirmation of metropolises, known as the "MAPTAM Act", aims to reform territorial organisation by strengthening metropolises and redefining the powers of authorities.

80 Law 2015-992 of 17 August 2015 on the energy transition for green growth, known as the 'LTECV', amends several articles of the Energy Code (articles L. 100-1, L. 100-2, and L. 100-4), and aims to strengthen the role of local authorities in mobilising their territories for the energy transition. It also reaffirms the role of the region as the leader in energy efficiency. The law also stipulates that territorial climate-air-energy plans (PCAETs) must be refocused at the inter-municipal level, with the aim of covering the entire territory.

81 Law no. 2015-991 of 7 August 2015 on the new territorial organisation of the Republic, known as the 'NOTRe law', aims to strengthen the powers of the regions and inter-municipalities while simplifying territorial organisation. It also reaffirms the role of the départements and communes in local management and territorial solidarity.

82 The SRADDET is defined in **articles L. 4251- 1 et seq. of the General Local Authorities Code**, supplemented by articles **R. 4251-1 et seq. of the same code**.

83 The SDRIF is defined in Articles L. 123-1 et seq. of the French Town Planning Code.

An indicative summary map illustrates the objectives of the SRADDET. In particular, this map can identify the acceleration zones defined in application of Article L. 141-5-3 of the Energy Code (see below).

In the Ile-de-France region, the mapping of acceleration zones for the installation of renewable energy production or storage facilities is included in a territorial master plan for the deployment of renewable energies, the SDRIF-e.

The SRADDETs and SRCAEs in Ile de France will have to be revised to bring them into line with the regional objectives of the EPP. Within six months of publication of the decree regionalising the objectives of the EPP, the region will initiate the procedure for amending the SRADDET or the SRCAE for the Ile-de-France region.

- **Territorial Climate Air Energy Plans (PCAET)[84] , local operational tools in the fight against climate change and the energy transition.**

Inter-municipal authorities with more than 20,000 inhabitants are required to draw up a PCAET. The PCAETs are the place where local authorities are invited to commit to implementing energy policy across their territory. The purpose of these plans is to define quantified targets for reducing greenhouse gas emissions, and to reduce energy dependency[85] . In particular, these plans must be compatible with the rules defined by the SRADDETs, especially as regards the development of renewable energies. They are based on a forward-looking study and a programme of actions involving all activities and players. The PCAET includes a map identifying the acceleration zones defined in application of article L. 141-5-3 of the Energy Code

Through the various regional plans (SRADDET, SDRIF and PCAET), the regions and inter-municipal authorities with more than 20,000 inhabitants are invited to define their energy trajectory for 2050, taking into account the objectives of the SNBC, and to undertake the short-term actions needed to achieve it.

Regional government departments are working closely with local authorities to help them implement the EPP at local level. In particular, they indicate the trajectory to be followed by the region in the context of the knowledge reports and, where applicable, issues notes, prior to the drafting of planning documents.

Pursuant to Article 68 of Act no. 2019-1147 of 8 November 2019[86] , the State drew up a report on the contribution of territorial climate-air-energy plans and regional plans for spatial planning, sustainable

[84] The territorial climate-air-energy plan (PCAET) is defined in **article L. 229-26 of the Environment Code**. **Articles R. 229-51 to R.229-56 of the Environment Code** set out the content of the plan, the scope of its objectives, and the procedures for drawing it up and reviewing it.

[85] Pursuant to L.229-26 of the Environment Code, the PCAET defines, for the territory of the public establishment or metropolis, "the programme of actions to be carried out in order, in particular, to improve energy efficiency, to develop electricity, gas and heat distribution networks in a coordinated manner, to increase the production of renewable energy, to develop the potential for recovered energy, including the potential for heat recovery from data centres, to develop energy storage and optimise energy distribution, to develop positive energy territories, [...]. This includes objectives relating to biogas production facilities". "This action programme may set targets for agrivoltaic installations as defined in Article L. 314-36 of the Energy Code.

86 Article 68 of Act no. 2019-1147 of 8 November 2019 on energy and climate, states that *"Within two years of the promulgation of this Act, the Government shall submit to Parliament a report on the contribution of territorial climate-air-energy plans and regional plans for planning, sustainable development and territorial equality to ecological and energy transition policies. This report includes an assessment of the support provided by the State for the implementation of territorial climate-air-energy plans and regional plans for spatial planning, sustainable development and territorial equality. In particular, this report compares this contribution with the national objectives and guidelines set out in the multi-annual energy*

development and territorial equality to ecological and energy transition policies. This report was submitted to Parliament on 11 April 2022. In terms of energy, it shows that :

- For renewable and recovered energies, the SRADDETs set overall targets, taking up or slightly improving on the general national objective of the PPE2, which aims to achieve a share of renewable energies in gross final energy consumption of "at least 33%" by 2030.
- The majority of SRADDETs generally present targets for increasing the production of renewable energy, by sector and detailed over time. Only certain sectors are not systematically given targets, such as high-temperature geothermal energy, liquid biomass, environmental heat (heat pumps), waste heat recovery and waste (primary energy recovery).

However, the targets for "covering" energy consumption by renewable energy production vary somewhat from one SRADDET to another.

- **Through its town planning powers and the development of its Local Town Planning Scheme (PLU), the local authority also has an additional tool at its disposal to orchestrate the development of renewable energies (RE), the coordination of energy networks, and the improvement of the energy efficiency of future buildings, on a municipal or inter-municipal scale.**
- **Lastly, the master plans enrich and strengthen this planning dynamic supported by the local authorities.**

By adopting energy master plans (SDE) or heating network master plans (SDRCU), local authorities are also demonstrating their proactive commitment to meeting today's energy challenges. These strategic tools, required by the Energy-Climate Act for heating networks commissioned between 1 January 2009 and 31 December 2019, underline the key role played by local authorities in regional energy planning. By mobilising these development levers, local authorities are asserting themselves as key players in the energy transition, combining a long-term vision with concrete action to optimise the sustainable management of energy resources.

7.2. Reinforcing the key role of local and regional authorities in planning the development of renewable energies and in their actions to promote energy efficiency

Through the policies they can implement at local level, **the links they form with a wide range of players and the funding they can provide**, local and regional authorities have a great deal of leverage when it comes to the ecological and energy transition. Through their direct powers, local authorities and municipalities can, for example, take action to develop renewable energies, recycled heat and cooling, upgrade energy networks, or take concrete action to decarbonise transport and buildings in their areas. **Accelerating the energy transition will require the continued strong involvement of local and regional authorities, particularly in terms of planning, and improved local governance around energy efficiency projects and actions.**

- **Planning renewable energies**

programme and the national low-carbon strategy. This report was submitted to Parliament on 11 April 2022. https://ecologie-preprod.

To ensure the success of France's energy policy, the development of renewable energies needs to be co-constructed with the regions. Recent legislative changes, such as **the 2021 Climate and Resilience Act (article 83) and the 2023 Renewable Energy Production Acceleration Act (article 15), have strengthened the key role of local and regional authorities**, and in particular the introduction of bottom-up planning for onshore renewable energy in France, to be carried out by elected representatives

Following consultation with their constituents, local authorities are invited to define acceleration zones where they would like to see renewable energy projects set up as a matter of priority. These acceleration zones can cover all types of renewable energy: photovoltaic, solar thermal, wind, biogas, geothermal, etc. All regions will be able to customise their acceleration zones according to the challenges facing their region, their potential for developing renewable energies and their political will. **The aim is for these zones to be sufficient to achieve the national and regional targets set out in the EPP**

These acceleration zones will serve as a basis for the work required by the European "RED III" directive, which asks Member States to identify enough zones to offer sufficient potential to achieve their renewable energy development targets. Within these zones, **"reinforced" acceleration zones will have to be identified, which will be subject to a strategic environmental assessment, in order to benefit from gains in terms of project appraisal times.**

Focus: The regional dimension of the EPP and the Regional Energy Committees

Article 83 of the 2021 "Climate & Resilience" Act states that regional targets for the development of renewable energies will be established by decree for mainland metropolitan France as from the publication of the present EPP, after consultation with the regional councils concerned, to contribute to the objectives of the national EPP (article L 141-5-1 of the Energy Code). **These objectives will take into account the regional renewable and recovered energy potential that can be mobilised.**

With a view to defining these regionalised renewable energy development targets for the PPE 3, **the Minister responsible for energy will ask the regional energy committee for each region located in mainland France to draw up a proposal for regional renewable energy development targets for the region**. On expiry of a period of two months from the date of the request, the regional committee's proposal is deemed to have been drawn up.

Within six months of the publication of the decree on the regionalised objectives of the EPP, **the region will initiate the procedure for amending the SRADDET to make the plan compatible.**

A common method and indicators for monitoring the **deployment and implementation of regional renewable energy development targets**, shared between the regions and the State as well as between local authorities in the same region, **will also be defined** in accordance with procedures laid down by decree.

The Regional Energy Committee (article L 141-5-2 of the Energy Code) is responsible for :

- Promote consultation, particularly with local and regional authorities, on energy-related issues within the region;
- Propose regional targets to the Minister for Energy, in line with the Multiannual Energy Programme.
- issue an opinion on the sufficiency of acceleration zones to enable the regionalised objectives of the EPP for the development of each type of renewable energy to be achieved .[87]

It can also debate and issue opinions on all issues relating to energy, energy storage and hydrogen that have an impact on the region. It is also involved in drawing up the energy section of regional plans (SRADDET, SDRIF).

In addition, the recast of the **Energy Efficiency Directive (DEE, 2023/1791/EU) requires local authorities and their groupings with more than 45,000 inhabitants to draw up local heating and cooling plans**. At this stage, it is envisaged that these plans will be integrated into the territorial climate air energy plans (PCAET), so as not to duplicate the documents that need to be produced by local authorities and their groupings.

- **<u>Promoting energy efficiency</u>**

[87] Initial opinions on the adequacy of the acceleration zones have already been issued on the basis of the first exercises in which the communes reported their zones, compared with other regionalised objectives, in particular the SRADDET objectives, pending publication of the EPP 3 and the decree on the regionalised objectives of the EPP 3 in 2025.

The transposition of the Energy Efficiency Directive (EED, 2023/1791/EU) will require local authorities and their groupings to contribute to achieving the following national objectives:

- Cumulative reduction in the final energy consumption of public bodies by 1.9% per year, compared with their energy consumption in 2021 (Article 5 of the EED);
- Renovation to a high level of energy performance, each year, of 3% of the surface area of buildings over 250 m2 belonging to public bodies (article 6 of the DEE);
- Biannual update of the inventory of public buildings (article 6 of the DEE) ;

7.3. A government that facilitates and works alongside local authorities through support and financial resources

➢ **To support the ecological transition**

The French government has begun work on the territorialisation of ecological planning with the creation of regional Conferences of the Parties, known as **"regional COPs". The aim is to enable local and regional authorities to take ownership of the planning exercise and to grasp the challenges of the climate emergency**. The aim of these COPs is to enable local and regional authorities to take ownership of the ecological planning exercise, to take their share of the national objectives and to translate them into concrete projects at the level of each citizen's catchment area. At the end of these months of debate, **regional roadmaps will have to be drawn up.** These will set out the **objectives for 2030, as well as the practical means that** each region plans to use to achieve them. This shared approach to ecological planning should ensure that the objectives are effectively achieved at national level.

In this context, the CRTE, now called "contracts for the success of the ecological transition", complete the approach by integrating the concrete projects resulting from the regional COPs. They offer **a simplified framework for contractualisation between local authorities and the State, becoming an effective tool for the detailed implementation of this territorial ecological planning.**

ACTION TER.1

CONTINUING TO PROVIDE SUPPORT AND FUNDING FOR THE ECOLOGICAL TRANSITION

- **To perpetuate the Green Fund** created in 2023 and dedicated to the ecological transition, which supports actions in the energy field (renovation of public buildings, public lighting, engineering support, etc.).
- **Continue the work of the regional COPs.**
- **Continue to support local authorities in drawing up CRTEs.**
- **Facilitate access to the engineering needs of local authorities** by better coordinating the services offered by operators (ANCT, ADEME, ANAH, ANRU, CEREMA, etc.).
- **The launch of the "Mon Espace Collectivité" platform,** a tailor-made support service for local authority projects, bringing together local authorities and the State in a single location to speed up projects and their impact on the region.

➢ **To support the development of renewable energies**

To help local councillors take advantage of the diversity of renewable energy sources and their positive spin-offs, the government is mobilising all its networks and those of its operators, with the aim of facilitating the process for local authorities. From now on, local authorities will have **a dedicated point of contact in the form of the prefectural referent for the appraisal of renewable energy and industrial projects required for the energy transition**. This mobilisation is also reflected in the **continued strengthening of the State's decentralised and central departments responsible for energy**, and in particular renewable energies, so that they can provide the necessary support to local elected representatives, alongside other players such as CEREMA, the "Générateurs" 24 network co-funded by Ademe and the Regions.

As part of this approach to facilitating the planning of renewable energies**, the government is making new tools available, such as a mapping portal** for visualising and analysing the issues to be taken into account in the development of renewable energies, ADEME fact sheets on renewable energies for local councillors, a network of local councillors to act as intermediaries in the regions, and the deployment of "turnkey" renewable energies.

ACTION TER.2

ACCELERATING AND PLANNING THE DEVELOPMENT OF RENEWABLE ENERGIES

- **Continue to support the Regional Energy Committees** in defining a proposal for a harmonised method for regionalising the national targets for the development of renewable energies, which will be a priority in the implementation of the EPP 3.
- **Continue to develop acceleration zones and the mapping portal** provided by the government to identify these zones. Develop it into a territorial energy dashboard for local authorities.
- **Mobilise and strengthen the Heat Fund** to support the expected trajectory in the development of renewable heat.
- **Encourage municipalities and inter-municipal bodies that** do not have heating networks but have the potential to deploy them **to carry out feasibility studies**
- **Strengthen local initiatives by extending the use of renewable heat coordinators**, at least one in each region, to support the projects of local authorities, businesses, etc.
- **Step up efforts to create heating networks** by providing personalised support based on new tools and by supporting renewable heating projects for private individuals as part of France Rénov'.
- **Promote the development of biomethane** by encouraging local and regional authorities to use the guarantees of origin issued by the facilities on their territory to certify the local and renewable origin of the gas consumed (as part of the biogas GO auctions, local and regional authorities can benefit free of charge from the GOs issued by the facilities located on their territory).

➢ **<u>To accelerate the reduction in energy consumption</u>**

In addition, the government has recently significantly increased the resources dedicated to funding and supporting local authorities in engineering actions aimed at reducing consumption, particularly those led by local authorities. This action should be continued.

ACTION TER.3

SUPPORTING ENERGY EFFICIENCY INITIATIVES

- **Mobilisation of CEE**[88] to support initiatives by local authorities and their groupings.
- **The Green Fund**, with a budget of €2 billion by 2024, is designed to help local authorities make the ecological transition, in particular by supporting the energy renovation of local public buildings and financing engineering support .[89]
- **The ACTEE+ programme** (Action des Collectivités Territoriales pour l'Efficacité Energétique), with a budget of €220 million up to the end of 2026, aims to develop energy efficiency projects for buildings through..:
    - technical and organisational support for local authorities, including a support unit staffed by experts, a resource centre with standard specifications that can be used directly by local authorities, guides, training and digital analysis tools;
    - co-financing of support and project management for the renovation of local authority public buildings and public lighting.
- **The "Heating for collective residential and tertiary sector buildings" grant** encourages the connection of buildings to heating networks or the installation of a low-carbon heating system .[90]
- Under the supervision of Anah, ensure the roll-out of the new territorial pact between the State and local authorities for the roll-out of the **France Rénov' public housing renovation service**, in particular by guaranteeing continued funding for household information and advice centres.

In addition, the government will step up its support for local authorities in transposing and implementing the Energy Efficiency Directive (DEE, 2023/1791/EU).

➢ **To support the transition in modes of transport**

The French government has also stepped up its efforts to promote clean mobility and modal shift through various programmes and plans:

ACTION TER.4

FINANCING LOW-CARBON SOFT MOBILITY AND ENCOURAGING MODAL SHIFT

- The ADVENIR programme (Support for the Development of Electric Vehicles through New Charging Infrastructures), to which additional €200 million will be added at the end of 2023 and which will run until the end of 2027, aims to finance new infrastructure for private use in collective housing, on-street charging points and depot charging points for heavy goods vehicles;

- The ALVEOLE + and AVELO 2 and 3 programmes, with funding of €28.9m, €25m and €37m respectively, are designed to finance the installation of equipped or secure cycle spaces and to

[88] The standardised sheets can be used for building renovation projects as well as the CEE programmes, the catalogue of which is available at this link: https://www.ecologie.gouv.fr/politiques-publiques/cee-programmes-daccompagnement

[89] Press release announcing the continuation of the Green Fund until 2027.

[90] Source : https://www.ecologie.gouv.fr/politiques-publiques/coup-pouce-chauffage-batiments-residentiels-collectifs-tertiaires

support sparsely populated areas in the planning, experimentation and management of their cycling policies, in order to develop the use of bicycles as a means of daily travel;

- A total of €1.5 billion has been earmarked **for aid for the purchase of low-polluting vehicles** in 2024. This aid includes the ecological bonus, the conversion premium and leasing aid for electric cars. Local authorities are eligible for some of these grants, as are private legal entities, and the amounts of these grants are higher in some areas. In particular, the conversion premium, which supports the introduction of low-emission zones, has been increased by up to €3,000 in these areas since [1]January 2023. Support for the electrification of heavy vehicles will be financed in 2024 by energy saving certificates, to the tune of an additional €130 million. Mobility organising authorities with a population of less than 400,000 can receive support for the purchase of new electric buses.

- Cycling plan and carpooling plan (see Annex on the Clean Mobility Development Strategy).

8. Appendix 1: Clean mobility development strategy

See separate document on the Clean Mobility Development Strategy (SDM P).